

# Understanding Waste Separation Behavior through the Application of an Extended Form of the Theory of Planned Behavior (TPB)

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**Understanding Waste Separation Behavior  
through the Application of an Extended Form of  
the Theory of Planned Behavior (TPB)**

**Dissertation**

to obtain the degree of Doctor at Maastricht University,  
on the authority of the Rector Magnificus, Prof. dr. Pamela Habibović,  
in accordance with the decision of the Board of Deans,  
to be defended in public  
on Monday, the 26<sup>th</sup> of June, 2023, at 13:00 hours

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## Acronyms

AAG	Active Approval Goal
APG	Active Procurement Goal
ATT	Attitude
AVE	Average Variance Extracted
BC	Bias Corrected
CE	Circular Economy
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CI	Confidence Interval
CR	Composite Reliability
EBSCO	Elton Bryson Stephens Company
EMTV	Environmental Motivation
EU	European Union
GenCB	Generic Consumer Behavior
GrCB	Green Consumer Behavior
GST	Goal Systems Theory
H	Hypothesis
INT	Intention
IoT	Internet of Things
IR	Indicator Reliability
LCA	Life Cycle Assessment/Analysis
MASEM	Meta-Analysis and Structural Equation Modeling
MGB	Model of Goal-directed Behavior
MKD	Mapping Knowledge Domain
ML	Maximum Likelihood
MOT	Motivation
MSW	Municipal Solid Waste
NAM	Norm Activation Model
NOR	(Subjective) Norms
PBC	Perceived Behavioral Control
PBEH	Past Behavior
PEB	Pro-environmental Behavior
PECB	Pro-environmental Consumer Behavior
PESTL	Political, Economic, Social, Technological, Legal (analysis)
PICO	Participants, interventions, comparisons, outcomes
PRC	People's Republic of China
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RBIN	Road Bin (functionality)
RMSEA	Root Mean Square Error of Approximation
RoB	Risk of Bias
RQ	Research Question
SD	Standard Deviation
SEM	Structural Equation Modeling
SLR	Systematic Literature Review
SI	Supplementary Information
SM	Supplementary Material
SME	Small Medium Enterprise
SN	Subjective Norms

SPSS	(IBM) Statistical Package for Social Sciences
SRCB	Socially Responsible Consumer Behavior
SWM	Solid Waste Management
TAK	Title, Abstract and Keywords
TLI	Tucker-Lewis index
TPB	Theory of Planned Behavior
TRA	Theory of Reasoned Action
TRGP	Theory of Reasoned Goal Pursuit
VBN	Value Belief Norm (Theory)
VS	Voluntary Simplifier
WEEE	Waste Electrical and Electronic Equipment
WTP	Willingness-To-Pay



# **Chapter 1: Introduction**

## 1.1. Background

Nowadays most of the nations at the worldwide level still struggle to adequately reduce the quantity of their waste, in fact a consistent percentage of it is still not recycled; quite often, it is directly sent to landfills or eliminated through incineration or illegal dumping (Joo & Kwon, 2015). The need for a systemic intervention is undelayable: the waste remedial measures need to be addressed at all levels, from the conceptualization phase of products or services to the disposal phase (Mihelcic et al., 2017). Indeed, they span from environmental design to the re-utilization of material (Reuter, 2011; Tseng et al., 2018), involving different sectors like legal and institutional support (Savage & Kong, 1993; Zulganef et al., 2019). These measures involve all levels of the population: from policy makers to final users with different level of responsibility (Conke, 2018; Puaschunder, 2017). The individual contribution to waste management improvement, although minimal in quantitative terms, is absolutely essential; unfortunately, quite often, consumer behavior shows inconsistencies when minimizing waste, separating and recycling waste (W. N. Wu et al., 2019; B. Zhang et al., 2019). Official data show how difficult is to increase the percentage of recycled waste both by industries and households (Ahmad et al., 2016) despite an increased and diffused interest in environmental matters in the latter years (Deutz & Frostick, 2009; Prendergast & Tsang, 2019; Schröder et al., 2019). Numerous practitioners have understood the importance of focusing on the individual, starting from the daily personal contributions to saving valuable resources, as demonstrated by Tseng et al. (2018) who state that “human behaviour is a strategic domain because of the enduring effects of both poor and good recycling habits” (p. 367).

Moreover, the review of the academic literature clearly indicates that the analysis of human behavior remains topical and pivotal. In fact, numerous theoretical frameworks are proposed by scholars to understand and predict human behavior with different outcomes. The most diffused theories and models in the study of recycling behavior are the Theory of Reasoned Action (TRA, Ajzen & Fishbein, 1970; Fishbein & Ajzen, 1977), the Theory of Planned Behavior (TPB, Ajzen, 1991), the Norm Activation Model (NAM, Schwartz, 1977) and the Value Belief Norm (VBN, Stern, 2000) Theory. Quite often these theories are applied in a combined or extended form by the addition of further predictors of recycling behavior. In this context, TPB and its extensions represent the most diffused theoretical framework; furthermore, numerous studies highlight TPB predictive capabilities.

## 1.2. Problem Statement

Although human behavior is usually goal-driven, the role of motivation and goal in recycling behavior is often underestimated or omitted in the most diffused socio-psychological theoretical frameworks, especially considering that this behavior is a kind of habitual behavior.

A correct analysis of human behavior cannot exclude the investigation of the role of habits, motivation and goal in relation to pro-environmental behavior, and, specifically, waste separation behavior.

Acknowledging that several theoretical frameworks have already proved their validity in understanding and predicting recycling behavior, the integration of the original constructs with additional ones creates a new conceptual model which may improve the predictive capability of the original theory, but may also not be in line with the principles governing the theory.

## 1.3. Purpose and Rationale of the Study

The purpose of this thesis is improving the understanding and the prediction of separation behavior through the analysis of the effects of habits, motivation, goals and other possible constructs on the intention to separate waste starting from the basis of the TPB. The rationale is grounded on the compatibility of TPB with some additional factors satisfying some specific criteria. In fact, on the one hand Ajzen does not preclude the possibility of adding additional factors to his theory. On the other hand, Ajzen warns scholars to correctly analyze the compatibility of these additional constructs with the TPB in order to be consistent with the assumptions and the founding principles of TPB.

Therefore, this thesis also analyzes the effectiveness of TPB and its extended forms in predicting waste separation behavior, including the integration of the TPB with the Goal Systems Theory (GST, Kruglanski et al., 2002) into the Theory of Reasoned Goal Pursuit (TRGP), recently proposed by Ajzen and Kruglanski (2019).

#### **1.4. Research Questions**

1. Considering waste separation behavior is very repetitive, what is the role of habits on this behavior? If habits impact separation behavior, what is the level of influence on separation intention?
2. Does motivation influence the intention to separate waste? If so, what is the level of influence of environmental motivation on separation intention?
3. Is separation behavior goal-driven? What is the level of influence of goals on separation intention?
4. Are there other constructs (compatible with the TPB framework) which can improve the understanding of waste separation behavior?

#### **1.5. Study Objectives**

1. Understanding of the status of the academic studies on pro-environmental behavior and specifically on waste separation behavior, including the most diffused theoretical framework, the gaps and the structure of knowledge through robust scientific methodology, such as systematic literature review (SLR), bibliometric analysis and mapping knowledge domain (MKD)
2. Application of an extended form of TPB and TRGP to separation behavior in order to assess their feasibility and capability to understand and predict this type of behavior. In particular, analysis of the role of habits, motivation and goals on separation behavior.
3. Defining the implications and policy suggestions based on the outcomes of the field studies. Providing recommendations for future research.

#### **1.6. Theoretical and Conceptual Framework**

The conceptual framework of this study is based on a reasoned approach to separation behavior, mainly rooted on the previously mentioned socio-psychological frameworks such as TRA and TPB. Contextually, this study acknowledges the limited analysis of the role of goals and motivation on recycling behavior in academic research. Therefore, it applies the TRGP framework to separation behavior in order to understand the role of these constructs on intention to separate waste. In fact, common goal-driven theories such as the Goal Setting Theory (Latham & Locke, 1979) and GST (Kruglanski et al., 2002) are rarely or never applied to recycling contexts at the household level. For example, the former theory lacks application to household behavior because it focuses on workplace, whereas the latter has been applied to some types of environmental behavior not exactly focusing on recycling or on consumer wellbeing (Corr eg e et al., 2018; Devezer et al., 2014; Nielsen, 2017).

For the sake of transparency and fairness, it is worth recalling some scholars who have analyzed constructs somehow related to motivation to recycle, such as Perugini and Bagozzi (2001) who highlight the importance of desire as a precursor of goal-directed behavior. Their Model of Goal-directed Behavior (MGB) is based on TPB and “posits that desires provide the direct impetus for intentions and transform the motivational content to act embedded in attitudes towards the act (Aact), anticipated emotions (AE), subjective norms (SN) and PBC (Perceived Behavioral control)” (Perugini & Bagozzi, 2001, p. 80). In any case, the construct of goal is not adequately addressed by MGB and, in general, by the literature on recycling behavior, except Seng et al. (2021) which study the effects of personal goals on food waste reduction. Seng et al. (2021) consider personal goals (at a general level) as a precursor of intention and behavior, but do not include motivation and do not articulate goals as happens with TRGP.

A careful analysis of the academic literature on recycling behavior offers other valid theoretical frameworks and constructs to better understand this type of behavior. Several scholars have combined TPB with NAM or VBN, reaching significant results (Bamberg & Moser, 2007; Wang, Guo, et al., 2018). Some scholars have gone further beyond the combination of these theoretical frameworks by adding other theories; for example, Xia et al. (2021) combine the Technology Acceptance Model (TAM, Davis et al., 1989) with TPB and NAM to analyze waste separation behavior of college students. In this case the effects of smart bins are considered through the inclusion of the TAM, which enhance the explanatory power of the conceptual framework by adding perceived usefulness and perceived ease of use. This example proves that the effect of new technologies, such as Internet of Things (IoT), may improve waste sorting behavior and TAM has the potential to capture the acceptance of new technologies by the final user.

In relation to additional constructs coupled with the typical TPB predictors, the literature offers a variety of predictors of intention and behavior. For example, Huang and Cheng (2022) analyze the intention to learn sustainability by adding the commitment to this behavior to the TPB framework. They find that commitment mediates the relationship between the antecedents of intention and intention; however, they do not provide a clear definition of commitment which is measured in terms of enjoyment, comfort and dedication. It follows the great importance of correctly defining the additional constructs added to TPB.

The reason for the selection of TPB as the reference theoretical framework for this research is motivated by several reasons. Numerous SLRs and meta-analysis have highlighted the validity of this theory in understanding and predicting recycling behavior (Concari et al., 2020; Miafodzyeva & Brandt, 2013; Phulwani et al., 2020). The TPB offers the possibility, under specific caveats, to include additional constructs as previously explained in subsection “1.3. Purpose and Rationale of the Study”. Recycling behavior, although habitual in nature and taking place in quite stable conditions, is likely a reasoned approach; in this sense, TPB has shown its applicability to reasoned behavior.

## 1.7. Methodology

This thesis does not include a specific chapter on methodology because Chapters 2 to 5 include a specific methodology section which describes the research process applied to each paper. In any case it is worth recalling some methodological steps applied during this research.

Considering the first objective of this research is understanding the status of the academic studies on recycling behavior, gaps and structure of knowledge, this thesis applies the typical SLR methodology as described by Petticrew and Roberts (2008). As explained in the methodology section of Chapter 2, a 7-step procedure is applied to the papers, starting with the questions definition and ending with the dissemination of results. In particular, in order to ensure a more robust and reproducible approach, this SLR:

- Pays particular attention to the selection of the terms and keywords (for the search query)
- Clearly defines inclusion and exclusion criteria, data extraction and evaluation criteria (Thi Hong Phuong et al., 2017)
- Utilizes not only one scientific database (as often happens for SLRs) but three main databases (Thi Hong Phuong et al., 2017), namely Web of Science, Science Direct and EBSCO (Elton Bryson Stephens Company) host
- Strictly adheres to the “Preferred Reporting Items for Systematic Reviews and Meta-Analyses” (PRISMA) protocol (Liberati et al., 2009; Moher et al., 2009).

