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ORIGINAL ARTICLE

# Are habits driven by motivation in large urban contexts? The role of goal pursuit in waste separation behavior

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## Abstract

Household waste separation constitutes a crucial component of sustainable waste management. This study employs a model grounded in the Theory of Planned Behavior (TPB) to investigate the determinants influencing the intention to engage in household waste separation. Structural equation modeling was applied to test the hypothesized relationships among constructs. The results confirm the robustness of traditional TPB predictors of intention: attitude ($\beta = 0.400$, $p < 0.001$), perceived behavioral control ($\beta = 0.396$, $p < 0.001$), and subjective norms ($\beta = 0.114$, $p < 0.05$). In addition, environmental motivation exerts a significant positive effect on both attitudes ($\beta = 0.318$, $p < 0.001$) and habits ($\beta = 0.642$, $p < 0.001$); habits influence intention ($\beta = 0.225$, $p < 0.01$), attitude ($\beta = 0.439$, $p < 0.001$), perceived behavioral control ($\beta = 0.721$, $p < 0.001$), and past behavior ($\beta = 0.225$, $p < 0.05$). Collectively, these findings demonstrate that extending the TPB framework to incorporate environmental motivation and habitual processes enhances its explanatory power, particularly when analyzing repetitive actions with minimal volitional control, such as waste separation. Finally, this paper provides policy recommendations and future research directions, including the development of targeted campaigns designed to activate pro-environmental goals.

**Keywords** Waste Sorting · Antecedents of Behavior · Habit · Theory of Planned Behavior (TPB) · Behavioral Theory · Large Urban Areas

## Introduction

In recent years, there has been a notable increase in the volume of academic literature on recycling behavior [1] indicating an enhanced sensitivity on waste-related issues. The analysis of these papers indicates that several matters are still debated among scholars, such as the most appropriate framework for analyzing recycling behavior at the consumer or household level [2, 3]. Numerous theories in the behavioral sciences domain have been proposed with different outcomes. As demonstrated by various recent meta-analyses, systematic literature reviews and bibliometric studies [1, 4–6], the most diffused frameworks are the Theory of Reasoned Action [7], the Theory of Planned Behavior (TPB) [8], the Norm Activation Model [9] and the Value Belief Norm theory [10]. In particular, the TPB, and its extended forms, are still undergoing consistent testing, often leading to different conclusions about their predictive capabilities. Many field studies demonstrate that the TPB is a valid construct to study human behavior in very different contexts (e.g., health, transportation, energy saving), but

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its typical components (namely attitude, subjective norms, perceived behavioral control (PBC), intention and behavior) do not always allow to highlight some peculiarities of recycling behavior. For example, in many advanced economies, people must strictly apply waste separation procedures since several years, therefore, recycling behavior is characterized by very repetitive actions in a stable context. In fact, recycling behavior has the characteristics for being considered as a habit as well, but very few scholars have kept in due consideration this factor [11–13]. In addition, it may be driven by specific motivations, not always so manifest; in this regard, TPB does not explicitly consider internal individual motivations. On the contrary, other approaches, like the goal directed behavior model [14] or the goal system theory [15], consider desire, motivations and goals as direct or indirect antecedents of behavior.

In addition, human behavior is highly influenced by very specific contextual factors that the TPB would incorporate in the antecedents of intention, like PBC. These factors are very heterogeneous and have different effects on behavior because they are context dependent. For example, recycling practices may be influenced by the presence of waste pickers who exert a tangible effect on local recycling behavior [16, 17], or by place dependence and place identity [18].

For these reasons, this paper aims at an enhanced understanding of waste separation behavior of the citizens living in the 8$^{th}$ municipality of Rome (Italy) (an area covering approximately 47 square kilometers with a population of more than 130,000 officially registered residents) through the utilization of an ad hoc model, based on the TPB, integrated by some variables that characterize waste-separation behavior, like habits, past behavior, motivation and functionality of the recycling bins. Traditionally, Fishbein and Ajzen include the effects of these variables in the typical TPB antecedents of intentions (attitude, subjective norms or PBC). However, although TPB has proved to be a general and solid construct which can be successfully applied in very different contexts [19], this paper aims at verifying whether the inclusion of these additional variables better predicts separating behavior by making these effects more visible and by defining more effective corrective interventions. While the authors presume to confirm the predictive capability of the TPB through the standard antecedents of intention, we expect a key role for habits and environmental motivation, and a limited influence of past behavior. In addition, this paper analyzes the respondents' structure of goals, their environmental awareness and their utilization of media in order to better tailor interventions.

Therefore, given this context, the considered elements and the theoretical lens applied, the guiding research question (RQ) of this study emerges as follows:

What are the key determinants influencing the residents' waste separation behavior in large urban areas?

This paper is structured in six sections and provides also some supplementary material (SM). After the introduction, Literature review and theoretical framework reviews the existing literature, defines the framework and identifies the hypotheses. Methodology describes the methodology and Results analyses the empirical results of the survey on the citizens living in the 8th municipality of Rome. Discussion discusses these results and assesses the moderating effects of habits, past behaviors, motivations and bins functionality, with some policy and managerial recommendations for interventions. Conclusions, limitations and future research directions presents the conclusions, limitations, and possible future research paths.

## Literature review and theoretical framework

The section aims at analyzing the theoretical framework and how habits, past behavior, motivation and contextual factors have been addressed in previous studies.

### Theoretical framework

Previous studies about recycling behavior have focused on different aspects like the analysis of socio-demographical factors, socio-psychological ones, socio-economic ones, legal-institutional ones, and contextual ones. Considering the general aim of these researches is understanding the complexity of human behavior and its relationship with the surrounding environment, the predominant approach is based on behavioral theories and models coming from social psychology. Numerous studies have proved the efficacy of these theories; however, they did not reach a unanimous consensus, especially considering the peculiarity of the contexts of investigation, the different focus of the research, the heterogeneous scholars' background. As demonstrated by several systematic literature reviews [6, 20], meta and bibliometric analyses [4, 21], the most recognized framework in the specific field of recycling behavior is based on the TPB [8], developed from the previous TRA [7]. Other quite diffused approaches are rooted on the Norm Activation Model [9], the Value Belief Norm Theory [10], the Model of Goal Directed Behavior [14], the Self-determination Theory [22, 23]. Some scholars have analyzed the reasons for the selection of a specific theory in spite of another one; for example, Bamberg and Moser [24] deem that authors mainly interested in individual self-interests probably opt for the reasoned choice approach (e.g., TRA and TPB), whereas scholars more focused on pro-social behavior adopt models based on Norm Activation Model

and Value Belief Norm Theory. This study selects the TPB framework both because of its proven efficacy in analyzing pro-environmental behaviors, and because of the possibility of adding additional constructs without distorting the essence of TPB, therefore potentially achieving a better understanding of human behavior. In particular, TPB keeps being applied to the study of waste-related behavior by researchers in the challenge of capturing the facets and peculiarities of this behavior.

Looking at the specific TPB constructs, Fishbein and Ajzen [25] consider intentions as the immediate predictor of behavior. As stated by Eagly and Chaiken [26], intention "represents the person's motivation in the sense of his or her conscious plan to exert effort to carry out a behavior". In the TPB, Fishbein and Ajzen [25] individuate three antecedents of intention, namely attitude, subjective norms and PBC. Attitude measures the level of desirability of a specific behavior. The influence of norms (in particular of relevant others, like parents) on the individual is measured through the construct of subjective norms; in fact, Fishbein and Ajzen are "interested in people's perception of the overall social pressure exerted on them to perform or not to perform a given behavior" [25]. Numerous scholars, like Oskamp et al. [27], analyze the effects of norms on recycling intentions with different outcomes. PBC represents the effects of perceived control (on the action to be performed) and self-efficacy. The former is volitional control over the behavior, the latter is the individual perception of having the skills to perform a behavior [25]. Actually, Fishbein and Ajzen [25] would rather use the terms capacity and autonomy as more appropriate and consider them as a single construct.

Consistent with the basic TPB principles, this paper thus formulates the following hypotheses (Fig. 1 shows the hypotheses by representing the cause-effect relationships between the model variables):

- **H1a$_{ATT-INT}$**. Attitude towards waste separation (ATT) positively affects waste sorting intention (INT).
- **H1b$_{NOR-INT}$**. Subjective norms (NOR) positively affect waste sorting intention.
- **H1c$_{PBC-INT}$**. Personal Behavioral Control (PBC) positively affects waste sorting intention.

## Past behavior and habits

Several studies have analyzed the influence of past behavior and habits on human behavior [28]. The literature shows that, at times, there is confusion or overlap between past behavior and habits, therefore it is necessary to clarify these concepts at first. Whereas the concept of past behavior is quite self-explanatory and it can be interpreted, in general

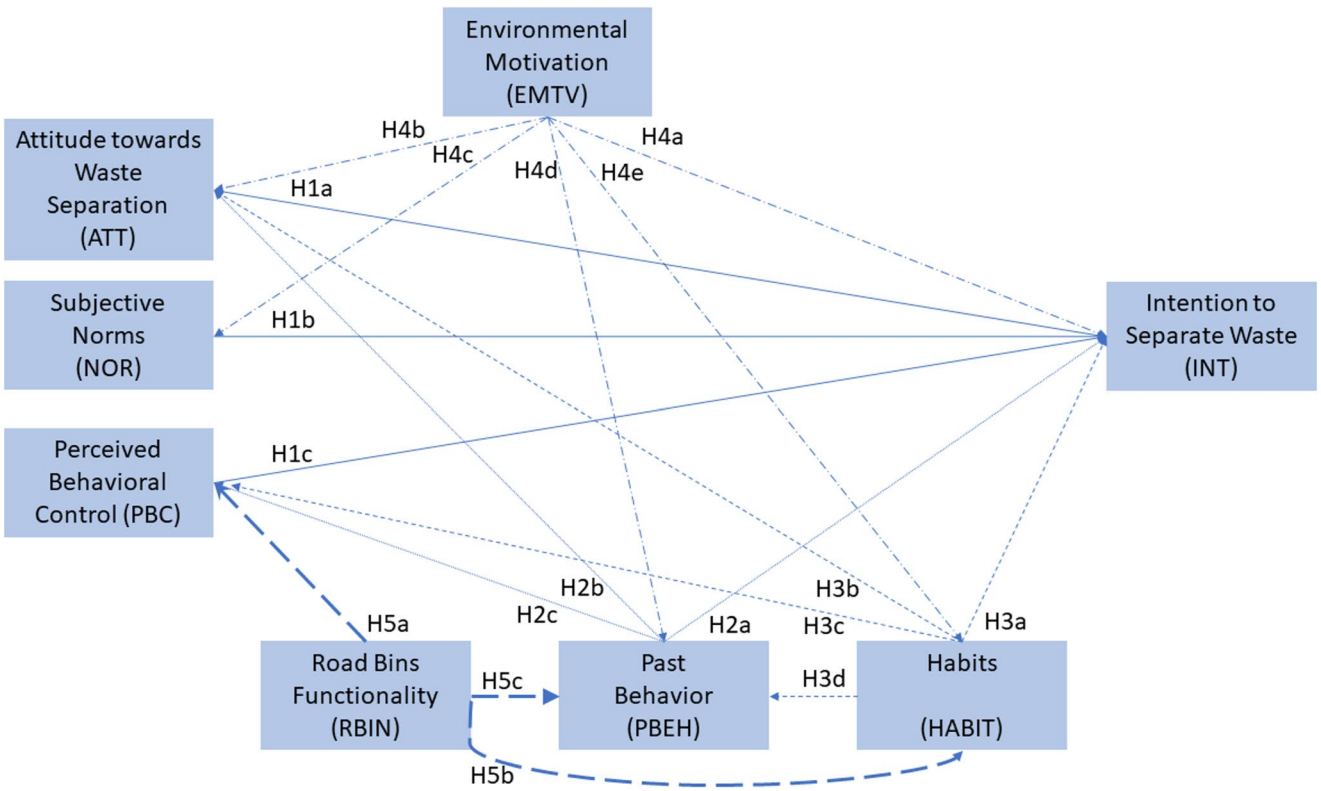


**Fig. 1** Research Framework

terms, as the previous execution of an action and the related activities, habitual behavior recalls some specific conditions, like minimal control and attention toward the activity, or the triggering of specific events. Ajzen [8] warns about not confusing the two concepts by explaining that "past behavior is best treated not as a measure of habit, but as a reflection of all factors that determine the behavior of interest". Aarts et al. [28] "conceive of habits as goal-directed automatic behaviors that are mentally represented. And because of frequent performance in similar situations in the past, these mental representations and the resulting action can be automatically activated by environmental cues".

The importance of considering both of them comes from the fact that "past behaviour can be a very good predictor of future action" [25]; indeed, "including past behavior as an additional predictor has consistently been found to produce substantial increase in the amount of explained variance in later behavior as well as in behavioral intentions" [25]. In other words, the effect of past behavior should be mediated by attitude, subjective norms and PBC, but past behavior also has a residual non-mediated effect on intention [25]. Some studies have shown a direct effect of past behavior on intention and an increase in model's predictive capability when considering past behavior [14, 29, 30]. This aspect is in contrast with the sufficiency assumption of TPB which routes the effects of past behavior through the TPB predictors of intention. In particular, very few papers have investigated both the direct and indirect effects of past behavior on intention [31]. Building also on Knussen and Yule [32] who infer that "past behavior is not generally viewed as a true component of the TPB", this paper analyzes the sufficiency assumption in the case of waste separation behavior and investigates direct and indirect effects of past behavior on intention. Therefore, it proposes the hypotheses as follows:

- **H2a$_{\text{PBEH-INT}}$**. Past behavior (PBEH) positively affects waste separation intention.
- **H2b$_{\text{PBEH-ATT}}$**. Past behavior positively affects attitude.
- **H2c$_{\text{PBEH-PBC}}$**. Past behavior positively affects PBC.

At the same time, "recycling [behavior] is habitual in nature" [12], repetitive and automatic [33]. In fact, habits involve the concept of automaticity, especially upon activation of a goal, or as soon as certain conditions occur. In this regard, Bargh [34] identifies four features of this automatic process, namely unintentionality, uncontrollability, lack of awareness and efficiency, with different combination of them in terms of presence and intensity.

For several scholars, habits are directly related to the existence and achievement of a goal. In fact, Aarts and Dijksterhuis [35] define habits as "frequent and consistent choices made to attain the same goal which determines the formation of an association between goal and an action". In the case of environmental behaviors like household recycling, the presence of a goal is not always so manifest, but habits can be activated by some triggering stimuli when a goal is present [28] (SM).

Aarts et al. [28] infer that papers on TPB tend to underestimate the "repetitive nature" of environmental behavior. Actually, we deem that this nature is brought back by Ajzen to the riverbed of the TPB. In fact, the authors argue that, albeit Ajzen recognizes the influence of past behaviors on future behavior, the TPB considers the effects of past behaviors, through its typical components, namely PBC, norms and intentions. Moreover, they claim that Ajzen's approach may not apply to repeated behaviors; this approach is supported by Verplanken et al. [36] who consider expectancy-value models (including the TPB) as not fully suited for less deliberate behaviors (which are activated by specific cues or contexts). Building also on Tseng et al. [37] who highlight the key role of habits and recommend further research on this construct in relation to recycling behavior, this study investigates the influence of habit on TPB constructs; in addition, it compares the (direct and indirect) effects of both past behavior and habits on intention and its applicable TPB antecedents.

Considering, at times, the academic literature considers past behavior frequency as a habit [38] or the behavior itself [39], we clarify that in this paper the term "past behavior" refers to past behavior frequency, whereas "habit" refers to the automatic part of a repetitive behavior characterized by the above-mentioned "unintentionality" and limited awareness.

Therefore, we propose some hypotheses as follows:

- **H3a$_{\text{HABIT-INT}}$**. Habit positively affects waste sorting intention.
- **H3b$_{\text{HABIT-ATT}}$**. Habit positively affects attitude.
- **H3c$_{\text{HABIT-PBC}}$**. Habit positively affects PBC.
- **H3d$_{\text{HABIT-PBEH}}$**. Habit positively affects past behavior.

## Motivation and goals

In the formulation of the Theory of Reasoned Goal Pursuit, Ajzen and Kruglanski [40] infer that "attitude and subjective norms, the central motivators of intentions and behavior in the TPB, are insufficient to explain action initiation". Indeed, although an individual may have a positive attitude toward a behavior and he/she may feel the social pressure to perform it, he/she may still not intent to perform that behavior. The motivation to act may come from an active goal, which is "a state of affairs or an outcome that people desire to attain through their actions" [41]; in other words,

motivation represents the desire to reach one or more specific goals, which are the motivators of action [40].

The influence of goals on human behavior varies depending on their hierarchical organization, the potential conflict with other goals (or inter-goal conflict) and goal imprecision [42]. Moreover, the salience of a goal at a specific time is influenced by contextual factors [43] (SM).

Obviously, the goal construct is quite dynamic because goals may change throughout time, may vary in magnitude, may be within or outside our reach; therefore, action may not start if it does not reach a certain level of desirability and attainment.

Otto et al. [44] infer that behavior stems from the interconnection of different types of motivations including the environmental one; for example, an individual may act for very different reasons such as utility, gratification, reward, fear, feeling of guilt. In the case of recycling behavior, motivation may come, for example, from subjective utility or from environmental concern. The former may be obtained by rewarding virtuous people who are able to reduce the quantity of non-recyclable material, the latter may be represented by personal sensitivity to environmental protection and pollution, or concern for limited access to resources. More recently, Tuu [45], building on the value-attitude-behavior framework and the goal-framing theory, highlights the positive impact of environmental protection motives on attitude toward food waste reduction at the household level.

Furthermore, Otto et al. [46] highlight the stability over time of environmental motivation (EMTV), although it may change in the long term; this property is very important because the scientific research in some fields is often limited by goal fluctuation. Therefore, Otto et al. [44] deem environmental motivation as a fundamental variable effecting recycling behavior. Other authors confirm the positive influence of (recycling) motivation and goals on intention [47, 48], however they do not investigate the effect of motivation on TPB predictors of intention.