The first objective of this research is further addressed through the bibliometric analysis and conceptual mapping aiming at revealing the structure and dynamics of the research on recycling behavior (Zupic & Čater, 2015). As explained in the methodology section of Chapter 3, “mapping the knowledge domain through a bibliometric analysis of the academic literature definitely helps in identifying current trends, research networks and relevant topics, especially considering that papers on recycling behaviour keep growing at an exponential rate” (Concari et al., 2022, p. 2). In fact, “although bibliometric analyses are based on quantitative and rigorous approaches, they can improve

the findings of a systematic literature review (SLR) by further analyzing the literature characteristics on a specific topic. Furthermore, they are valuable tools to assess the performances of institutions, journals or scholars. If supported by a solid text mining, they can also offer new insights on the field of investigation.” (Concari et al., 2022, p. 2). As per previous paper, some additional measures have been applied to this bibliometric analysis to ensure a solid and scientific approach:

- Utilization of three very diffused scientific databases, namely Science Direct, Web of science and EBSCO host (da Silva et al., 2012) creating an extensive body of literature
- Utilization of two different analytical tools, namely “VOSviewer” and “SciMAT”, in order to capture more information from databases (e.g., “harmonization of mapping and clustering of bibliometric networks” (Waltman et al., 2010, p. 630), evolution of clusters)

Chapters 4 and 5 utilize and apply four sequential steps (Zhang et al., 2021):

1. Correctly framing the topic of investigation through the analysis of the applicable theoretical frameworks and related constructs (with the support of an ad hoc literature review) and subsequent definition of the hypotheses to be tested
2. Selection and set up of the data collection and analysis method (e.g., quantitative/qualitative method, sample size and type, eliciting questionnaire, test of questionnaire, final questionnaire, Structural Equation Modeling (SEM))
3. Application of SEM with a 2-step procedure (Anderson & Gerbing, 1988):
  - a. Assessment of measurement model via Confirmatory Factor Analysis (CFA)
  - b. Assessment of measurement/structural models and hypotheses testing
4. Analysis of results, discussion, proposals of intervention measures and future research areas, limitations of research

Whenever possible, depending on sample size and type, SEM also includes multi-group analysis and mediation analysis in order to better understand the differences among groups of population, the driving factors (e.g., predominance of a construct in a town compared to another one) and the indirect effects or mediating role of specific constructs.

Another important methodological aspect which is worth mentioning is the correct definition of constructs, both in epistemological terms and in measurement procedures. In fact, the scientific analysis of constructs starts from the correct understanding of the underlying theoretical framework, the clear definition of terms and measurement of them (in this regard the academic literature often shows confusion between past behavior and actual behavior). This aspect is fundamental to prevent the misinterpretation of applied theories and models, overlapping of constructs and wrong outcomes. The section about definitions provides a description of the main terms utilized in this dissertation; the remaining key terms are explained in the applicable chapters.

## 1.8. Assumptions

This dissertation is based on some assumptions which are worth clarifying at this stage.

First of all, it is assumed that TPB and its extended forms (under specific conditions) have the capability to predict different types of human behavior, ranging from dietary habits (Soorani & Ahmadvand, 2019) to practicing physical activity, from utilization of means of transportation (Carrus et al., 2008) to pro-environmental behavior (Aslam et al., 2019), including energy saving, demolition waste recycling (Jain et al., 2020), e-waste management (Priyono et al., 2020), household recycling (Lizin et al., 2017) and, specifically, waste separation behavior (Nigbur et al., 2010). This assumption is mainly supported by extended literature of the last decades showing the great predictive capability of the TPB framework. Numerous scholars (Davis et al., 2006; Strydom, 2018) have applied TPB and its extended forms in a successful way since the formalization of this theory by Ajzen (1991). Furthermore, several SLRs, meta-analyses and bibliometric analyses confirm the validity of this approach (Miafodzyeva & Brandt, 2013; Si et al., 2019). Not only, some scholars have also conducted comparative studies between TPB and other theoretical framework indicating the solidity of TPB; for example, Aguilar-Luzon et al. (2012) conclude that “it has a greater degree of fit and greater capacity to predict recycling behavior than the value-belief-norm model regarding the environment” (p. 2797).



Another quite diffused assumption is the acceptance of self-reported measures as acceptable measures of observed behavior. In this regard, there is an abundance of literature debating this issue. It is worth recalling Fishbein and Ajzen (2011) who highlight the risks of self-reports compared to direct observations: “people may not be able to accurately recall their past behavior, or, usually due to self-presentation concerns, they may choose not to report it accurately” (p. 37). Some suggested corrective measures rely on the investigator who may adopt methods to maximize the accuracy of measures by assuring the anonymity of the respondents or by motivating respondents to report the truth. At the same time, it is often impossible to directly observe the behavior to be analyzed (e.g., waste separation at the household level) or to correctly assess it (e.g., quantity of waste, correct separation of waste). Therefore, this thesis concurs with Fishbein and Ajzen (2011)’s conclusion that “the vast majority of empirical investigations rely on self-reports rather than direct observations of behavior” (p. 38). Another very debated point in the academic literature is the dynamics of goals: prioritization, fluctuation, predominance, etc. In this regard, GST provides a clear explanation of goals’ characteristics, such as “equifinality” and “multifinality”. Considering the specific field of investigation of this thesis (waste separation behavior), it is assumed that, in advanced economies, environmental goals and motivation are quite stable constructs, especially at the household level. Otto and Kaiser (2014), Kaiser et al. (2014), Otto et al. (2018) highlight the stability of environmental motivation over time, although it may be subject to modifications in the long run. It is clear that environmental goals may also change their priority levels depending on the individual contingent needs, but it is also true that the stable household environment in which separation behavior takes place offers contextual elements (e.g., smell, visual cues, standard position of bins) which trigger (latent) environmental goals.

## **1.9. Delimitations**

This thesis focuses on waste separation behavior at the individual or household level. It does not consider this type of behavior at the workplace or managerial pro-environmental behavior because the analysis of these behaviors would require addressing other topics such as company sensitivity to environmental issues, managerial mindset, availability of recycling bins and facilities at the workplace. Therefore, the outcomes of this thesis cannot be generalized to the workplace.

## **1.10. Limitations**

This thesis presents some limitations.

First of all, the sample utilized for the field studies may not be representative of the entire population. In some cases, there are some segments of population which are not adequately represented; for instance, it is not easy to reach the elders if the collection method is represented by an on-line questionnaire. Also, Ahmad et al. (2016) highlight that the inferences coming from a sample made of students can be applied to educational or governmental contexts. At the same time, national rules may limit the possibility of directly interviewing minors to ensure child protection.

Moreover, the sample size will directly impact the validity of the statistical measures. In fact, a limited sample increases the risk of internal inconsistency for scales, low Comparative Fit Indexes (CFI) and similar indexes, high Root Mean Square Error of Approximation (RMSEA). Not only, multi-group analysis usually requires samples of minimum 100 respondents per group (Sudman, 1976), therefore comparing segments of population (e.g., based on age or income) of citizens coming from different towns becomes unreliable or statistically insignificant.

Also, self-reported measures represent a limitation compared to the possibility of conducting direct interviewing. Nevertheless, the above-mentioned literature supports the validity of the research based on self-reported measures. Obviously, this limitation has to be kept in due consideration by scholars when responders are queried about socially desirable or undesirable behaviors (e.g., complying with the law or using drugs) because the chances of self-presentation biases are very likely.

Consequently, these limitations cause some caveats in all type of deductions, generalizations, suggestions and implications proposed by this thesis.

## 1.11. Definitions

In order to avoid confusion among common terms related to waste separation or misinterpretation of results, it is worth clarifying the meaning of some key terms.

Being said that there are several types of waste-related behaviors depending on the actors (consumers, householders, workers, students, policymakers, managers, educators), context (advanced economies versus developing economies, contaminated areas versus non-contaminated ones), level of investigation (e.g., micro vs macro analysis, individual versus managerial), geographic dimension (e.g., municipal, regional, national, supra-national), socio-demographic dimension (e.g., age, neighborhood), the research may focus on different temporal phases ranging from the design and production of goods to the recycling, re-utilization, incineration or storage of waste. In the case of waste-related behavior at the individual level in specific locations such as households and universities, an individual may perform different activities such as prevention, reduction, minimization, separation (or sorting), recycling, re-use, composting. Considering this study focuses specifically on waste separation activities conducted by a generic individual (e.g., householder or student, not a worker) during their daily life, it is essential to define the meaning of the above-mentioned activities and understand the nuances of terms in order to better understand the reviewed literature.

In general terms, recycling refers to “the action or process of converting waste into reusable material” (Foundation, 2023); at the household level, many scholars refer to recycling when they analyze activities like separating the waste while preparing a meal, storing and collecting the waste in the different bins according to the local collection scheme, disposing it into road bins as defined by the waste company (e.g., curbside, also known as door-to-door collection, commingled bins, road bins). Actually, although the utilization of the term “recycling” encompasses numerous activities related to waste-management, it does not capture the specificity of some of them. Therefore, it is acceptable to utilize the term “recycling” when referring to a group of waste-related activities, but it is advisable to adopt more specific terms when focusing on peculiar activities, such as separating waste, re-utilizing it or composting it. In the latter case, a householder may perform composting by putting leftover food and grass from his/her backyard in the composter in order to produce good potting soil (in this case the householder completes the recycling process by transforming waste into reusable material). Furthermore, a householder may conduct re-use (or re-utilization) by re-introducing an item in the consumption cycle after its first utilization; in this case the final user contributes to waste minimization as well, as it happens when he or she utilizes re-usable shopping bags. Tonglet et al. (2004) infer that the waste minimization takes place both during the purchase phase and repair or re-use; however, some scholars may include some minimization activities in the generic recycling. Similarly, numerous authors utilize the term recycling to refer to the waste separation and collection process by the final users (e.g., university students emptying their food trays in the bins of the dining facility).

This ample interpretation of recycling behavior leads to different conceptual approaches, including different conceptualization of recycling knowledge and waste separation knowledge. This type of issue is partially justified because waste management is often context dependent. However, it calls for the need of a clear taxonomy when scientifically investigating waste-related behaviors.

The definitions of the constructs related to the adopted theoretical framework (e.g., attitude, intention, motivation) are specified in the next chapters during the description of the applicable framework.

## 1.12. Structure of the Thesis

This thesis is created “by compilation” (Green, 2021), which means that Chapters 2 to 5 are made of papers previously published or under revision by some scientific journals. These articles are integrated by other traditional thesis chapters, namely the introduction and conclusions; the stand-alone chapter on methodology (of a typical thesis) is not present because all methodological aspects are addressed inside each single article to avoid redundancy and to be tailored to the specific situation.

In addition, Chapters 2 to 5 are complemented by appendixes; for published papers, full appendixes are available online only for graphical and brevity reasons, therefore this thesis presents the most applicable spreadsheets only.

Several reasons have led to the decision of a thesis by compilation.

First of all, the need to initially and exactly define the topic of investigation, the related body of knowledge and the areas to further investigate. In this regard, a SLR offers the possibility of correctly framing the problem, understanding the status of the academic research on the selected topic and possible gaps; furthermore, it helps classifying key factors or conceptualizing important aspects. Considering the vastness of the topic and the increasing number of papers on recycling behavior, a bibliometric analysis and conceptual mapping improve the framing of the problem and, as mentioned before, contribute to the comprehension of the structure and the dynamics of this research field.

Another important reason is that SLRs and bibliometric analyses make the researcher understand the importance of applying a rigorous and reproducible methodology while conducting academic research. In fact, the researcher has to correctly define the area of investigation starting from the selection of the database and the ideal search query, the correct definition of inclusion and exclusion criteria, and the choice of the best available tools. Furthermore, the researcher has to apply the academic research principles in a sound manner from the early stages of his/her research; in fact, principles such as integrity, transparency, reproducibility, accessibility, responsibility, respect for others, and rigorousness have to accompany the entire research process.

Chapter 4 and 5 are typical research papers based on case studies aiming at answering the research objectives and questions. In fact, in these chapters the researcher deeply analyzes a specific area of investigation by conducting research on the field (e.g., quantitative analysis), understands the essence of the existing applicable theoretical frameworks (e.g., TPB, TRGP), proposes and tests a conceptual framework through powerful statistical methods. Furthermore, the researcher analyzes the implications of his/her research, proposes suggestions for possible policy changes and new directions for future research because his/her research does not have to remain a sterile academic exercise.