Therefore, although environmental motivation may vary depending on different factors, this paper intends to understand how this construct can improve the predictive power of the TPB by analyzing its relationship with intention, attitude, subjective norms, past behavior and habits (for possible direct and indirect effects).

- **H4a$_{\text{EMTV-INT}}$**. Environmental motivation positively affects waste sorting intention.
- **H4b$_{\text{EMTV-ATT}}$**. Environmental motivation positively affects attitude.
- **H4c$_{\text{EMTV-NOR}}$**. Environmental motivation positively affects subjective norms.
- **H4d$_{\text{EMTV-PBEH}}$**. Environmental motivation positively affects past behavior.
- **H4e$_{\text{EMTV-HABIT}}$**. Environmental motivation positively affects habits.

## Contextual factors

Although Fishbein and Ajzen [25] recognize the existence of numerous background factors ranging from the individual sphere (e.g., personality, mood, emotion, values, stereotypes, past behavior) to the social sphere (e.g., education, age, gender, religion, race), they state that "there is no necessary connection between background factors and (behavioral, normative, or control) beliefs" [25]. Nevertheless, we must admit that some local factors (out of the personal control) may objectively impede or limit the capability of an individual to correctly perform recycling procedures. For example, the lack of recycling bins in the vicinity of the house or the reduced frequency of waste collection may severely impact people's capability of correctly recycling the waste they produce [49]. For these reasons, Kechagias and Dimitriadis [47] infer that the construct of "spatial planning of recycling bins" significantly influence people's recycling. At the same time, Fan et al. [50] conclude that the "availability of infrastructure" (referring to the physical and logistical resources that facilitate waste separation behaviors, which encompasses the presence of accessible and properly designated bins for different types of waste, clear signage indicating sorting categories, and the overall convenience of the waste management system) directly influences individuals' behavior even in the absence of strong personal motivation and moderates the relationship between intention and behavior in Singapore and Shanghai.

In line with Fishbein's and Ajzen's consideration that the above-mentioned factors are considered through PBC, we introduce the construct of (perceived) "functionality of bins" to analyze its effect on PBC, habit and past behavior. This construct considers the position of the bins, their capacity and the practicality from the final user's point of view during the daily use (e.g., easiness to introduce the waste inside the bins) [51]. Therefore, considering also the outcomes of Geiger et al. [4]'s meta-analysis suggesting to further investigate the impact of contextual factors on waste related behaviors, we formulate the hypotheses as follows:

- **H5a$_{\text{RBIN-PBC}}$**. The functionality of recycling bins (RBIN) positively affects PBC.
- **H5b$_{\text{RBIN-HABIT}}$**. The functionality of recycling bins positively affects habit.
- **H5c$_{\text{RBIN-PBEH}}$**. The functionality of recycling bins positively affects past behavior.

## Methodology

### Research design

This paper is based on a quantitative research method to analyze the application of the TPB to waste separation behavior [39] in Rome (Italy). A cross-sectional survey design is applied in order to get a representative sample of the population [38]. Considering waste recycling for tourists may be influenced by specific factors such as habits at home [52], heritage site [53], emotional bonding and in-group norms [54], the sample was not taken among tourists but among Roman residents. After the initial eliciting questionnaire and the test phase, the final questionnaire was distributed in the 8th municipality of Rome through both a freely accessible platform for on-line fill in and trained interviewers administering the questionnaires in informal places (like railway stations, shopping areas, city streets, squares). The sampling process was simple random with no incentives for participants.

The sample size has been determined with the support of G*Power software [55] because power analysis has to consider the specific characteristics of one's own model as well [56]. In fact, the capability to detect a target effect in SEM is influenced by "sample size and effect size, as well as less familiar considerations, such as number of indicators of latent variables, indicator reliability, and the values of other parameters in the model" [56]. For the model utilized in this study, G*Power provides a power of 0.86 for a sample size of 150 respondents (with significance criterion $\alpha = 0.05$, 1000 simulations), therefore 178 full questionnaires guarantee adequate power.

### Structure of the questionnaire

The questionnaire was made of 4 parts, some of them not (or partially) utilized in this paper (e.g., institutional and informational aspects). The socio-demographical part included questions about age, gender, education, family size, district, employment state, income and type of waste collection service. The socio-psychological part investigated the typical TPB components (attitude, subjective norms, PBC and intention) and other related factors, namely past behavior, habits, bins functionality, goals, motivations and environmental concerns. The questions frequently offered a measurement scale to indicate the level of agreement or disagreement; in some cases, they were based on multiple-choice answers. Occasionally, open-ended answers were permitted to gain further insights on respondents' characteristics (e.g., reasons for separating waste).

### Constructs and measures

All scale items were based on previously utilized validated scales (SM).

### Data analysis

After the initial descriptive statistics with IBM SPSS 26, Structural Equations Modeling (SEM) with IBM AMOS 28 was utilized to test the proposed extended TPB model and the related hypotheses. The reason for applying SEM comes from its robustness and power as a statistical tool in socio-psychological sciences [57]. The data were analyzed in a 2-step approach: initially, we tested the measurement model for the internal reliability, convergent and discriminant validity of constructs with SPSS 26; subsequently, we assessed the structural model for its ability to predict the endogenous variables [58] and we analyzed the relationships among the constructs.

## Results

### Sample descriptive statistics

The overall response rate was approximately 95% ($N=178$). The demographical sample composition was made of 62.9% ($N=112$) female and 37.1% ($N=66$) male. The adult sample showed a predominance of the age range 45 to 64 (48.3%), being slightly overrepresented compared with the data provided by the National Registry for the entire city of Rome (SM). The education level was quite high (high school or university); the occupation was mainly represented by clerks 48% ($N=27$) and retired personnel 29.8% ($N=53$). The average family composition was 2.7 people/family versus 2.1 for the city of Rome (SM).

The analysis of scores in terms of means, standard deviations, ranges, kurtosis and skewness show a reasonable normal distribution (Kolmogorov-Smirnov test of normality, histograms or normal Q-Q plot). The analysis excluded cases pairwise and removed some extreme outliers.

The analysis of goal priorities (Fig. 2) indicates that the sample places significant emphasis on love and friendship, living in a clean city, and maintaining good health (with more than 90% of respondents ranking these goals as high priorities). Protecting the environment emerges as a high priority for more than 85% of the sample, reflecting a strong concern for sustainability among citizens. Similarly, living in a safe and secure city is highly valued by 80% of respondents. Work represents a high priority for more than 70% of the sample, suggesting that professional fulfillment remains important; whereas, goals such as traveling, making money,

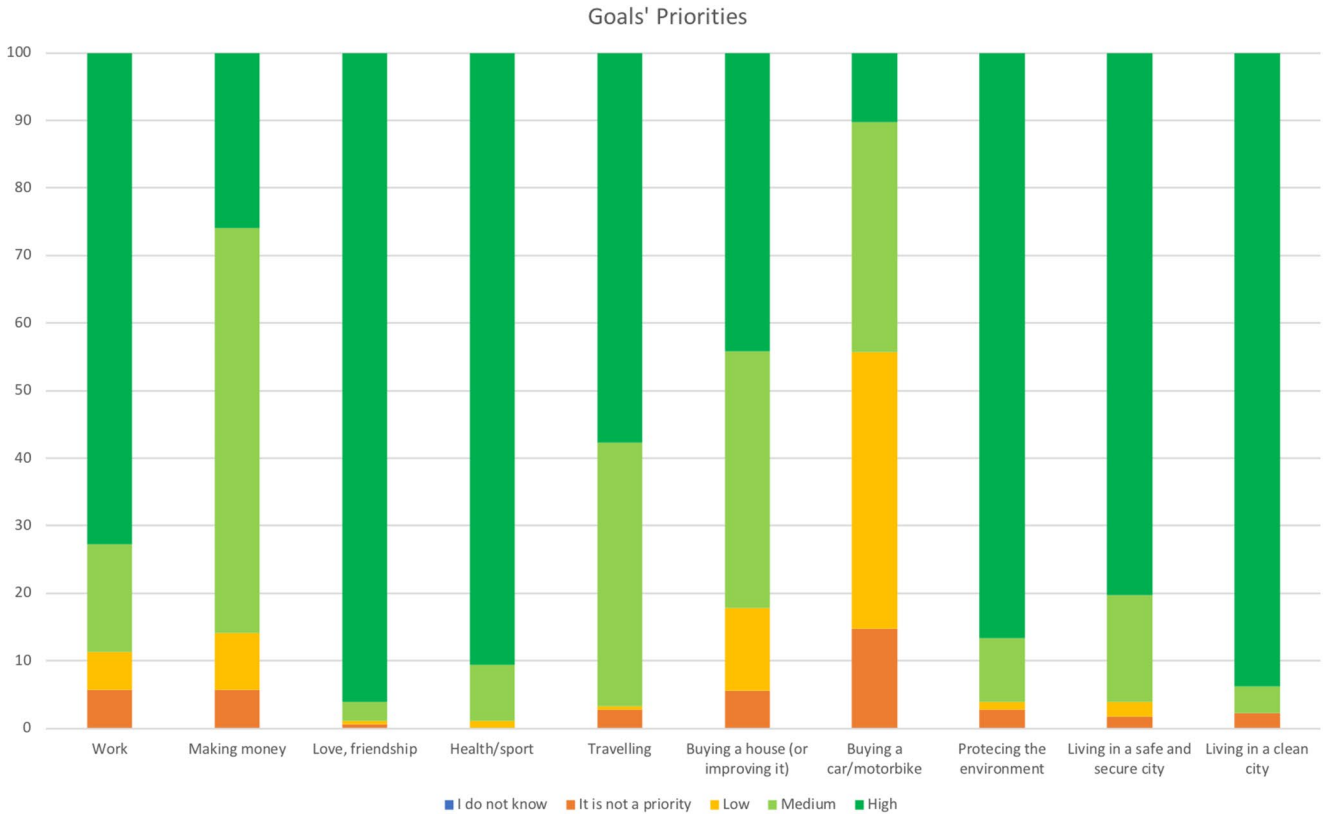


**Fig. 2** Goals' Priorities

buying a house or car receive comparatively lower levels of prioritization. This trend may reflect the specific socio-cultural and urban dynamics of citizens living in the 8th municipality of Rome, where environmental and social concerns, including safety and cleanliness, have emerged as relevant to the residents' daily experiences and quality of life.

The analysis of the level of environmental awareness (in relation to waste) indicates that 97% of the respondents has a high to very high level of awareness (Fig. 3).

The analysis of the reasons for separating waste offers some insights on respondents' motivations (Fig. 4). Whereas many people think that separating waste is a valid reason to offer a better future for our children and to protect the environment, some people separate waste because they simply want to stick to the rules or because of the fear of being sanctioned (in case of improper handling of their waste).

The survey also analyzed the level of respondents' interaction with social media channels as a source of information and knowledge, in terms of frequency and type of media (Fig. 5). Most of the respondents access internet daily or every other day; similarly happens for television (TV); whereas almost 70% of respondents access the newspapers with the same frequency. Among social media, the most frequently used are Facebook and YouTube.

## 4.2 Assessment of measurement model

The software AMOS 28 was utilized to conduct a confirmatory factor analysis applying the maximum likelihood estimation, especially considering that this type of analysis is utilized for testing existing theories [59].

The internal consistency of all measures has been checked through Cronbach's α coefficient. Overall, the items show good internal consistency being above 0.700 [60] (Table 1 and SM).

The assessment of the reliability and the validity of the scale is conducted through different steps. The reliability of a scale provides an indication of its independence from random errors; it is measured in terms of its temporal stability and internal consistency [61]. The validity of the scale is analyzed in relation to its constructs through convergent and discriminant validity. Convergent validity is indicated by all factors' loadings above 0.500; composite reliability (CR) above 0.700 shows the internal consistency of each set of indicators [62]; average variance extracted above 0.500 indicates convergent reliability [58]. Table 1 shows that these requirements are met. The discriminant validity is tested by applying the Fornell-Larcker criterion, which verifies that the square root of average variance extracted per each construct is above all bivariate correlation coefficients