Last but not least, the preparation of research articles exposes the researcher to the strict requirements of the publication process on academic journals including the demanding peer review process. Furthermore, the publication of a scientific article makes the researcher understand the importance of disseminating the results of his/her research, sharing points of views and promoting an interdisciplinary approach.

### **1.13. Summary of Chapters**

As previously described, Chapter 1 introduces the topic of investigation by providing the background of the study, its purpose, rationale and significance. It analyzes the main available theoretical frameworks, and it introduces the proposed conceptual framework in order to be able to answer the RQs. In addition, it introduces the overall methodology, and it specifies the assumptions, the delimitations and limitations of the research in order to correctly define the research field and expectations. Lastly, it explains the key terms by defining their meaning, therefore preventing possible misunderstanding and confusion.

Chapter 2 utilizes the SLR methodology to study the concepts and factors related to pro-environmental consumer behavior in relation to waste management through an interdisciplinary approach. In particular it describes how these concepts are addressed in the academic literature on waste management. It investigates the interplay between pro-environmental consumer behavior (PECB) and generic consumer behavior (GenCB); moreover, it analyzes the factors and conditions which favor this interplay. To ensure a robust and rigorous approach, this SLR utilizes three databases in the timeframe 1975-2019, it applies a solid search query, it follows the “Preferred Reporting Items for Systematic Reviews and Meta-Analyses” (PRISMA) guidelines and it reduces the risk of bias by adopting the “ROBIS” methodology. The findings reveal that, regardless of the numerous types of behavioral models applied to pro-environmental behaviors, these models mainly refer to a limited number of theoretical frameworks, namely TRA, TPB, NAM and VBN. Moreover, the above-

mentioned level of interplay is quite limited, however it is significantly influenced by a favorable context or institutional-legal framework. The spectrum of promoting factors and conditions is wide and it involves different sectors such as economics, law, social psychology, government and institutions. Lastly, this article highlights the limitations of the research in this field, the importance of a more interdisciplinary approach, the role of intervention measures by key stakeholders and the need for a clear classification of factors and conditions.

Chapter 3 applies bibliometrics and knowledge domain mapping to recycling behavior to the body of literature produced in the timeframe 1975-2020. More than 2,000 articles coming from three scientific databases are analyzed through two bibliometric tools and text mining. The findings reveal that the production of papers on recycling behavior keeps growing at an exponential rate and 60% of papers have been published between 2015 and 2020, confirming the global interest on this topic. Leading nations are mainly from the European Union, North America and Commonwealth. However, other nations such as China and Malaysia are expanding their academic production. This chapter describes the intellectual configuration of the knowledge on recycling behavior and individuates several conceptual sub-domains focused, for example, on food waste, WEEE, plastic bags, determinants of recycling behavior; other sectors are also getting topical such as IoT, LCA, utilization of bitcoins, circular and smart cities, products obsolescence. Moreover, the findings also indicate that waste management and the related human behavior represent a universal challenge and requires an interdisciplinary approach at all levels ranging from the individual to the institutional. In fact, this chapter highlights the importance of a more comprehensive view of the area of investigation starting from the holistic analysis of all stakeholders including their goals and motivation.

Chapter 4 analyzes waste separation behavior at the household level in Rome through the utilization of a model based on TPB: specifically, it studies the influence of environmental motivation, habits, past behavior and functionality of bins (besides the typical TPB predictors, namely attitude, subjective norms, PBC) on intention to separate waste. The results of this study are analyzed through SEM: they confirm not only the validity of the typical TPB predictors, but also the key role of environmental motivation on attitude and habits, and the influence of habits on attitude, PBC, intention and past behavior. This chapter also applies mediation analysis to these constructs; in fact, it reveals that environmental motivation has an indirect effect on intention through attitude, and habits on intention through PBC and attitude. These outcomes clearly show that, when the TPB framework is applied to waste separation behavior, it benefits the addition of habits and environmental motivation. Furthermore, this chapter demonstrates that habitual behaviors such as waste separation are driven by motivation as well. The final part of this chapter proposes some suggestions for policy makers and researchers; for example, it highlights the importance of activating householders' pro-environmental goals to increase the efficacy of recycling campaigns.

Chapter 5 aims at understanding the effects of goals on waste separation intention and at testing the potential of TRGP when applied to separation behavior considering this framework has the potential for improving the understanding of human behavior. It is worth mentioning that, at present, no study has verified the efficacy of TRGP on recycling behavior, therefore this chapter applies it to the study of separation behavior of the households of Maastricht and Zwolle, the Netherlands. The outcomes definitely indicate that active procurement goals (APG) and motivation influence separation intention; specifically, the effects of APG on attitude and motivation are statistically significant; moreover, motivation is a very reliable proxy of intention to separate. At the same time, active approval goals (AAG) do not significantly influence subjective norms and motivation. Therefore, this study confirms that the TPB framework can benefit the addition of further constructs by increasing its explanatory power. Furthermore, TRGP changes the "compensatory nature of the expectancy-value model" in which "each product of the belief strength times outcome evaluation is given equal weight" (Ajzen & Kruglanski, 2019, p. 779); in fact, in TRGP, AAP and APG have a privileged status and predominate on non-active goals. Lastly, this chapter proposes some suggestions on how to promote behavioral changes.

Chapter 6 recaps the analysis and outcomes of the previous chapters; in particular, it highlights that separation behavior, although habitual in nature, is goal driven. Not only that, the impact of AAG and motivation on separation behavior are significant and TRGP definitely improves the understanding of this type of behavior. This chapter, after recalling the main limitations of this thesis (e.g., self-reported measures in spite of observed measures), describes the implications of this research and offers some ways ahead for future research.

## **Chapter 2: A Systematic Literature Review of Concepts and Factors Related to Pro-Environmental Consumer Behavior in Relation to Waste Management through an Interdisciplinary Approach**

Published as

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## **Abstract**

Although there has been a steady increase in the number of studies on consumer behavior in relation to sustainable development, there is limited focus on the product disposal phase. This systematic literature review intends to: (1) clarify how concepts related to pro-environmental consumer behavior are understood and analyzed in the academic literature on waste management; (2) discover any interplay between pro-environmental consumer behavior and generic consumer behavior, and the conditions and factors that favor it. A typical systematic literature review methodology was applied to the papers available on Web of Science, Science Direct and EBSCO (Elton Bryson Stephens Company) host between 1975 and 2019, leading to the selection of 699 final papers. The findings reveal that: (1) Although scholars tend to create a variety of pro-environmental consumer behavior models depending on their specific field of inquiry, all approaches can be traced back to a limited number of reference theories; (2) The overall level of interplay between pro-environmental consumer behavior and generic consumer behavior is limited, nevertheless a favorable context or a supportive institutional-legal framework can significantly influence it; (3) A plethora of conditions and factors favor this type of interplay, involving social psychology, laws, economics, institutions and more; (4) Several critical issues appear in the analyzed papers, especially some scholars' assumptions to be able to identify all key factors. It follows the need for a more interdisciplinary approach, a deeper analysis of the effectiveness of the intervention measures at the governmental and institutional level, and a clear classification of factors and conditions (as proposed by this review).

## **Keywords**

Systematic literature review; pro-environmental consumer behavior; waste management; green consumer; theory of planned behavior (TPB); pro-environmental behavior; waste; consumer; consumer behavior; pro-environmental behavior factors

## 2.1. Introduction

The recent academic literature, official governmental publications and business studies show a significant interest in consumer behavior. The predominant focus is on the economic and marketing aspects, often motivated by strategic and lucrative reasons in the private sector; however, an increasing number of scholars and decision makers have investigated the social, cultural, psychological and ecological motivations and implications of consumer actions. This provides a branch of alternative research and an opportunity for a complementary investigation into the more diffused economic and marketing analysis. In fact, in the last few years a steady increase in studies on consumer behavior, in relation to sustainable development, demonstrates the need, especially by academia and executives, to expand the economic and social analysis of consumer activities towards a more interdisciplinary approach. In this regard, it must be emphasized that the production and sale of a product for the consumer market does not finish with the purchase by the consumer and his/her assistance through a customer service. This process should include not only a careful evaluation of the impact of a product on the environment, but also the consumer's contribution to this impact through his/her daily actions including waste recycling. For example, the production process has to be preceded by the environmentally friendly design of the product (also known as eco-design), taking account of both the recycling limitations that the consumer may experience during the disposal phase, and the features of the waste treatment plants (Gwenzi et al., 2018). Moreover, these issues are further exacerbated by weak governmental interventions and ineffective regulations, as highlighted by Wiesmeth and Häckl (2017). In fact, they state that environmental "policies in waste management, including policies on one-way drinks containers and waste electrical and electronic equipment, and implementations of extended producer responsibility with further applications to waste electrical and electronic equipment, reveal more or less severe deficiencies" (p. 332). It follows that a correct analysis of the impact of all human activities on the environment requires an interdisciplinary approach involving many fields like engineering, chemistry, ecology, economics, marketing, law, business management, sociology, and psychology. Actually, in some cases like environmental engineering, we observe great progress (Hong et al., 2006; Mihelcic et al., 2017), but note with regret that the predominant focus is still on the consumer purchase phase, often discarding the consumer disposal and recycling phase, that are becoming more and more important because of the deep consequences on the environment in terms of pollution and resources utilization. Institutions and academia have to fully understand that, as stated by Tseng, Tseng et al. (2018), "human behavior is a strategic domain because of the enduring effects of both poor and good recycling habits" (p. 367). In particular, there still is limited research on the interplay between pro-environmental consumer behavior (PECB) and generic consumer behavior (GenCB). In this paper, the interplay is interpreted as the interaction between people with high pro-environmental sensitivity and the ones who are not concerned about sustainable development. This type of relationship influences both the effectiveness of recycling at the final user level, and the diffusion of good recycling practices among consumers. Acknowledging that this effectiveness is tied to the availability of a robust recycling infrastructure and a supportive legal framework (Bliacheris, 2014; Feldman & Perez, 2012), the consumer can significantly contribute to it with his/her daily and apparently insignificant activities like waste disposal and recycling. In fact, Wiesmeth and Häckl (2017) affirm that "all agents, who are affected by the goals of a certain environmental policy, have to be integrated into this policy" (p. 336). In this sense, the institutional and social framework, in addition to a supportive context (Mannemar Sønderskov, 2011), definitely favor the interaction among people or the shift of consumers towards "greener" behavior through spillover and other effects (Feldman & Perez, 2012; Xu et al., 2018). Unfortunately, the existing literature shows that these aspects of PECB are not adequately and systematically addressed; in fact, Geiger Geiger et al. (2019) "indicate that future studies could more systematically examine the effects of contextual factors on recycling, as well as the interplay of individual and contextual factors" (p. 78).



Furthermore, although the most recent literature is increasingly utilizing terms like pro-environmental behavior (PEB), recycling behavior, and green behavior, the meaning and the interdisciplinary implications of these terms are still contested, because they are often influenced by the scholar's background (Hursh, 1984). Similarly, the plethora of theoretical frameworks applied in the numerous field studies proves that the selection of the most suitable model is contested too. Thus, there are high chances that a scholar conducting an interdisciplinary study on human behavior in relation to waste management struggles to find an adequate model incorporating the key factors. For example, this happens when a researcher from law or economics has the need to understand the mechanisms governing PECB; he/she would definitely benefit from models that explain how human behavior is less rational than expected. In fact, the predominant paradigm in economics is based on rationality and maximization of profits, whereas sociology and psychology explain how human behavior is not as rational or linear as expected; consequently, the latter disciplines opt for a different approach and terminology (e.g., "reasoned behavior" (Ajzen, 1991, 2015)). Moreover, the complexity of behavioral models is further exacerbated by the utilization of a consistent number of factors in addition to the typical ones like intention, norms, attitude and awareness of consequence. Consequently, the analysis and classification of these factors would definitely help researchers in better evaluating what to measure and how to correlate it with other variables.