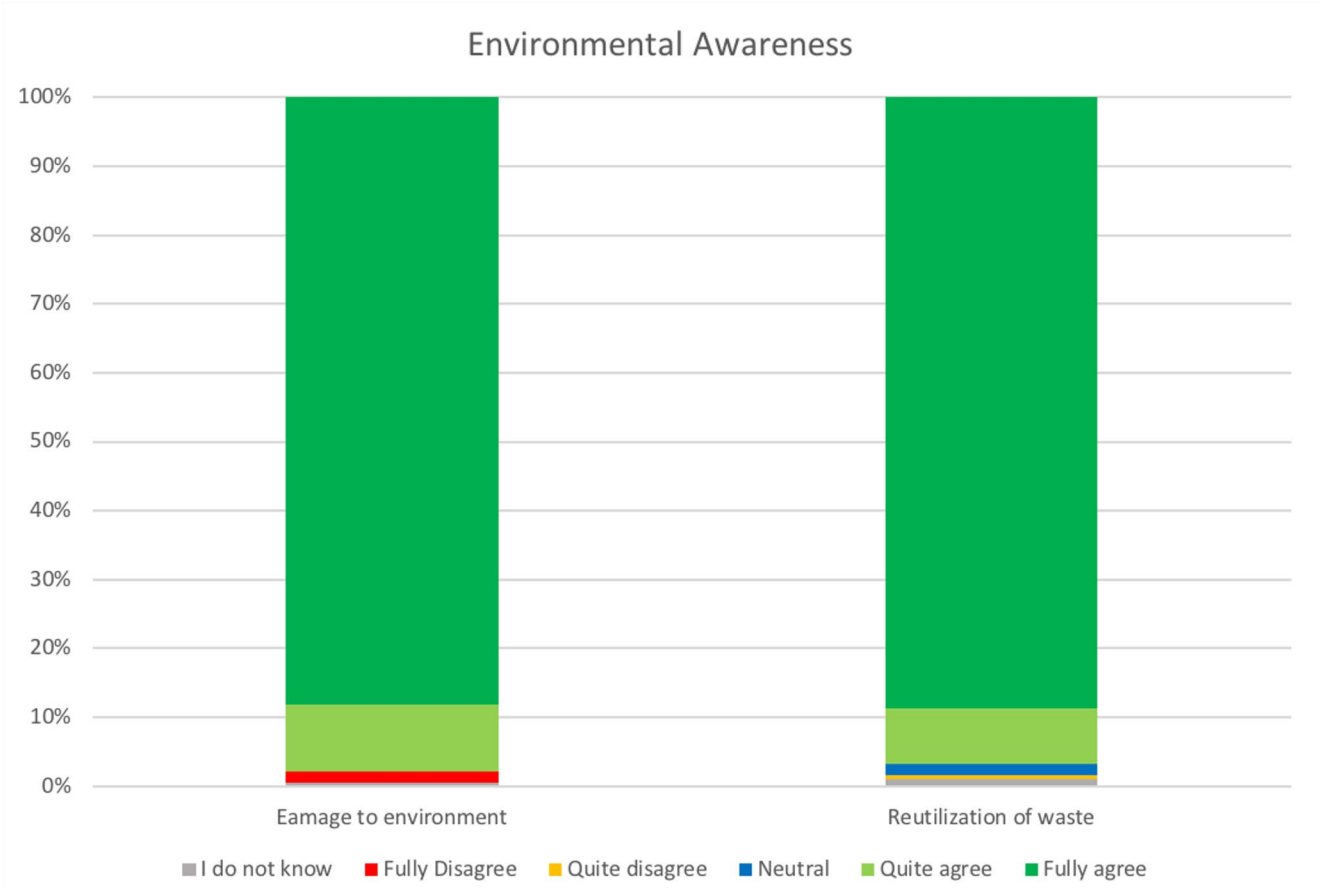


**Fig. 3** Environmental Awareness

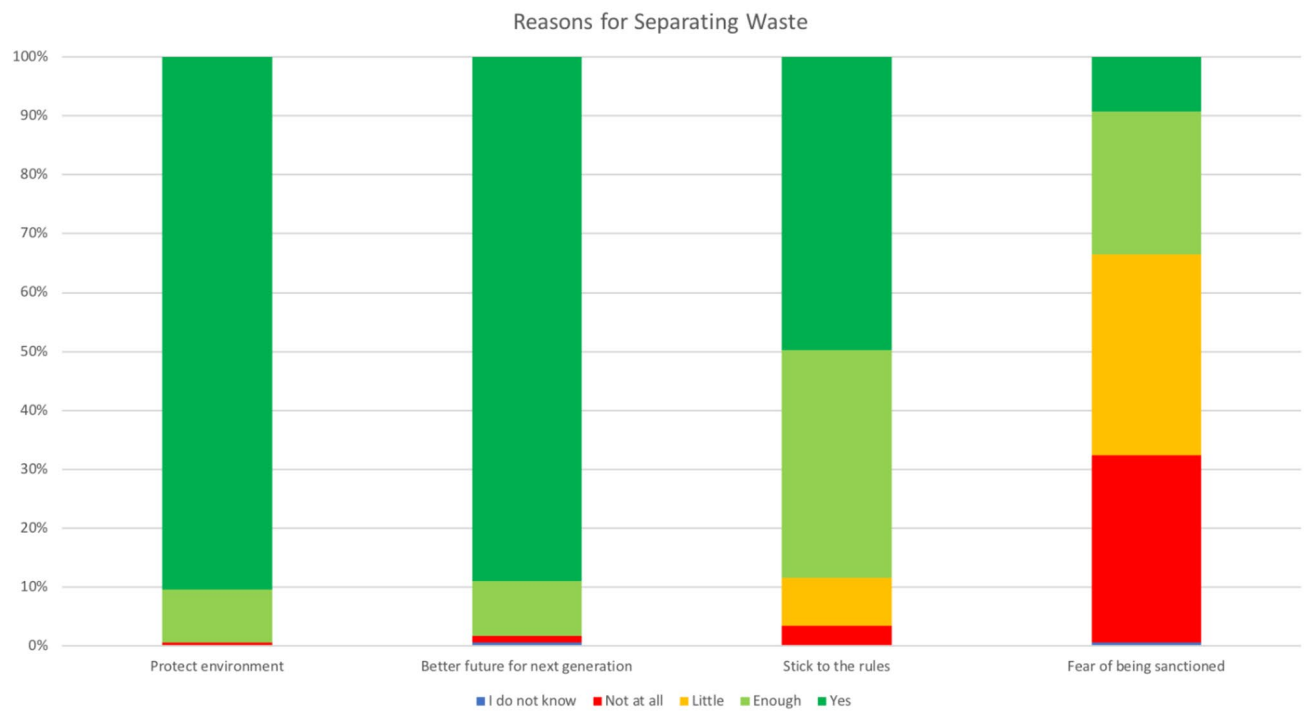


**Fig. 4** Reasons for Separating Waste

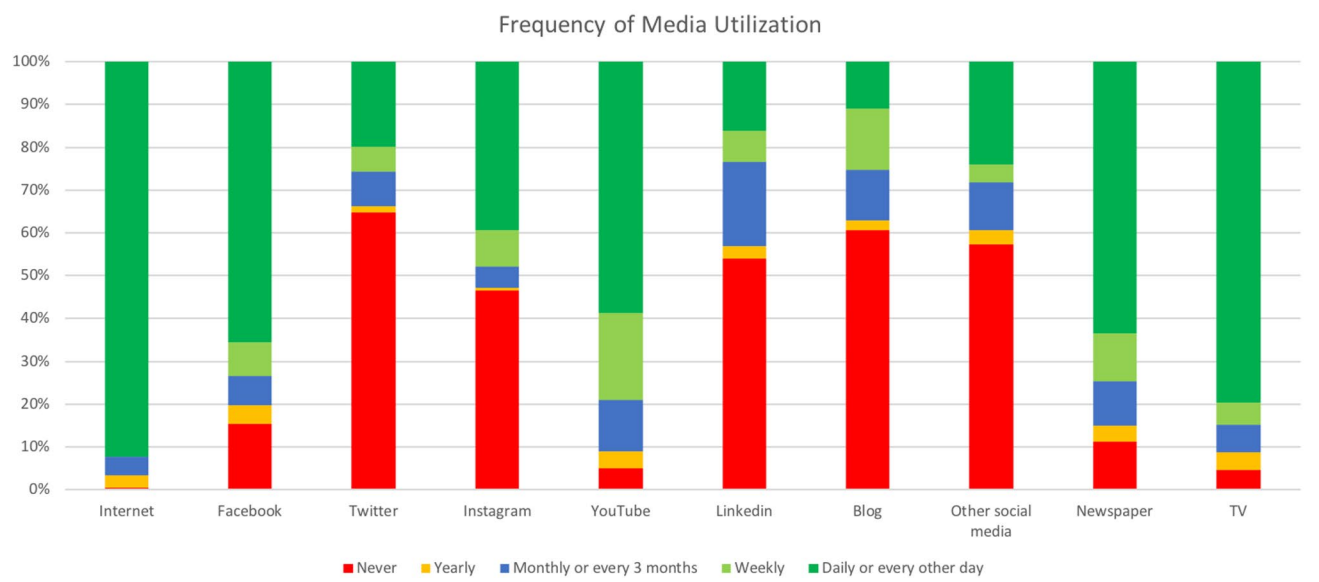


**Fig. 5** Frequency of Media Utilization

with other constructs; this criterion shows that the measurement model exhibits discriminant validity; therefore, we conclude that the proposed measurement model is adequate (Table 2 and SM).

## Assessment of structural model

The structural model is used to test the structural relationships previously described in Sect. 2. First of all, we verify the fitness of the model in accordance with standard thresholds [63, 64]. Overall, the model displays acceptable fit indexes: ratio $\chi^2/df = 1.767$; comparative fit index = 0.937; Tucker and Lewis Index = 0.927; root mean square error of approximation = 0.066, 90% CI (Confidence Interval)=[0.055, 0.076]; standardized root mean square residual = 0.071 (SM). AMOS 28 is subsequently used to test the previously defined hypotheses in the structural model based on the extended TPB (Table 3) and to assess the mediating role of environmental motivation, past behavior and habits on intention to recycle through bootstrapping (Table 4).

Table 3 shows that the standard TPB predictors of intention significantly and positively influence separation behavior: attitude has ß=0.400, $p < 0.001$ (effect size [65] $f^2 = 0.214$); subjective norms have ß=0.114, $p = 0.046$ ($f^2 = 0.008$); PBC has ß=0.396, $p < 0.001$ ($f^2 = 0.099$). Therefore, the hypotheses H1a, H1b and H1c are accepted. Among these antecedents of intention, subjective norms are the weakest predictor. Moreover, the model explains 75.7% of the variance in intention ($R^2 = 0.757$), 45.7% of the variance in attitude ($R^2 = 0.457$), 19.2% of variance in subjective norms ($R^2 = 0.192$) and 50.7% of variance in PBC ($R^2 = 0.507$) (Fig. 6). Further considerations on CI and effect size are available in SM.

The additional constructs show different levels of significance. Past behavior shows a non-statistically significant effect on intention (ß=0.026, $p=0.643$, $f^2=0.001$) and attitude (ß=-0.069, $p=0.316$, $f^2=0.011$), and a statistically significant and negative effect on PBC (ß=-0.199, $p=0.003$, $f^2=0.085$). Therefore, the hypotheses H2a and H2b are rejected, whereas H2c is accepted. Habits have significant and positive effects on intention (ß=0.225, $p=0.045$, $f^2=0.016$), attitude (ß=0.439, $p<0.001$, $f^2=0.134$), PBC (ß=0.721, $p<0.001$, $f^2=0.884$) and past behavior (ß=0.225, $p=0.049$, $f^2=0.024$). Therefore, the hypotheses H3a, H3b, H3c and H3d are accepted. Environmental motivation has a non-significant impact on intention (ß=-0.071, $p=0.339$, $f^2=0.016$), subjective norms (ß=0.071, $p=0.492$, f2=0.005) and past behavior (ß=0.017, $p=0.877$, $f^2=0.001$) considering their probability p is well above 0.05 and t-values are low. On the contrary, the environmental motivation has a significant and positive impact on attitude (ß=0.318, $p<0.001$, $f^2=0.044$) and, in particular, habit (ß=0.642, $p<0.001$, $f^2=0.635$). Therefore, the hypotheses H4a, H4c and H4d are rejected, whereas H4b and H4e are accepted. Road bins functionality has a statistically non-significant impact on PBC (ß=0.055, $p=0.433$, $f^2=0.006$) and past behavior (ß=0.005, $p=0.956$, $f^2=0.001$); on the contrary, RBIN has a quite significant and positive impact on habits (ß=0.165, $p=0.020$, $f^2=0.011$). Therefore, hypotheses H5a and H5c are rejected, whereas H5b is accepted.

**Table 1** Indicators Loadings

| Constructs | Indicator Code | Indicators | Loadings | Cronbach's α | Composite Reliability | Average Variance Extracted |
|---|---|---|---|---|---|---|
| Intention (INT) | INT1 | I want to separately collect waste in the next 3 months | 0.766 | 0.884 | 0.847 | 0.723 |
| | INT2 | I will separately collect waste in the next 3 months | 0.877 | | | |
| | INT3 | I intend to separately collect waste in the next 3 months | 0.901 | | | |
| Attitude (ATT) | ATT1 | Waste as a resource to reutilize | 0.865 | 0.826 | 0.776 | 0.635 |
| | ATT2 | Inappropriate waste management may damage the environment | 0.787 | | | |
| | ATT3 | Separating waste in the next 3 months is bad/good | 0.734 | | | |
| Perceived Behavioral Control (PBC) | PBC1 | Separating waste in the next 3 months it is difficult/easy | 0.877 | 0.870 | 0.752 | 0.766 |
| | PBC2 | I can separate waste in the next 3 months within my available time and space | 0.873 | | | |
| Subjective Norms (NOR) | NOR1 | People most important to me think I should separate waste in the next 3 months | 0.957 | 0.827 | 0.710 | 0.748 |
| | NOR2 | Most people like me separate waste in the next 3 months | 0.762 | | | |
| Past behavior (PBEH) | PBEH1 | How often have you separated "organic" waste (food) in the past 3 months? | 0.823 | 0.920 | 0.928 | 0.763 |
| | PBEH2 | How often have you separated plastic waste in the past 3 months? | 0.939 | | | |
| | PBEH3 | How often have you separated glass waste in the past 3 months? | 0.834 | | | |
| | PBEH4 | How often have you separated paper waste in the past 3 months? | 0.892 | | | |
| Habits (HABIT) | HAB1 | Have you automatically separated waste in the respective bins in your house in the past 3 months? | 0.747 | 0.890 | 0.958 | 0.621 |
| | HAB2 | Have you been separating waste in the respective bins in your house since long time ago? | 0.873 | | | |
| | HAB3 | Would you feel uncomfortable not separating waste in your house? | 0.717 | | | |
| | HAB4 | Separating waste is a consolidated daily/weekly routine of my life | 0.777 | | | |
| | HAB5 | Do you separate waste even before you realize you are doing it? | 0.818 | | | |
| Environmental motivation (EMTV) | EMTV1 | Does "respecting the environment" motivate you to separate waste? | 0.948 | 0.899 | 0.870 | 0.831 |
| | EMTV2 | Does "getting a better future" motivate you to separate waste? | 0.874 | | | |
| Functionality of road bins (RBIN) | RBIN1 | Position of road bins | 0.776 | 0.822 | 0.876 | 0.611 |
| | RBIN2 | Capacity of road bins | 0.815 | | | |
| | RBIN3 | Practicality of road bins | 0.752 | | | |