It follows the need to fill these gaps through a systematic literature review including ad hoc research questions to investigate these issues, especially considering both the increased interest on PECB in academic research in the last decade, and the lack of extensive, rigorous and recent reviews on this topic (D. Li et al., 2019; Ma & Hipel, 2016; Miafodzyeva & Brandt, 2013).

### **2.1.1. Research Questions**

Therefore, this study aims to contribute to the understanding of PECB in relation to waste management by answering some research questions through a systematic literature review (SLR) as follows:

- Research question 1: How are the concepts of PECB and similar terms understood and analyzed in the academic literature on waste management?
- Research question 2: How is the interplay between PECB and GenCB?
- Research question 3: What are the conditions and factors (if any) that favor this interplay, or the shift of GenCB towards PECB?
- Research question 4: What are the main issues in the research on PECB?

### **2.1.2. Methodology**

In order to avoid research biases or missing essential information, the typical systematic review methodology (Petticrew & Roberts, 2008) has been applied to this paper. As stated by Petticrew and Roberts (2008), "systematic reviews are literature reviews that adhere closely to a set of scientific methods that explicitly aim to limit systematic error (bias), mainly by attempting to identify, appraise and synthesize all relevant studies (of whatever design) in order to answer a particular question (or set of questions)" (p. 9). In comparison with traditional methods, SLRs grant more repeatability and transparency, as well as a greater impartiality in judgements through a reduced influence of bias and preconceptions (Petticrew & Roberts, 2008). Consequently, the methods applied to a SLR allow to improve the reliability and trustworthiness of the study, and enhance the consistency and the legitimacy of the analysis and the related deductions (O'Keefe et al., 2016).

In the academic environment SLRs are quite diffused in many areas of investigation, especially in health research and biology, but they are becoming increasingly common in environmental studies on subjects such as climate change adaptation (Bisaro et al., 2018; Islam et al., 2020; Thi Hong Phuong et al., 2017), water policy (Candel, 2014; Gallego-Ayala, 2013; Tiedeken et al., 2017) and food security (Candel, 2014; Charlton et al., 2016; Thompson et al., 2010; Warren et al., 2015), although, to our knowledge, no SLR focuses on consumer behavioral aspects related to waste

management through a holistic analysis of socio-demographical, psychological, cultural and environmental characteristics. For example, Ma and Hipel (2016) concentrate on the social dimensions of municipal solid waste management; Almosa et al. (2017) on social marketing in relation to littering behavior; Schanes et al. (2018) on specific waste like the household food, and Canali et al. (2017) on food waste drivers.

This SLR has been integrated by a meta-analysis of collected data with the purpose of also providing a quantitative description of some specific aspects, like the geographical distribution of selected articles or the number of articles per year (Appendixes A and B).

### **2.1.3. Limitations and Implications**

This paper analyses adult consumer behavior in relation to waste management in normal situations (e.g., daily household waste disposal), so it does not investigate managerial processes or governmental policy, supply chain, sales practices, retailers or workers related issues. The behavior at workplace is excluded from this SLR because it presents specific characteristics, requiring ad hoc investigation. For example, the correct analysis of workers' behavior would involve factors related to leadership and teamwork (Norton et al., 2015), company goals and ethics, performance, workplace culture (Loverock et al., 2018) and organizational structure (Lo et al., 2012), eco-design and eco-production, and workplace habits (Holland et al., 2006). Similarly, the study of waste management behavior of minors requires the analysis of peculiar factors too; moreover, in this case, the general trend in literature is to focus on educational aspects, teaching tools (Chan, 2000; Cuccurullo et al., 2013; Gizzi et al., 2019), kids' judgment and personality development (Honig & Mennerich, 2013; Krettenauer, 2017; Long et al., 2014); hence, the study of minors should be separately treated. In addition, this paper does not analyze consumer behavior in specific contexts like national parks, or people handling peculiar type of waste like toxic materials. In very limited cases this SLR takes into consideration some articles on the supply chain management or managerial processes, just because they also analyze the consumer behavior by bringing new insights to this SLR's topics.

Consequently, this paper does not contribute to any managerial practice or analysis related to marketing or economic aspects, but it provides useful insights on the different academic approaches utilized to study the consumer behavior in relation to waste management throughout the last years.

The selected papers have been peer-reviewed and published between 1975 and 31 December 2019 in the English language in three main scientific databases: Web of Science, Science Direct and EBSCO (Elton Bryson Stephens Company) host. Further details are provided in Section 2.2 of this paper and in Supplementary Material (SM) spreadsheet (available online).

### **2.1.4. Structure of the Paper**

This article is structured into five sections (including Appendixes A, B and a SM spreadsheet available online) as follows:

- Introduction
- Data and methods
- Results
- Overall analysis and discussion of results
- Conclusions

## **2.2. Data and Methods**

### **2.2.1. Introduction on Systematic Review Methodology**

This SLR intends to summarize and disclose the results of the existing peer reviewed literature concerning the concepts and the factors characterizing PECB and its interplay (if any) with GenCB in relation to waste management during normal daily activities (excluding workplaces). This aim is motivated by the fact that, so far, SLRs of academic papers on waste management focus on a variety

of specific aspects but lack interdisciplinary investigation and understanding of the human behavior in relation to waste management. In fact, as also demonstrated by Silchenko et al. (2015), the articles generally denote a limited cross cutting view and they often focus on specific sectors like technology (e.g., infrastructure, waste treatment and transportation), laws (e.g., illegal dumping), management (e.g., supply chain management), healthcare, biochemistry (e.g., biodegradation processes, micro-pollutants), economics and marketing, education and nutrition.

Although several researchers investigate consumer products and the related waste, the attention often falls on the product itself or its utilization (de Oliveira Santos et al., 2020), not on the consumer behavior, especially when considering the disposal and recycling. When the scholars focus on the efficacy of waste management at the local or municipal level, the need to include human behavior in their analysis becomes pressing in order to understand, for example, how to encourage households to minimize waste or increase their awareness of environmental issues (Zacho & Mosgaard, 2016).

The method utilized by this SLR is based on researches conducted by several scholars in the last decades, including Petticrew and Roberts (2008), Littell et al. (2008), Cooper (2015), Hart (2018), Candel (2014), and Thi Hong Phuong et al. (2017).

According to Petticrew and Roberts (2008) the systematic review is made up of seven stages, namely:

- Stage 1: Questions definition
- Stage 2: Determination of necessary studies to answer the questions
- Stage 3: Execution of the comprehensive literature search to individuate the above-mentioned studies
- Stage 4: Screening of the results of the literature search (applying inclusion/exclusion criteria)
- Stage 5: Appraisal of the included studies
- Stage 6: Synthesis of studies and assessment of heterogeneity
- Stage 7: Disseminate results

In this article, stages 1 through 4 are addressed in Section 2, and stages 5 and 6 in Section 3. The dissemination of results will take place through the publication of this SLR in an academic journal and insertion in a PhD thesis.

Moreover, this SLR is conducted in accordance with “Preferred Reporting Items for Systematic Reviews and Meta-Analyses” (PRISMA) statement (Liberati et al., 2009; Moher et al., 2009) in order to ensure a more robust and reproducible approach.

### **2.2.2. Questions Definition**

The first stage has the purpose to correctly frame the problem by precisely identifying the area of interest and defining applicable questions considering both stakeholders’ needs and available literature. This systematic investigation on human behavior in relation to waste management is clearly influenced by the existing literature in terms of topics and type of concerns, but it intends to fill some gaps in this literature by defining a set of questions to allow an interdisciplinary understanding of some topics, and contribute to further advancing the studies in this specific field.

- Research question 1  
Research question 1 aims at satisfying the need for clarity in the plethora of existing conceptualizations and equivocal definitions about pro-environmental and similar terms like green consumer behavior (GrCB). For this reason, the answer to this research question initially provides the definitions of the main terms utilized by the analyzed literature; subsequently it explains how the basic concepts are understood in the academic literature starting from the theories and models in which they are applied. Moreover, it tries to understand if they are influenced by the type of approach adopted by the scholars or the context in which the analysis takes place.
- Research question 2  
Research question 2 intends to analyze the level of interplay (if any) between PECB and GenCB. The question aims at unveiling possible interactions among consumers giving due

consideration to their concerns and perceptions. In fact, the pro-environmental consumer is often driven by altruistic concerns, whereas the generic consumer is more influenced by a hedonistic or egocentric approach (although these differences may vary among Western and Asian nations) (Aoyagi-Usui et al., 2003; Evans & Abrahamse, 2009; Zsóka et al., 2013). This research question intends to understand, for example, if a pro-environmental consumer interacts with a generic consumer, or if the latter shifts its behavior towards more sustainable positions under certain conditions (e.g., spillover effects). This question is complemented by the next one.

- Research question 3  
Research question 3 further investigates the previous question by unveiling conditions and factors that influence this type of interplay or possible changes in consumer behavior in relation to waste management. In fact, there are cases where factors and conditions like proximity or social influences favor the interplay among consumers.
- Research question 4  
Research question 4 analyses some critical aspects of the studies on PECB (in relation to waste management) that might influence and limit the scope and the validity of the deductions in the peer-reviewed literature to date.

### **2.2.3. Determination of Necessary Studies**

Considering this SLR aims at an interdisciplinary understanding of PECB, there is an exiguous number of restrictions on the type of papers to be screened by this research. In fact, besides the fact that all articles are written in English, all journals (available on the selected databases) are kept in consideration; consequently, the investigated papers come from disciplines like economics, marketing, laws, sociology, psychology, education, nutrition, communications and engineering. Conversely, studies focusing on industrial processes without any consideration on consumer behavior, or chemical analysis of waste material, are excluded from this research.

### **2.2.4. Execution of the Comprehensive Literature Search**

The execution of the literature search is based on some specific steps finalized to apply a reproducible and rigorous analysis of the papers. Several authors of SLRs recommend going through well-defined methodological steps (Thi Hong Phuong et al., 2017) as follows:

- Selection of terms and databases
- Inclusion and exclusion criteria
- Data extraction and evaluation of review findings
- Limitations

#### **2.2.4.1. Selection of Terms and Databases**

The initial assessment of the literature has the purpose to better frame the research by identifying key concepts and search terms, especially considering that waste management and PEB have changed throughout the years. For example, waste management has significantly modified its approach to waste from an initial mere focus on the disposal phase to a more holistic and integrated one; moreover, terms like GrCB have been progressively replaced by other words like eco-friendly behavior, eco-conscious consumer, environmentally friendly behavior or PEB. Thus, the search query (

Table 1) has been tailored on two macro-areas of investigation related to waste management and PEB. The first macro-area involves key concepts and terms related to waste management, like minimization (or minimization), recycling, re-utilization (or re-utilisation) and incineration; the second macro-area focuses on key concepts and terms related to pro-environmental behavior like green behavior, eco-friendly (or environmental-friendly) behavior and ecological behavior (SM).