**Table 2** Correlation Matrix

| | ATT | NOR | PBC | INT | RBIN | PBEH | HABIT | EMTV |
|---|---|---|---|---|---|---|---|---|
| ATT | 0.797 | | | | | | | |
| NOR | 0.286 | **0.865** | | | | | | |
| PBC | 0.439 | 0.307 | **0.875** | | | | | |
| INT | 0.709 | 0.425 | 0.730 | **0.850** | | | | |
| RBIN | 0.070 | 0.063 | 0.166 | 0.139 | **0.781** | | | |
| PBEH | 0.086 | 0.019 | 0.026 | 0.093 | 0.042 | **0.873** | | |
| HABIT | 0.627 | 0.427 | 0.683 | 0.756 | 0.165 | 0.236 | **0.788** | |
| EMTV | 0.589 | 0.315 | 0.431 | 0.520 | 0.001 | 0.161 | 0.642 | **0.912** |

Note: The values (in bold characters) along the diagonal indicates the square root of average variance extracted of the latent variable

**Table 3** Structural Equation Modeling (SEM) – Hypotheses Testing

| Hypothesis | Predictor | | Dependent variable | *p*-value | t-value | ß (beta) | CI 95% | Hypothesis Acceptance |
|---|---|---|---|---|---|---|---|---|
| H1a | ATT (attitude) | —> | INT ($R^2$=0.757) | *** | 4.780 | 0.400 | [0.159, 0.683] | Accepted |
| H1b | NOR (Subjective Norms) | —> | INT ($R^2$=0.757) | 0.046 | 1.991 | 0.114 | [0.021, 0.314] | Accepted |
| H1c | PBC (Perceived Behavioral Control) | —> | INT ($R^2$=0.757) | *** | 4.514 | 0.396 | [0.121, 0.664] | Accepted |
| H2a | PBEH (Past Behavior) | —> | INT ($R^2$=0.757) | 0.643 | 0.464 | 0.026 | [-0.093, 0.161] | Rejected |
| H2b | PBEH (Past Behavior) | —> | ATT ($R^2$=0.457) | 0.316 | -1.003 | -0.069 | [-0.247, 0.055] | Rejected |
| H2c | PBEH (Past Behavior) | —> | PBC ($R^2$=0.507) | 0.003 | -2.935 | -0.199 | [-0.352, -0.032] | Accepted |
| H3a | HABIT (Habits) | —> | INT ($R^2$=0.757) | 0.045 | 2.003 | 0.225 | [0.079, 0.555] | Accepted |
| H3b | HABIT (Habits) | —> | ATT ($R^2$=0.457) | *** | 4.407 | 0.439 | [0.115, 0.697] | Accepted |
| H3c | HABIT (Habits) | —> | PBC ($R^2$=0.507) | *** | 8.669 | 0.721 | [0.496, 0.884] | Accepted |
| H3d | HABIT (Habits) | —> | PBEH ($R^2$=0.056) | 0.049 | 1.965 | 0.225 | [0.014, 0.496] | Accepted |
| H4a | EMTV (Environmental Motivation) | —> | INT ($R^2$=0.757) | 0.339 | -0.957 | -0.071 | [-0.0274, 0.168] | Rejected |
| H4b | EMTV (Environmental Motivation) | —> | ATT ($R^2$=0.457) | *** | 3.361 | 0.318 | [0.160, 0.739] | Accepted |
| H4c | EMTV (Environmental Motivation) | —> | NOR ($R^2$=0.192) | 0.492 | 0.687 | 0.071 | [-0.268, 0.469] | Rejected |
| H4d | EMTV (Environmental Motivation) | —> | PBEH ($R^2$=0.056) | 0.877 | 0.154 | 0.017 | [-0.202, 0.236] | Rejected |
| H4e | EMTV (Environmental Motivation) | —> | HABIT ($R^2$=0.439) | *** | 8.276 | 0.642 | [0.385, 0.826] | Accepted |
| H5a | RBIN (Road Bin functionality) | —> | PBC ($R^2$=0.507) | 0.433 | 0.784 | 0.055 | [-0.101, 0.196] | Rejected |
| H5b | RBIN (Road Bin functionality) | —> | HABIT ($R^2$=0.439) | 0.020 | 2.329 | 0.165 | [0.017, 0.306] | Accepted |
| H5c | RBIN (Road Bin functionality) | —> | PBEH ($R^2$=0.056) | 0.956 | 0.055 | 0.005 | [-0.185, 0.187] | Rejected |

Note: ***=*p*-value < 0.001

**Table 4** Indirect Effects

| Effect of | through | Type of effect | ß (beta) | Lower Bound (BC) of 95% CI | Upper Bound (BC) of 95% CI | Two tail Significance (*p*) |
|---|---|---|---|---|---|---|
| EMTV on INT | | Total Indirect | 0.591 | 0.458 | 0.756 | 0.001 |
| EMTV on INT | HABIT | Indirect | 0.147 | 0.000 | 0.244 | 0.050 |
| EMTV on INT | PBEH | Indirect | 0.000 | -0.011 | 0.018 | 0.770 |
| EMTV on INT | NOR | Indirect | 0.007 | -0.010 | 0.046 | 0.314 |
| EMTV on INT | ATT | Indirect | 0.103 | 0.032 | 0.213 | 0.007 |
| PBEH on INT | | Total Indirect | -0.117 | -0.238 | -0.016 | 0.021 |
| PBEH on INT | PBC | Indirect | -0.084 | -0.182 | -0.026 | 0.006 |
| PBEH on INT | NOR | Indirect | -0.011 | -0.051 | 0.004 | 0.147 |
| PBEH on INT | ATT | Indirect | -0.030 | -0.104 | 0.026 | 0.293 |
| HABIT on INT | | Total Indirect | 0.487 | 0.333 | 0.684 | 0.000 |
| HABIT on INT | PBC | Indirect | 0.620 | 0.319 | 0.951 | 0.001 |
| HABIT on INT | NOR | Indirect | 0.099 | -0.005 | 0.275 | 0.060 |
| HABIT on INT | ATT | Indirect | 0.381 | 0.167 | 0.698 | 0.001 |
| HABIT on INT | PBE | Indirect | 0.013 | -0.037 | 0.106 | 0.500 |

## Mediation (indirect effects)

The mediating role of motivation, past behavior and habits on intention is tested through bootstrapping in AMOS 28 [66]. The bootstrap method is based on 2000 samples and 95% bias-corrected (BC) confidence level in order to obtain 95% confidence level around estimates for indirect effects; the output is analyzed for direct, indirect and total effects.

The analysis of estimates in AMOS 28 includes the test whether the indirect effect is statistically significant through the study of the lower and upper bounds of the 95% BC confidence intervals. If the value 0 falls between the lower and upper bound, the indirect effect is statistically not significant (actually, the effect could be positive or negative); vice versa, if 0 falls outside, the indirect effect is statistically significant. At the same time, the test of the two-tail significance must be below 0.05. Considering the indirect effect is usually made of the sum of single indirect effects, it is essential to test the single effects for their contributions through the user-defined "estimands" option in AMOS. The confidence intervals of single effects are then tested as previously described (Table 4).

Table 4 shows that environmental motivation has a statistically significant indirect effect on intention through attitude (ß=0.103, $p$=0.007). At the same time, the effect of environmental motivation on intention is not mediated by subjective norms (ß=0.007, $p$=0.314), past behavior (ß=0.000, $p$=0.770) and habits (ß=0.147, $p$=0.050).

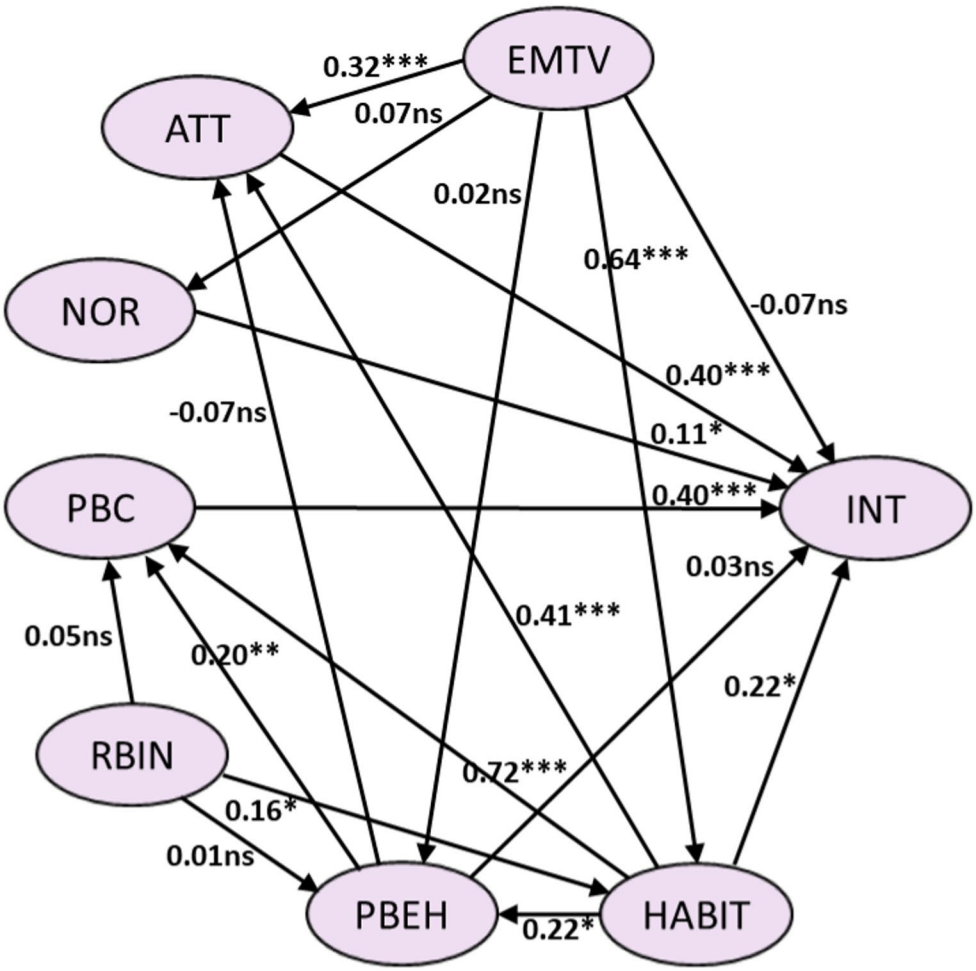


**Fig. 6** Extended TPB Model - SEM Estimation Results. ***=*p*-value < 0.001, **=*p*-value < 0.01, *=*p*-value < 0.05, ns > = 0.05

Moreover, Table 4 shows a limited mediation effect of PBC on the relationship between past behavior and intention (ß=-0.084, $p=0.006$), whereas the indirect effect of past behavior on intention through subjective norms and attitude is not statistically significant (respectively, ß=-0.011, $p=0.147$, and ß=-0.030, $p=0.293$).

On the contrary, the mediated effects of habits on intention are significant, in particular the indirect effect through PBC (ß=0.620, $p=0.001$) and attitude (ß=0.381, $p=0.001$) are very statistically significant. At the same time the indirect effects through subject norms and past behavior are not statistically significant; in fact, the former shows ß=0.099 ($p=0.060$), the latter ß=0.013 ($p=0.500$). These values show that in case of specific repetitive behaviors, taking place in quite standard conditions (like waste separation), the effect of habits is significant and quite pervasive. It follows that TPB may benefit from the addition of habits when analyzing repetitive behaviors with a very limited volitional control by the individual, particularly in the case of waste separation behavior.

## Discussion

This study applies an extended TPB model to waste-separation behavior by analyzing the typical TPB antecedents of intentions with the addition of some constructs which improve the understanding of this specific behavior. In fact, separation behavior is usually performed in a very repetitive manner in very consuetudinary locations (e.g., households, workplace), in specific ways (e.g., recycling bins in the kitchen, door-to-door collection, road receptacles, weight tariffs) and it is influenced by the context (e.g., visual cues, presence of waste pickers, illegal waste management). Furthermore, waste separation takes place in different environments in terms of legal framework, environmental sensitivity, educational programs, governmental interventions, rewards, economic incentives, fine systems. In turn, these exogenous conditions impact the individual sphere through environmental motivation and concern, lifestyle, goals, social recognition, etc., therefore creating very specific conditions for each case study.

As per our expectations, this study confirms the predictive capability of the TPB as a general framework for analyzing

human behavior. In fact, the above-mentioned results demonstrate the key role of attitude and PBC as the main antecedents of intentions to recycle (respectively, ß=0.400 and ß=0.396, $R^2$ = 0.457 and $R^2$ = 0.507, Table 3). Differently from other fields, the influence of subjective norms is quite limited (ß=0.114, $R^2$ = 0.192) compared to attitude and PBC. This outcome does not surprise us if we consider the social context of recycling in Rome; in fact, the regular execution of waste-related activities (e.g., separating waste, composting) does not really contribute to the social recognition of the individual in such context; moreover, there are no real important referents for recycling activities. Actually, this result is consistent with some empirical findings by Knussen et al. [38] and Mondejar-Jimenez et al. [58], who found a very limited estimated direct effect of subjective norms on intention toward food waste (ß=0.004).

Although Fishbein and Ajzen [25] are not in favor of adding additional constructs to the typical TPB predictors, our findings suggest that the addition of some specific precursors improves the predictability of waste separation intention. This represents an original contribution of this paper to the field. Fishbein and Ajzen [25] deem that five criteria should be met by each additional construct. First of all, they apply the principle of compatibility which indicates that the construct should be related to behavior (besides being measurable). The construct represents "a casual factor determining intention and action" [25], being "conceptually independent" from the other predictors, providing a significant improvement of prediction of intention or behavior. Moreover, they state that the construct should work in different social context in order to satisfy the principle of generalization. In this regard, the authors acknowledge that the TPB has succeeded in being able to explain a wide spectrum of behaviors like energy saving behavior, sport activities, dietary behavior, transportation preferences. At the same time the TPB is very focused on volition control and does not put much emphasis on routine activities (which are often under a very limited volition control), as it may happen during recycling activities in the context of consolidated waste management procedure. The question of sufficiency of constructs is also highlighted by Fishbein and Ajzen [25]; they infer that the real contribution of new constructs may be marginal when improving the measure of the typical TPB predictors. Actually, the findings of this paper provide empirical evidence of the great direct influence of habits on the basic constructs of the TPB, namely intention (ß=0.225), attitude (ß=0.439) and PBC (ß=0.721) (Fig. 6). Moreover, our findings show that past behavior does not reach the same level of influence of habits; actually, this research shows that past behavior has a limited negative effect on PBC (ß=-0.199), indicating that a high frequency of waste separation does not necessarily imply a high level of perceived control by individuals. In this regard, it is worth noticing that, in this paper, past behavior is measured in terms of frequency of waste collection, whereas habits are analyzed in terms of routine actions and automatic behavior.

Overall, our findings on past behavior met our expectations, and are quite aligned with Fishbein and Ajzen [25]'s convincement that the influence of this construct is mediated by PBC, attitude and norms. In fact, the effect of past behavior is mediated by the beliefs to be able to perform and control recycling. On the contrary, as suggested by our literature review, the direct and indirect effects of habits deserve further attention when studying waste separation behavior. In this type of behavior, the performance is repeated numerous times during the day and, especially, under the same circumstances (e.g., disposal of trash in the same bins under the basin of the kitchen while preparing the meal or having a coffee); therefore, the effect of the context on behavior is not negligible in specific situations. In this sense, Fishbein and Ajzen [25] infer that "behavior is assumed to come under the direct control of stimulus cues, bypassing intentions and perceptions of behavioral control". Furthermore, Fishbein and Ajzen [25] recognize that "with repeated performance, behavior is said to habituate, and its habit strength … is assumed to influence later action", however they disagree in considering habits as a predictor of intention.

In this paper, the analysis of direct and indirect effects shows the strong influence of habits in both ways. As mentioned in Sect. 4, the direct and mediated effects of habits on intention are significant, especially the indirect effects through PBC (ß=0.620) and attitude (ß=0.381), indicating that the analysis of separation behavior through the TPB should include habits among the precursors (Table 4). In this case, the measurement of habits requires a careful definition of the survey questions in order to avoid confusion between past behavior and habits. In this study, the high values of path coefficients for waste separation intention contradict the research of Fishbein and Ajzen indicating that the total effect of habits is evident with a predominance of indirect effects (ß=0.487, Table 4) over direct effects (ß=0.225, Table 3). We may infer that Fishbein's and Ajzen's parsimony towards additional predictors is more applicable to other types of behavior under a more volitional control, like losing weight or conducting regular physical activity. We also recognize that the study of habitual behaviors requires a careful analysis of non-volitional mechanisms as additional predictors of intention and behavior.

In accordance with Ajzen and Kruglanski [40]'s recent research on the effects of goals and motivation on behavior, this study highlights the direct effect of environmental motivation on some precursors of intention, besides a limited indirect effect of environmental motivation on intention through attitude (ß=0.103, $p$ = 0.007). The previous tables

on structural equation modeling indicate that the direct relationships EMTV-ATT and, especially, EMTV-HABIT have a significant path coefficient, respectively ß=0.318 and ß=0.642; on the contrary, EMTV-INT, EMTV-NOR and EMTV-PBEH are not significant (Fig. 6).