**Table 1.** Search query.

Source	Query
Web of Science	<p>TS=((waste management OR waste minimi*ation OR waste recycling OR waste reuse OR waste re-use OR waste reutili*ation OR waste re-utili*ation OR waste reduction OR waste prevention OR waste destruction OR waste separation OR waste valori*ation OR waste collection OR waste disposal OR waste incineration) AND (green behavior* OR pro-environmental behavior* OR proenvironmental behavior* OR eco-friendly behavior* OR ecofriendly behavior* OR ecologica* behavior* OR eco-innovat* behavior* OR ecoinnovat* behavior* OR eco-conscious behavior* OR ecoconscious behavior* OR ecologi* conscious behavior* OR environment* friendly behavior*))</p> <p>Indexes= Science Citation Index (SCI-EXPANDED), Social Sciences Citation Index (SSCI), Arts &amp; Humanities Citation Index (A&amp;HCI), Conference Proceedings Citation Index- Science (CPCI-S), Conference Proceedings Citation Index- Social Science &amp; Humanities (CPCI-SSH), Emerging Sources Citation Indexes (ESCI).</p> <p>Timespan=1988 until 31 December 2019</p> <p>Language=English</p> <p>Types of documents=All</p>
Science Direct	<p>Title-Abstract-Keywords (TAK)=((waste management OR waste minimisation OR waste minimization OR waste recycling OR waste re-use OR waste re-utilisation OR waste re-utilization OR waste reduction OR waste prevention OR waste destruction OR waste separation OR waste valorisation OR waste valorization OR waste collection OR waste disposal OR waste incineration) AND (green behavior OR green behaviour OR pro-environmental behavior OR pro-environmental behaviour OR proenvironmental behavior OR proenvironmental behaviour OR pro environmental behavior OR pro environmental behaviour OR eco-friendly behavior OR eco-friendly behaviour OR ecofriendly behavior OR ecofriendly behaviour OR eco friendly behavior OR eco friendly behaviour OR ecologic behavior OR ecologic behaviour OR ecological behavior OR ecological behaviour OR eco-innovative behavior OR eco-innovative behaviour OR ecoinnovative behavior OR ecoinnovative behaviour OR eco innovative behavior OR eco innovative behaviour OR eco-innovation behavior OR eco-innovation behaviour OR eco-conscious behavior OR eco-conscious behaviour OR ecoconscious behavior OR ecoconscious behaviour OR eco conscious behavior OR eco conscious behaviour OR ecologic conscious behavior OR ecologic conscious behaviour OR ecological conscious behavior OR ecological conscious behaviour OR ecologically conscious behavior OR ecologically conscious behaviour OR environment friendly behavior OR environment friendly behaviour OR environmental friendly behavior OR environmental friendly behaviour OR environmentally friendly behavior OR environmentally friendly behaviour))</p> <p>Timespan=All years until 31 December 2019</p> <p>Language=English</p> <p>(Please note Science Direct does not accept wildcards and more than 8 Boolean operators at a time, so the search query has been broken down in multiple queries, refer to supplementary material)</p>
EBSCO	<p>(waste management OR waste minimi*ation OR waste recycling OR waste reuse OR waste re-use OR waste reutili*ation OR waste re-utili*ation OR waste reduction OR waste prevention OR waste destruction OR waste separation OR waste valori*ation OR waste collection OR waste disposal OR waste incineration) AND (green behavior* OR pro-environmental behavior* OR proenvironmental behavior* OR eco-friendly behavior* OR ecofriendly behavior* OR ecologica* behavior* OR eco-innovat* behavior* OR ecoinnovat* behavior* OR eco-conscious behavior* OR ecoconscious behavior* OR ecologi* conscious behavior* OR environment* friendly behavior*)</p> <p>Source complete</p> <p>Publication type=All</p> <p>Document Type=All</p> <p>Expanders:</p> <ul style="list-style-type: none"> <li>• Apply equivalent subjects</li> <li>• Apply related words</li> </ul>

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Limiters:

- Scholarly (Peer Reviewed) Journals
  - Published date=All years until 31 December 2019
  - Language=English
- 

The utilization of the three above-mentioned databases has the purpose to mitigate the fact that no database alone can guarantee full coverage of the selected topics; in fact, these databases have a different coverage in terms of topics, journals and geographical areas (Biesbroek et al., 2013).

#### **2.2.4.2. Inclusion and Exclusion Criteria**

Some inclusion criteria have been identified to limit the scope of this SLR as follows:

- Time and topics: all eligible papers available on Web of Science (from 1988), Science Direct (from 1990) and EBSCO host (some articles are as old as 1972) until 31 December 2019 concerning PECB in relation to waste management
- Subject areas: this SLR is not limited to social, psychological or environmental sciences, but it includes a wide range of fields (like economics, marketing, laws, engineering) because it intends to investigate human behavior at an interdisciplinary level
- Type of papers: all peer-reviewed papers (both empirical and theoretical) from scientific journals, available on Web of Science, Science Direct and EBSCO. The great variety of literature favors a complete and correct evaluation of the competencies and advances on this SLR topic
- Language: papers written in English

A very limited number of exclusion criteria has been applied to this SLR, namely:

- Journals on topics not related to consumer behavior (e.g., chemistry, metallurgy, physics, mathematics, geology, surgery, genetics, zoology) or investigating very specific aspects of it (e.g., criminology)
- Topics related to professional environments (e.g., workers, retailers, managers, with the exception of the papers analyzing consumer behavior), education of minors and teaching methods, because this SLR studies pro-environmental and generic adult consumers
- Specific types of waste (e.g., nuclear, hazardous) because of their peculiarities in handling and treatment
- Specific locations (e.g., protected areas, territories under specific environmental laws, national parks, disaster locations) because this SLR would be highly context dependent

For further details refer to SM tab 2 online.

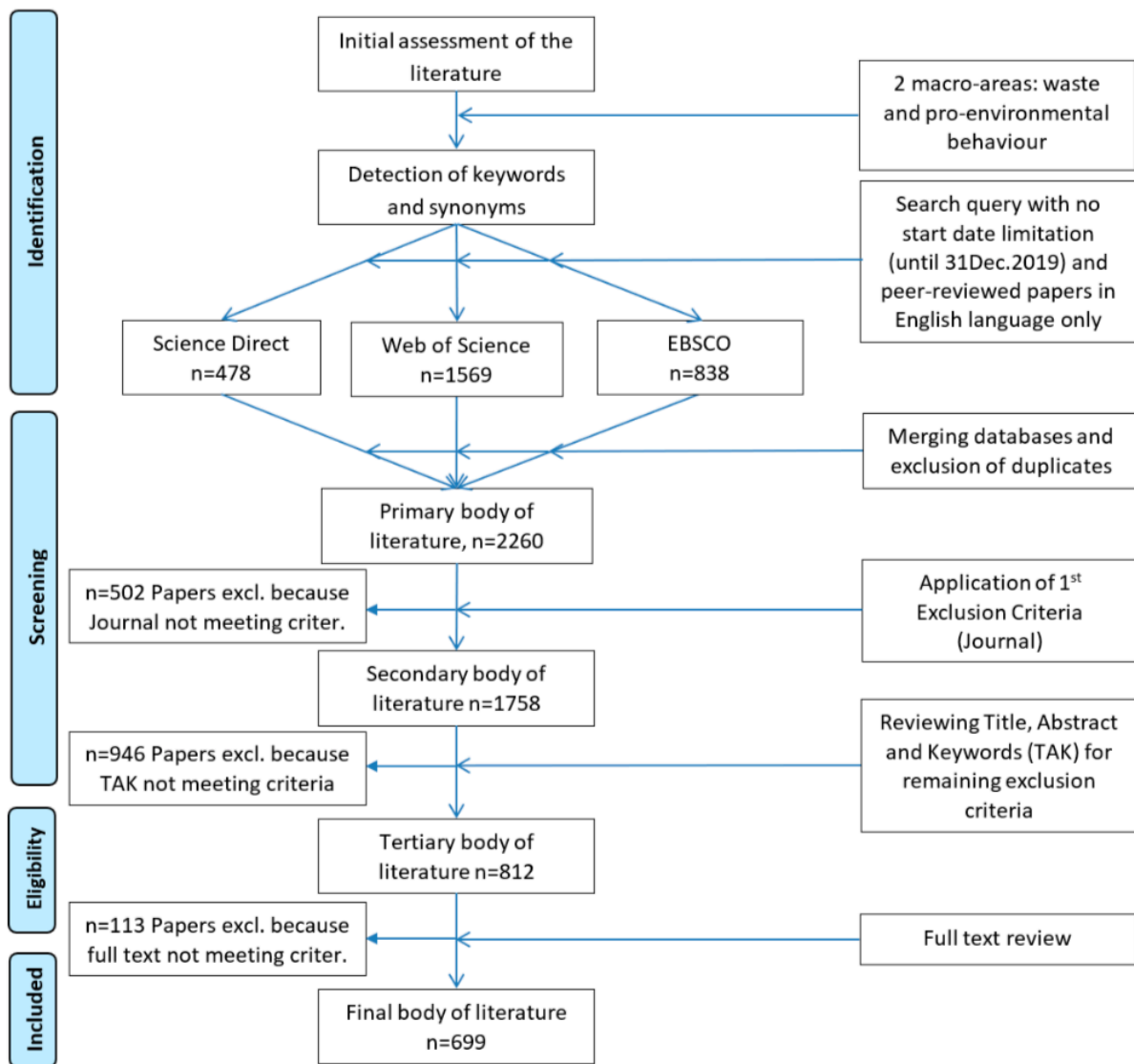
#### **2.2.4.3. Data Extraction and Evaluation of Review Findings**

The initial search produced 1569 papers from Web of Science, 838 from EBSCO and 478 from Science Direct (please note that duplicates are automatically removed by the EBSCO engine); after merging databases and excluding all duplicates, the primary body of literature was made of 2260 papers. Subsequently, the exclusion criteria were applied to eliminate papers that were not applicable, as follows (Figure 1, based on the PRISMA flow diagram (Liberati et al., 2009)):

- Papers published in scientific journals with very specific areas of investigation, not related to this SLR (the details of the first exclusion criteria are explained in Section 2.2.4.2; the full list of excluded journals is available in SM tab 2); after this screening, the body reduced to 1758 papers
- Not relevant papers in relation to this SLR's topics, through the review of the title, abstract and keywords (TAK); the body went down to 812 papers



- Not relevant papers in relation to this SLR's topics through the review of the full text; final body of 699 papers



**Figure 1.** Data collection process.

The full text of the 699 selected papers was classified utilizing a data extraction protocol (SM tab 3) based both on general and specific information, respectively the former: title, author, date of publication, journal of publication, abstract, etc., and the latter: theoretical framework (e.g., theory of planned behavior (TPB)), type of journal (e.g., economic, environmental, social matters), keywords, geographic area, etc. (SM tab 4). The protocol was autonomously developed (including a procedure about resolving possible disagreements) and tested on 20 randomly-selected included papers (Mistiaen & Poot, 2006); it was subsequently refined to support research questions and cope with available data. A single author independently screened the papers and extracted the data on the basis of the extraction protocol, whereas another author autonomously checked a sample of manuscripts with no disagreement on selected papers.

#### 2.2.4.4. Limitations

In relation to the selection of papers, this review does not adopt a full double independent screening of manuscripts and mitigates this issue through the above-mentioned sample check by the other authors. Apart from the limitations mentioned in Section 2.1.3, this review does not assess the quality

of included papers, considering the interdisciplinary approach would made this activity quite impracticable. Moreover, the authors recognize the potential risk of bias in their inferences, so they adopted “ROBIS” to assess this risk in this SLR (Higgins & Altman, 2008; Whiting et al., 2016). Although “ROBIS” it is mainly designed for the medical field, it is considered “the first rigorously developed tool designed specifically to assess the risk of bias in systematic reviews” (Whiting et al., 2016, p. 225). After application of this tool, the risk of bias in this review was low, especially considering that this SLR is a narrative synthesis.

## 2.3. Results

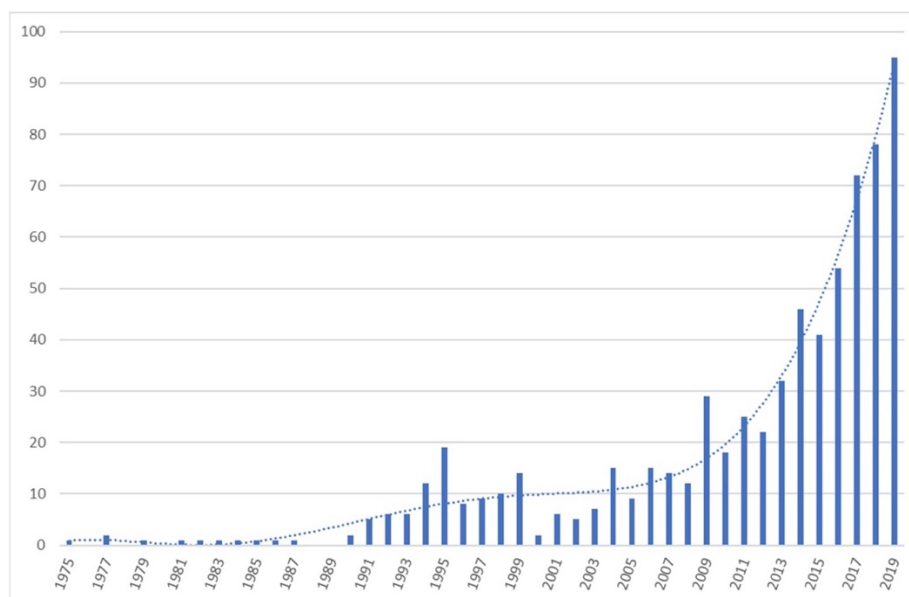
### 2.3.1. General Results

Some immediate descriptive results can easily be drawn from this SLR through a general analysis of meta-data. In fact, the study of meta-data provides clear indications about the year of publication, the geographical area of interest, the thematic scope and the type of journal, to name a few.