These results are in line with our expectations that motivation has some effects on the precursors of intention; contextually, we did not expect motivation to influence PBC, since motivation does not influence skills and individual perception to control waste separation. Overall, it would be quite limiting not to consider motivation or goals when analyzing any kind of behavior [67]; although we recognize the principles of parsimony and generalization, we cannot forget about the effect of motivation. Moreover, these results support the recent Ajzen and Kruglanski [40]'s approach which integrates two different theoretical perspectives, the TPB and the goal system theory into the theory of reasoned goal pursuit. According to Ajzen and Kruglanski [40], active procurement goals influence, directly and indirectly (through attitude), the motivation to act. Furthermore, in some cases, the TPB precursors of intention may not be sufficient to action initiation. In fact, people may display a positive attitude towards recycling, and they may also feel the social pressure to conduct recycling, however the lack of an active goal (e.g., environmental protection) and the motivation to achieve this goal may not form the intention to perform that behavior. Unfortunately, the effect of environmental motivation is difficult to quantify because it depends on several factors like the magnitude of the goal, its desirability and its attainability, which may fluctuate though time and different contexts. It is worth noticing that almost 90% of our sample has graded environmental protection as a high priority goal in their lives (Fig. 2) and around 97% of respondents has a high to very high level of environmental awareness (Fig. 3). Moreover, as explained by Ajzen and Kruglanski [40], an active procurement goal differs from an active approval goal; in fact, the former influences the attitude toward a specific behavior, whereas the latter shapes subjective norms. In this paper, results indicate that the environmental protection goal and the related environmental motivation exert their effect on attitude, and do not cause any effect on subjective norms. Our rationale regarding the latter statement is based on the fact that in Rome waste separation appears not to be under the strong influence of salient referents (such as parents, friends, teachers, political or social leaders).

The analysis of recycling bins functionality aims at understanding the type and extent of impact of specific contextual factors on separation behavior. This approach is motivated by the presence of objective limitations in the study area concerning the daily waste separation and collection practices. In fact, in the areas of Rome not served by curbside collection services (also known as "door-to-door"), citizens are required to bring their own household waste to big road containers, which show several deficiencies. For example, road bins are frequently overfilled, thus citizens are unable to return their waste in the road containers, and they end up with leaving their own waste outside the bins on the street; moreover, the location and size of the road bins are often sub-optimal. Therefore, citizens motivation and determination in executing the correct waste separation and collection procedures is daily challenged and stressed. Nevertheless, the analysis of the collected data shows that RBIN does not influence PBC and PBEH. This outcome does not mean that service deficiencies have negligible effects on final users; actually, it indicates that the daily difficulties experienced by inhabitants while applying waste separation procedures are still manageable at the individual level and convey in the PBC (or other) constructs. At the same time, the relationship RBIN-HABIT is quite significant, indicating that these difficulties influence citizens' habits (ß=0.165, $p=0.020$), hence highlighting the importance of indirect effects of some constructs on others.

## Policy and managerial recommendations

Our study offers valuable insights for waste management companies, policymakers, and public institutions. These stakeholders must develop a comprehensive understanding of the values of the target audience, in addition to the contextual factors, to activate the appropriate goals beyond the necessary threshold. Otherwise, the information provided to end users may prove ineffective or inadequate [68, 69]. In particular, these stakeholders should design tailored campaigns aimed at activating pro-environmental goals that influence recycling behavior. Such measures may range from environmental education in schools for younger generations to raising environmental awareness among senior citizens, incorporating intergenerational learning [70], procedural knowledge [71, 72], and social network analysis [73]. However, several limiting factors exist in Italy, particularly in Rome. For instance, Italian school curricula still lack adequate environmental education, there are no reward or economic incentive schemes for Roman citizens [74], waste is disposed of in roadside receptacles that are not regularly or efficiently emptied, and improper waste disposal in public bins is rarely sanctioned. Additionally, recycling knowledge remains limited, there has been no significant improvement in recycling rates in Rome in recent years, and there is a lack of guilt associated with not recycling, as well as minimal concern about the risk of sanctions for improper recycling practices. Although the legal framework at the national and supra-national levels appears robust and well-defined, it must align with real-life conditions. Unfortunately, the discrepancies between environmental protection

regulations and the challenges faced in their implementation undermine individuals' determination and motivation to adhere to proper recycling practices. Under critical or suboptimal conditions, such as daily waste recycling in Rome, the willingness to separate waste is continuously subjected to numerous demotivating factors. Consequently, shifts in goals and motivations are a tangible reality. In this context, tailored institutional campaigns become essential, bearing in mind that "to drive behavior, the goal must be deemed more important or desirable, that is, it must offer greater subjective value than other possible goals" [40].

## Conclusions, limitations and future research directions

This study uses an extended TPB model to analyze key factors influencing waste-separation behavior in the context of a large European metropolitan city, where waste separation and collection are well-established procedures. In particular, this paper contributes to the research on waste separation behavior by providing insights into specific precursors of intention to separate waste (e.g., habits and environmental motivation), which integrate and contextualize the typical TPB antecedents of intention; in addition, this paper digs into the reasons for separating waste and the respondents' relationship with media.

The results of this study suggest that, in a stable context and for routine activities (like waste separation at the household level), the influence of habits is significant. Considering the activation of some waste separation activities (e.g., through visual cues) is not under the full volitional control of the individual, the TPB may benefit the support of additional non-volitional factors (like habits) for the analysis of routine behaviors.

Furthermore, although recycling activities represent a mandatory activity for all citizens in Rome, motivation and goals play a key role in promoting separation behavior, as demonstrated by the significant path coefficients of the relationships EMTV-ATT and EMTV-HABIT. At the same time, our findings indicate that past behavior (as a measure of frequency of waste separation) does not influence intention nor attitude, although it has some influence on PBC. Together, these findings address the initial research question.

Overall, building upon the TPB and expanding it with specific constructs, this paper opens a window on possibly overcoming the limitations deriving from the exclusive application of the typical TPB constructs to the waste separation behavior; in fact, the addition of habits and motivation significantly improves the predictive capability of the TPB for waste separation in Rome.

Even though this study utilizes a relatively small sample of Roman citizens with all consequent limitations, the solid research methodology, based on a grounded theoretical framework, allows to highlight the direct and indirect influence of some precursors of intention. Our findings may prove useful to other researchers analyzing habitual and goal-driven behaviors, especially considering that there are limited papers integrating the effects of motivation in the TPB construct.

### Limitations

This study faces also some limitations. First and foremost, this study relies on self-reported behavior rather than actual observed behavior. As a result, certain biases may arise, such as the potential overestimation of residents' compliance with waste management regulations and the inclination to attribute inefficiencies to the waste collection service. Therefore, we acknowledge that direct observation and measurement of individuals' behavior could yield different results [75]. Second, the measurement of certain constructs may require further refinement, and their respective scales should consider additional aspects of waste separation. For instance, past behavior is currently assessed based on the frequency of specific waste separation activities, such as sorting plastic and paper. However, other past actions—such as participation in national clean-up initiatives or membership in voluntary organizations dedicated to the collection of cardboard or used clothing—are presumed to have negligible influence on past waste-separation behavior. Third, the sample, drawn from a specific municipality in Rome, may not be fully representative of the city's overall population. Fourth, when analyzing dynamic constructs, the temporal dimension may serve as a crucial factor. Specifically, challenges associated with identifying active goals within a given timeframe and context hinder the ability to fully ascertain whether a goal is indeed active at the moment when intention translates into actual behavior [40]. Fifth, this study recognizes that the proposed model may not be entirely generalizable to waste management contexts beyond waste separation. Additional constructs may be necessary to account for other significant influencing factors. Consequently, future research should explore the potential inclusion of alternative, more relevant variables to ensure the identification of the most critical precursors of intention and behavior. Furthermore, subsequent studies could enhance their external validity through comparative analyses with similar urban settings.

### Future research directions

Given the substantial evidence obtained, several findings warrant further consideration for future research.

Considering that waste separation behavior often occurs under highly stable conditions and is characterized by repetitive actions, future studies should conduct a more in-depth analysis of the role of habits as a determinant of both intention and behavior. As the TPB primarily focuses on volitional behavior, it tends to underestimate the influence of habits by incorporating them within the standard TPB predictors of behavior. While we acknowledge Fishbein and Ajzen [25]'s assertion that "the existing evidence shows that intentions can predict routine as well as relatively novel behaviors", in many advanced economies, household waste separation has become an ingrained practice carried out in a stable environment with limited volitional control. For instance, analyzing habits may prove beneficial when local waste management companies introduce new recycling procedures due to the implementation of innovative waste management technologies. In such cases, examining habits could provide insights into how to efficiently adapt routine household practices to new requirements. Similarly, the study of habits in cities where recycling procedures are not yet well established may facilitate the design and implementation of effective new household-level waste recycling programs. Furthermore, integrating the TPB with an analysis of individuals' motivations and goals may enhance the understanding of recycling behavior. In turn, a deeper comprehension of people's behavior enables the development of more targeted public interventions, particularly in contexts such as Rome, where empirical data indicate a lack of significant improvement in recycling rates over recent years. Moreover, conducting comparative analyses with cities of similar characteristics may offer valuable insights into both individual behavior and the effectiveness of specific intervention measures. For example, a comparative study examining the impact of incentives and penalties could yield further understanding of behavioral patterns and provide practical recommendations for improving recycling rates (SM).

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