#### 2.3.1.1. Temporal and Geographical Analysis

The figures to follow (including figures in Appendixes A and B) provide visualizations of the general trends and macro-areas of interest. In some cases, the change in scale or granularity of the graphical representation allows further insights to be noted.

In relation to the analysis of the year of publication (Figure 2 and SM spreadsheet tab 5), evidence shows that in the 1980s there were basically no articles on this SLR’s topic. Then, starting from 1990 until approximately 2008 there was not a consistent production of peer-reviewed articles as it happens nowadays. In fact, not more than two articles per year were published in the 1970s and 1980s indicating that the interest in this SLR’s topic was still limited. The 1990s and the first years of the third millennium show an increased production of papers with a relative peak in 1995, possibly indicating a reaction from the academic world after the Earth Summit, organized in 1992 in Brazil by the United Nations, characterized by the signature of important agreements (e.g., the convention of biological diversity, the framework on climate change, and the “Agenda 21”). The curve shows another quite steady increase after the year 2000, when the United Nations adopted the “Earth Charter” and the “Millennium Goals”. After 2008 the dotted trend line highlights an exponential growth in the last decade; this progress is definitely in line with the increased and diffused attention to sustainable development matters throughout academia and governmental bodies.



**Figure 2.** Number of papers per year with trend polynomial dotted line.



A deeper investigation of the peak of papers in 1995 (in comparison with the trend line) indicates that the steep increase of articles is also motivated by the fact that some authors published several articles in the same year, like Porter et al. (1995), Potter et al. (1995) and Cobern et al. (1995).

Further details on temporal and geographical analysis are available at Appendixes A and B.

### **2.3.1.2. Thematic Scope and Areas of Investigation**

In relation to the type of waste analyzed by this SLR, there is a strong predominance of:

- Household waste (Phillips et al., 2011; Tonglet et al., 2004), especially food (Chakona & Shackleton, 2017; Crociata & Mattoscio, 2016; Mezghenni & Zouari, 2016; Morone et al., 2018; Schmidt, 2016; Wolters et al., 2019; Woon & Lo, 2016; Y. Wu et al., 2019; Zhu et al., 2017), composting in some cases (Edgerton et al., 2009; Loan et al., 2019; McKenzie-Mohr et al., 1995; Sintov et al., 2019)
- “Waste electrical and electronic equipment”, also known as “WEEE” or “e-waste” (Echegaray & Hansstein, 2017; Martinho et al., 2017; Milovantseva & Saphores, 2013; Nnorom et al., 2009; Ongondo & Williams, 2011; Selby et al., 2014), including small household appliances, personal care appliances (Pierron et al., 2017) or end-of-life products (Kianpour et al., 2017)
- Urban/municipal solid waste (Chalcharoenwattana & Pharino, 2018; De Feo et al., 2017; Park, 2018; Singh & Raj, 2019; Skourides et al., 2008)

Other quite recurring types of waste are plastics (Amenábar Cristi et al., 2019; Dilkes-Hoffman et al., 2019; Zulganef et al., 2019), metal cans (Castro et al., 2009; Ryan & Bernard, 2006; Sung et al., 2019), and batteries (Hansmann et al., 2006; Lizin et al., 2017; Ohnmacht et al., 2018), besides the purchase of green products (Mainieri et al., 1997; Park & Ha, 2012; Selvakumar et al., 2019) or electronic products (Danish et al., 2019; Liu et al., 2019), considering waste management impacts the acquisition phase too.

This predominance is motivated by the scope of this SLR on consumer behavior, and its direct impact on the environment through its daily activities involving food, electrical and electronic equipment, and waste discharge. Moreover, the consumer relationship with this type of waste offers the possibility to better understand the mechanisms governing its behavior, and to verify the soundness and applicability of existing socio-psychological theories and models to the field of waste.

It follows that the main places of investigation are households (Dai et al., 2015; Milovantseva, 2016; Schmidt, 2016), neighborhoods (Williams & Dair, 2007), residential areas (Ancuta et al., 2014), municipal areas (Ancuta et al., 2014; Barr, 2007; Skourides et al., 2008), and small- to medium-sized towns (Barr, 2007), including some less common locations like urban labs, distinct urban mines (Pierron et al., 2017), community gardens (Kim, 2017). Other recurring places are represented by schools and universities (Byrne & O’Regan, 2014; Guevara Martínez, 2013; Lazell, 2016; McCoy et al., 2018; Tangwanichagapong et al., 2017), especially dining facilities (Whitehair et al., 2013) and cafeterias (Sussman et al., 2013). Some papers also focus on shopping areas (e.g., grocery stores (Beitzen-Heineke et al., 2017)) and green or sustainable buildings (Joachim et al., 2014; Joo & Kwon, 2015; Wu et al., 2013; Wu et al., 2016).

Concerning schools and universities, the advantage of analyzing an institute or a faculty resides in the easiness in reaching a defined champion of population and carrying out a complete investigation through the distribution of paper/electronic questionnaires or the conduct of interviews.

In the case of shopping centers, the focus of the researches is generally on customers’ purchase phase, and on the consequences of this phase on the subsequent disposal and recycling; whereas, in the case of urban labs or green building, the attention revolves around the interaction among individuals or the impact of pro-environmental attitudes and intentions on routine activities.

### **2.3.1.3. Type of Investigated Personnel**

Although the investigated samples are very different in type, there is a diffused tendency in studying the behaviors of households (Nainggolan et al., 2019; Pearson & Amarakoon, 2019), students (Ahmad & Nordin, 2014; Passafaro et al., 2019) and consumers of basic necessities (including green products) (Lease et al., 2014; Petljak et al., 2019) or electrical and electronic devices (Chuang & Liao,

2018; Nowakowski, 2019), mainly mobile phones and tablets (Liu et al., 2019; Martinho et al., 2017; Ohnmacht et al., 2018).

It is worth reminding that this SLR does not focus on workers and managers, although some selected articles consider both the consumer behavior and the retailer/supplier behavior.

#### 2.3.1.4. Journal of Publication

Bearing in mind the scope of this SLR, the selected journals mainly focus on fields like sustainable development, environment, resources management, ecology, sociology and psychology; and in a reduced measure on education, economics, marketing and nutrition (Figure 3 and SM spreadsheet tab 8 online). To be more precise, the most utilized journals are as follows: “Environment and Behavior” (71 articles),

“Resources, Conservation and Recycling” (49 articles), “Journal of Cleaner Production” (38 articles), and “Journal of Environmental Psychology” (36 articles) (full list available in SM tab 9).

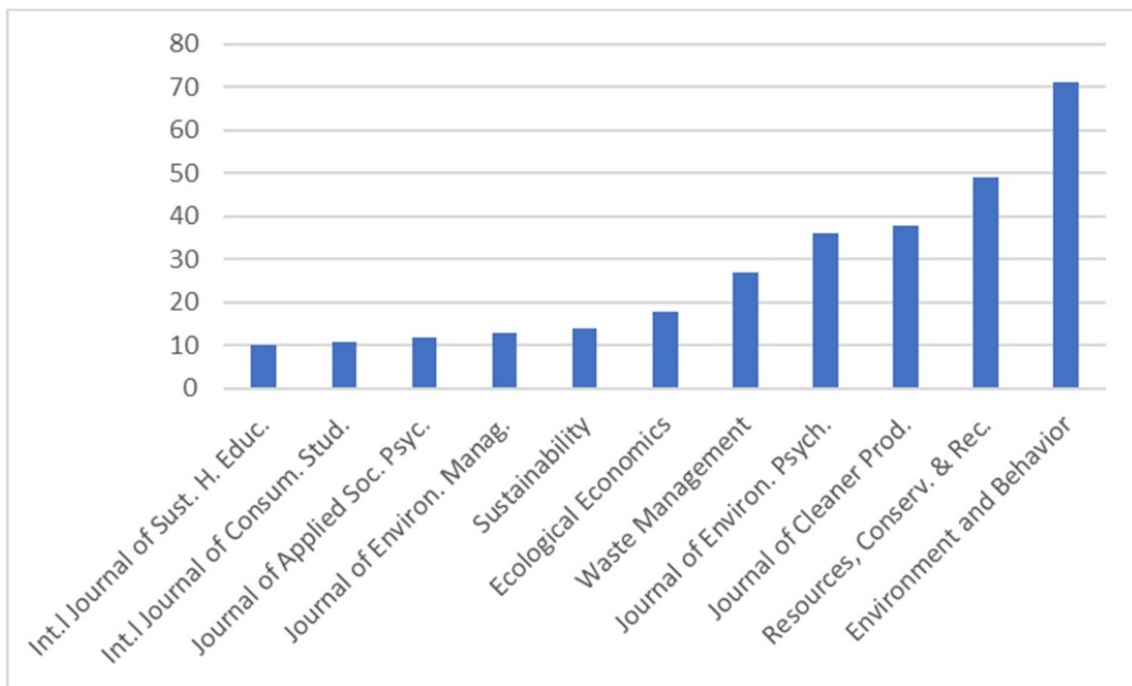


Figure 3. Number of papers in the most utilized journals.

### 2.3.2. Research Question 1

How are the concepts of PECB and similar terms understood and analyzed in the academic literature on waste management?

#### 2.3.2.1. Definitions

Before analyzing how these concepts are understood in the academic literature, it is important to provide the definitions of PECB and GrCB. In fact, although a limited number of selected papers dedicate some attention to the ontology, at times some confusion or misunderstanding about these concepts arise when investigating human behavior in this specific sector. That being said, there is no unequivocal or universally agreed definition of these terms, and their meanings are context- and time-dependent. This study selects Kollmuss and Agyeman (2002)’s definition of PEB as the “behavior that consciously seeks to minimize the negative impact of one’s actions on the natural and natural and built world” (p. 240). This approach is also supported by Steg and Vlek (2009) who define PEBs as the “behaviours that harm the environment as little as possible, or even benefit the environment” (p. 309). By adding the word “consumer” this SLR intends to focus on the individual as the final purchaser and end user of the product or service, until the dismissal or re-utilization phase

of a product (e.g., recycling, minimization, disposal, separation). This approach is supported by Kianpour et al. (2017) who recall Kuester (2012) (p. 1326) to define consumer behavior as “the study of individuals, groups, or organizations and the processes they use to select, secure, use, and dispose of products, services, experiences, or ideas to satisfy needs and the impacts that these processes have on the consumer and society” (p. 3).

Steg and Vlek (2009) interpret GrCB as a type of PEB, which can be defined as a “form of consumption that harms the environment as little as possible, or even benefits the environment” (p. 113); according to Couto et al. (2016) a green consumer is “any individual whose buying decision behavior is influenced by environmental concerns” (p. 307). Kianpour et al. (2017) refer to Leonidou et al. (2010) to better understand the characteristics of GrCB by stating that “green consumers demonstrate an interest in such product’s characteristics as chemical content and recyclability and, favorably discriminating consumption towards bioorganic, energy efficient or biodegradable packaging products” (p. 3). Leonidou et al. (2010) further analyze their purchasing behavior by defining “green purchasing, that is, activities that lie in the personal domain and have a direct effect on the natural environment” (p. 1322).

It is important to clarify that this SLR is not interested in the customer itself, although in some papers the authors analyze not only the re-utilization and recycling phase, but also the purchase and marketing phase. In these cases, the paper may focus, for instance, on the customer of green products with low-impact packaging, but also on the consumer trying to minimize packaging, correctly dispose of it or reuse it (Choshaly, 2017). In other cases, scholars analyze the customer satisfaction or perception of recycling services considering its impact on recycling behavior (Taberner et al., 2015).

### **2.3.2.2. Theoretical Framework**

Through the analysis of the theoretical framework utilized in the selected papers, this SLR shows which theories have been recalled providing support to the empirical findings, and which ones have been tested to verify their applicability to consumer behavior in relation to waste management.

Although the basic principles and the nature of the environmental actions taken by the pro-environmental consumer have been studied in very different contexts, and many scholars have attempted a transdisciplinary approach to include all possible factors (López-Mosquera et al., 2015; Zhang et al., 2011), the predominant theoretical framework is rooted in the socio-psychological field, especially considering that this SLR focuses on human behavior.

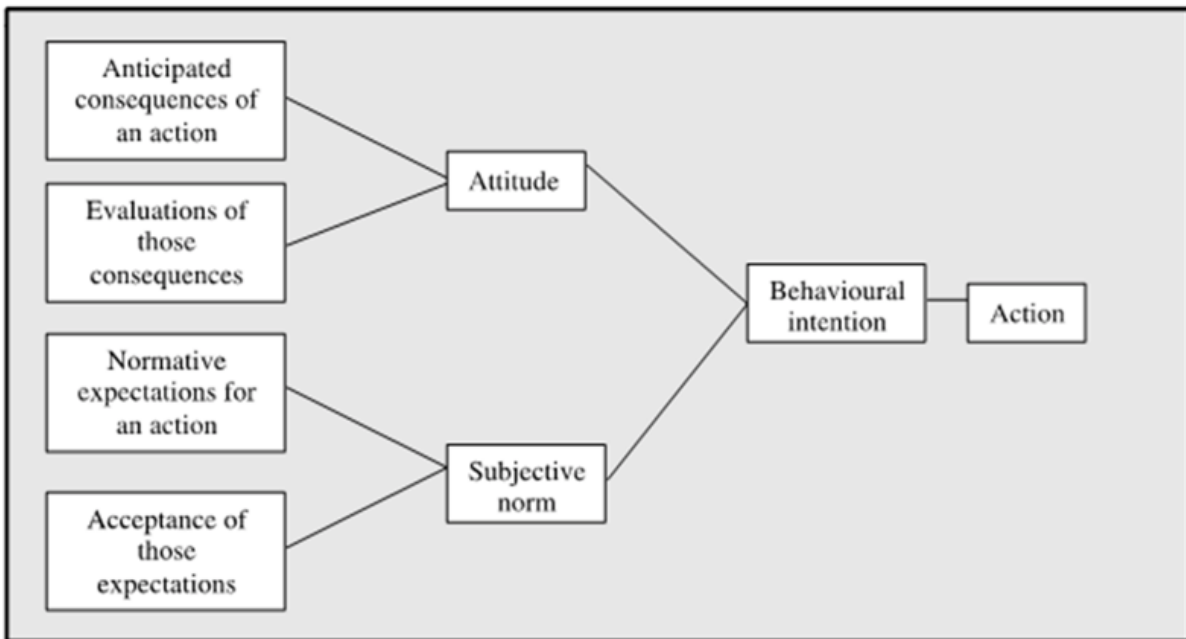
In the last 30 to 40 years the attitude-behavior inconsistency has represented, and currently still represents, the pivotal point of many theories, especially among social psychologists (for example, Eiser and Eiser (1986) talks about the “attitude-behavior discrepancy”). Moreover, LeDoux (1995) and Damasio (1998) infer that emotions in human cognition keep assuming an important role in many scientific domains besides cognitive psychology and neuroscience.

The separation of deliberate cognition from emotions that characterized the mid-twentieth century is now replaced by the utilization of an integral approach in which the interconnection between reasoned processes and emotion represents the road to follow to understand the roots of the human concern for the environment Damasio (1998).

### **Theory of Reasoned Action (TRA)**

Analyzing the most diffused theoretical constructs chronologically, the first one to recall is the TRA from Fishbein and Ajzen (Ajzen, 1980; Ajzen & Fishbein, 1970; Fishbein & Ajzen, 1977). This theory aims to explain human behavior through “a set of hierarchically linked constructs” (Barr, 2004, p. 233). The TRA intends to unveil the connections between human behavior intentions and its actions. Looking at the model depicted in Figure 4, the behavioral intention is made of two components, called attitude and subjective norm. The former is the attitude towards an object; it is interpreted as the results of the anticipated consequences of an action and the evaluation of those consequences. The latter (the subjective norm) derives from the normative expectations for an action (or awareness) and the acceptance of those norms; subjective norms derive from the perceptions of

an individual in relation to his/her social acceptance. The term ‘reasoned’ relates to the assumption that people have reasons for their behavior.



**Figure 4.** Theory of Reasoned Action (TRA), adapted from Fishbein and Ajzen (1977).

### Norm Activation Model (NAM) Theory

Other scholars recall, in recent times too (Gatersleben et al., 2019; Liu et al., 2018; Wang, Guo, et al., 2018; Xianfang et al., 2017; B. Zhang et al., 2019), the NAM theory proposed by Schwartz (1977). This model is based on the fact that the activation of personal norms could have a significant impact on individual behavior. It has to be noted that the mentioned activation of personal norms requires some conditions to happen: there must be the consciousness (from the individual point of view) that not maintaining a pro-social behavior will probably negatively affect other people, and, at the same time, the individual has to understand its responsibility (towards other people) in case of negative consequences (Figure 5).

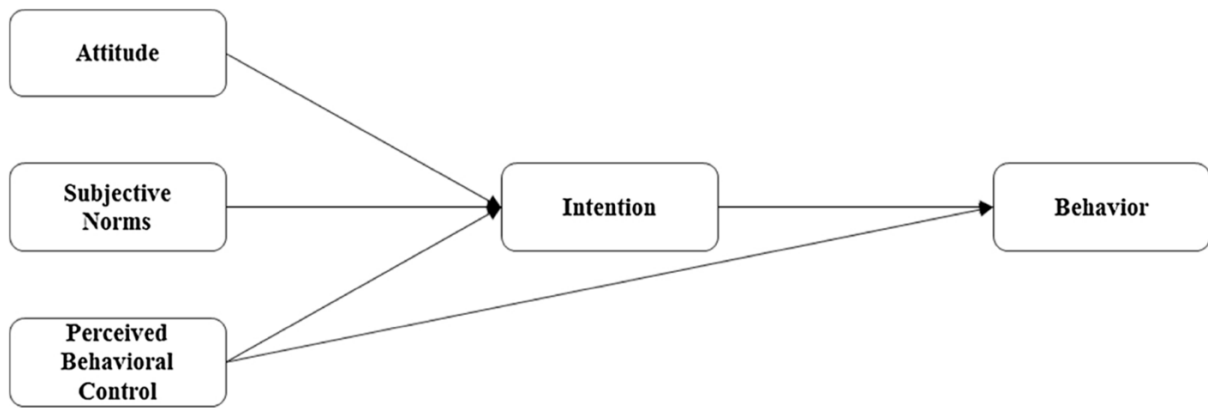


**Figure 5.** Norm Activation Model (NAM), adapted from Wang, Guo, et al. (2018).

The key points of the NAM theory are that personal norms need to be activated to influence human behavior (Church et al., 2019), and there are a variety of activation forms; moreover, under specific conditions, these norms have significant impact on the individual’s pro-social behavior.

### Theory of Planned Behavior (TPB)

The evolution of the TRA is represented by the TPB (Ajzen, 1991; Ajzen & Madden, 1986) (Figure 6), and subsequently, the enhanced or extended forms of it (Aslam et al., 2019; Botetzagias et al., 2015; Soorani & Ahmadvand, 2019; Zhang et al., 2017).



**Figure 6.** Theory of Planned Behavior (TPB), adapted from Wang, Guo, et al. (2018).

The TPB (and its successive combinations with other constructs) is clearly the most predominant and influential theory among studies on consumer behavior, including ones on those concerning environmental behavior. In general terms, the TPB represents a step forward in comparison with the TRA thanks to the addition of the so-called “perceived behavioral control”, a psychological factor related to the perceptions of the individual in relation to his/her ability to act (Barr, 2004). In fact, to better understand human behavior in a social group with complex relations, it is important to consider aspects like self-efficacy and perceived skills.

Bamberg and Moser (2007) inferred that the TPB “is based on a more hedonistic model of human beings” (p. 16) in comparison with the NAM theory, because individuals normally tend to avoid or prevent punishments on the one hand, and they are motivated by rewards on the other hand; consequently, the overall attitude is the result of the balance between negative and positive perceptions of consequences. In fact, as often stressed by Ajzen (2015), “the TPB does not propose that people are rational or that they behave in a rational manner” (p. 133); consequently, many studies on environmental behavior assume that individuals make reasoned choices and try to maximize their benefits and social approval while minimizing cost, efforts and discomfort (Steg & Vlek, 2009).

Several scholars extend the TPB model by adding one or more variables to increase the predictive capability of the original TPB. For example, L. Xu et al. (2017) added perceived moral obligations, perceived policy effectiveness and past behavior to a TPB-based model to study household waste separation behavior. They concluded that “subjective norms, perceived behavioral control, past behaviour and intention significantly predict household waste separation behavior, with past behaviour being the most significant construct to predict individuals’ intention and behaviour” (p. 1). Other extended forms of the TPB include environmental knowledge (Cheung et al., 1999; Kianpour et al., 2017) with different results; in some cases, the predictive capability of the model significantly improves (Cheung et al., 1999; Kianpour et al., 2017), in other cases it does not bring any clear gain (Laroche et al., 2002). Wang, Dong, et al. (2018) added facility conditions, governmental policy, willingness to pay and perceptions of results (besides demographic factors) to the typical components of the TPB. They inferred that “urban residents’ willingness to pay is more sensitive to perceptions of results and policy implications than separate collection intentions in China” (p. 256).

### **The Value-Belief-Norm (VBN) Theory**

The VBN theory is mainly based on three pillars: the value theory, the NAM theory and the New Environmental Paradigm. It was created by Stern (2000) in 2000 to focus on the importance of individual perceptions in relation to moral obligations (Figure 7).



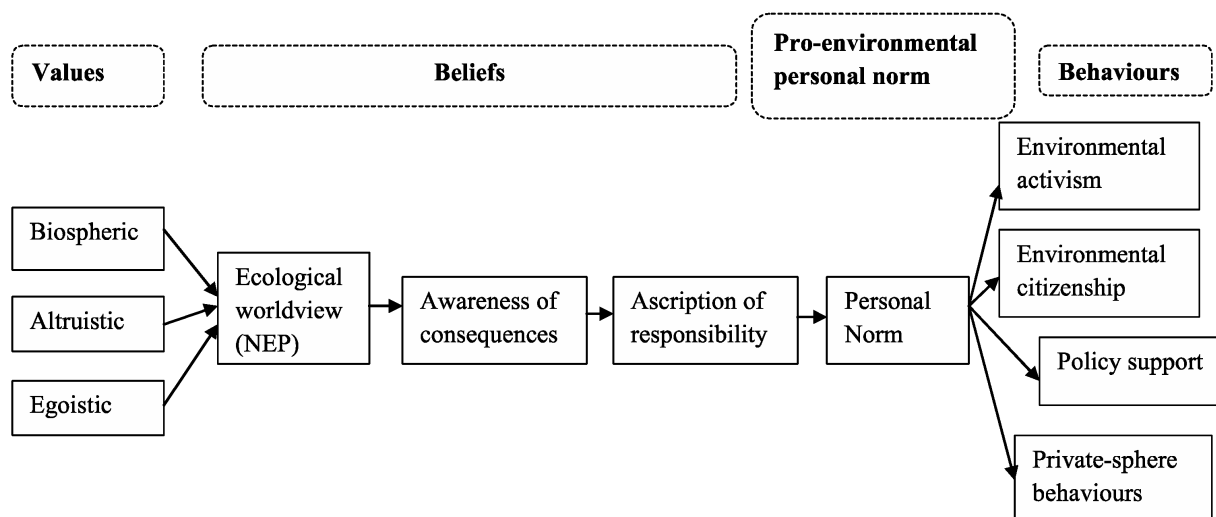


Figure 7. Value-Belief-Norm (VBN) theory, adapted from Yuan et al. (2016).

### Other Theories, Models and Conceptualizations

In the selected articles several other theories and models have been recalled or created, like the neutralization theory by Sykes and Matza (1957); however, a complete analysis is not feasible in this section for brevity reasons (for further details refer to Appendixes A, B and full list in SM on line). Despite the great variety of approaches, most of these theories can be traced back to the TRA, or better yet, the TPB (that represents the evolution of the TRA), and to a lesser extent, to the NAM and the VBN theory (Table 2), full lists of theory and models available in SM tab 10). This review shows that, from the dawn of the research on environmental behavior to now, the TPB and its extended forms have provided a recognized framework for explaining human behavior in relation to waste management, as in the case of plastic bags utilization (Sun et al., 2017), recycling behavior (Botetzagias et al., 2015; Taylor & Todd, 1995b; Wan et al., 2017), and household and solid waste separation (Ayob et al., 2017; Chan, 1998).

Table 2. Most utilized theories/models.

Theory/Model	Theory/Model's Author	Utilisation (Number of Papers)
Theory of Planned Behaviour (TPB) and related models	Ajzen (1991)	229
Theory of Reasoned Action (TRA) and related models	Fishbein and Ajzen (1970)	109
Norm Activation Model (NAM)	Schwartz (1977)	70
Value Belief Norm (VBN) theory	Stern (2000)	61

Note: Mathematical theories/models are not included in this table.

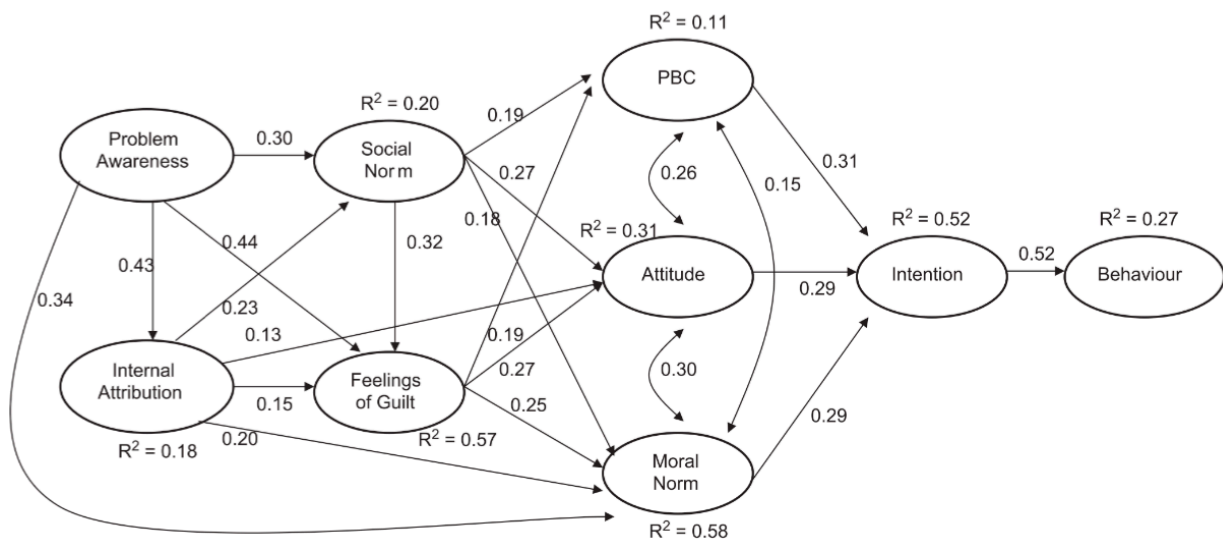
As explained by Bamberg and Moser (2007), the theoretical models utilized to explain PEB (like the TPB and the NAM) reflect the widely diffused view that PEB is a combination of self-interests (like minimization of one's own risks or maximization of personal interests and satisfactions) and altruistic concerns for other people, nature, next generations, etc. In their view, scholars who mainly focus on self-interests are probably going to adopt models based on reasoned choice (like the TPB), while researchers that give priority to the social motivation of PEB, probably rely on the NAM, where personal and moral norms have direct implications on pro-social behavior.

#### 2.3.2.3. Integration of Theories and Models

In the latter years, several scholars have tried to apply the TPB in combination with other theories or models to better explain human behavior in relation to the environment and, specifically, to waste management. Generally, this type of integration aims at giving adequate importance at factors underestimated in some theories or models. In fact, the complexity of pro-environmental behavior,

“viewed as a mixture of self-interest (e.g., to pursue a strategy that minimizes one’s own health risk) and of concern for other people, the next generation, other species, or whole ecosystems” (Bamberg & Moser, 2007, p. 15), is reflected in the difficulty of selecting the most suitable framework. In some cases, we acknowledge a predominance of approaches based on self-interest, hedonism or conservation, in others pro-social factors take over more egoistic concerns. This issue often leads most scholars to opt for a specific theory (or model), knowing in advance that there is the need to introduce further variables to correctly analyze their field studies. Consequently, finding the right balance when integrating theories or a model is a very delicate operation that requires a solid theoretical knowledge, strong familiarity with the context and a great acumen.

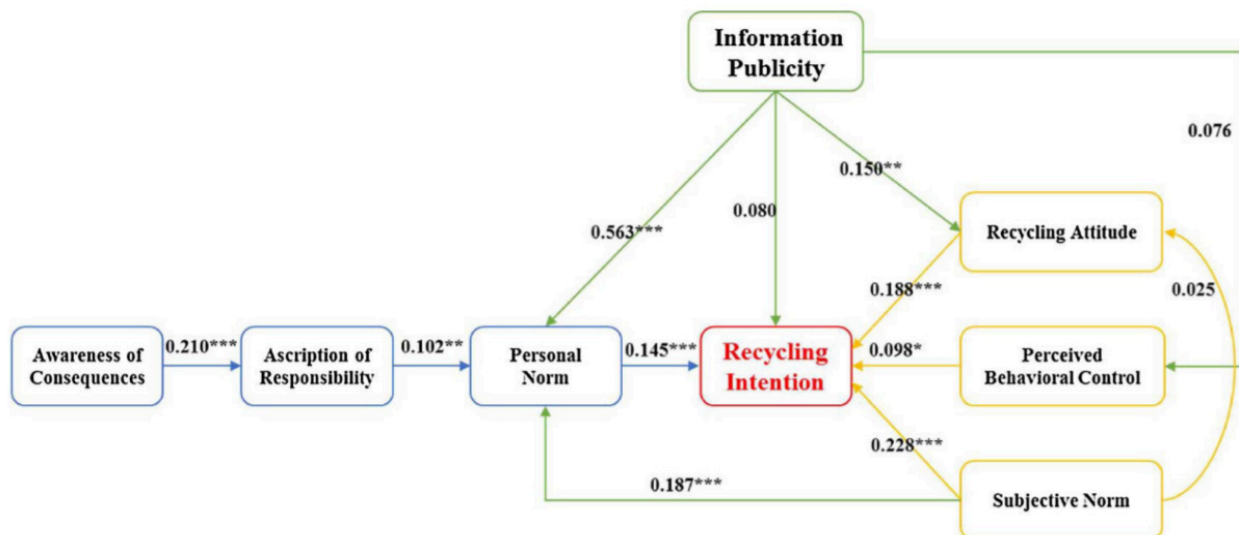
For instance, Bamberg and Moser (2007) decided to combine the TPB and the NAM (Figure 8) because “proenvironmental behaviour is best viewed as a mixture of self-interest and pro-social motives” (p. 16). The results of their integrated “meta-analysis and structural equation modeling” (MASEM) support this approach and show that intention is the immediate predictor of behavior (27% variance). Moreover, both the typical factors of the TPB and the ones of the NAM are significant (direct or mediated) predictors of intention. In fact, the TPB antecedents of intention explain 52% of variance, while “problem awareness, internal attribution, feelings of guilt, and social norms all significantly contribute to the prediction of moral norm” (p. 21), by as much as 58%.



**Figure 8.** Example of integration of the Theory of Planned Behavior and the Norm Activation Model (TPB-NAM), adapted from Bamberg and Moser (2007).

Another example of integration of the TPB and the NAM is provided by Wang et al. (2012) (Figure 9). They utilized a case study in China to analyze citizens’ participation in an in an e-waste recycling project, and understand the influencing mechanisms of information publicity.

They combined the TPB and the NAM because they inferred that “there is difference between subjective norms in TPB and personal norms in NAM theory; subjective norms in TPB are mainly the pressure or feelings that a person acquires from the community or people outside; however, personal norms in NAM put more emphasis on self-concept” (p. 2). They concluded that both the behavioral antecedents of the TPB (namely recycling attitude, perceived behavioral control, subjective norms) and personal norms (considered by the NAM) affect recycling intentions, but personal norms have a much stronger influence (on recycling intentions) than subjective norms; moreover, they inferred that personal norms of the NAM are significantly affected by subjective norms of the TPB.



**Figure 9.** Example of integration of the Theory of Planned Behavior and the Norm Activation Model (TPB-NAM), adapted from Wang, Guo, et al. (2018).  
 Note: \* $p < 0.1$ , \*\* $p < 0.05$ , \*\*\* $p < 0.01$

Zhang et al. (2018) integrated the TPB with the expectancy theory to better understand the effectiveness of a point reward system; they found a “significant correlation between the influence of a willingness to participate in formal E-waste recycling and participating expectancy, subjective attitude, objective environment” (p. 475). Meanwhile, B. Zhang et al. (2019) sought “to explore the influences of personal attitudes, facilities accessibility, and government stimulus on” the “discrepancy between intention on household waste sorting and the actions taken to support this environmental initiative among residents in China” (p. 447). Their study confirmed this discrepancy and the negative influence of governmental stimulus and facilities accessibility on the intention-behavior relationship.

It is also worth mentioning an example of a combination of multiple theories: Lin Xu et al. (2017) blended the TPB, the VBN, the NAM and social marketing theories to understand how external factors influence the individual recycling behavior. They inferred that market incentives and government facilitators positively influence recycling intentions; moreover, they found different effects of incentives and facilitators depending on gender, income and age.

To conclude, although some models are characterized by high values of variance, it is not possible to define the ideal combination of theories that best describes consumer behavior about waste management; in fact, numerous factors and conditions play a key role in the final equation with positive and negative effects (e.g., context, type of investigated personnel, area of investigation).

#### 2.3.2.4. Different Dimensional and Analytical Approaches

In addition to the academic debate on the best theoretical framework to apply, this SLR highlights different dimensional and analytical approaches utilized by scholars to investigate PECB, GrCB and related concepts. The most diffused ones are as follows:

- meso, macro, micro scale (Saari et al., 2017);
- individual versus collective dimension (Poortvliet et al., 2018);
- Private versus public sphere (Gkargkavouzi et al., 2019)
- National versus global dimension (Ongondo & Williams, 2011)
- Personal, social and organizational levels (Taberner et al., 2015)
- Cognitive, affective or connotative dimensions (Mezghenni & Zouari, 2016)

This review also highlights both how difficult it is to combine these different approaches, and a diffused agreement on the need to conduct a holistic approach when analyzing these concepts (Blok et al., 2015; Kasidoni et al., 2015; Nemecek et al., 2016). In fact, Sanchez et al. (2016) proposed a



multidimensional model finalized at promoting PEB, including environmental attitudes and beliefs, socio-demographical factors, economic characteristics and some variables related to environmental sensitivity. Zhang et al. (2011) suggested conducting a complete analysis covering political, economic, social, technological, legal (also known as PESTL) and environmental factors.

At the same time, this review shows how these approaches are generally limited by biases and personal views depending on the scholar's personal background and focus. For example, scholars with a socio-psychological background tend to focus on the factors connected to the social context, culture, religion, ethnicity, habits, personal/social norms, personality, feelings and perceived control, to name but a few. Conversely, authors with a background in industrial ecology or environmental engineering focus on aspects like the limitations on PECB caused by inadequate recycling systems, the analysis of the cost/benefits ratio of different recycling systems, the creation of eco-design and eco-efficient products, and the best ways to make the consumer aware (Deutz & Frostick, 2009; Mihelcic et al., 2017; Pahl-Wostl, 2019).

This situation leads to the utilization of models characterized by quite heterogeneous factors. In fact, besides the utilization of some standard variables like age, income, environmental knowledge or motivation, other factors are highly dependent on the type of approach utilized by the authors (e.g., socio-psychological, socio-institutional, socio-economic).

It follows that, when dealing with consumer behavior, and especially with PECB, it is essential to construct complex models that include situational factors, socio-demographic characteristics, psychological variables, economic influences, technological and organizational impact, legal framework, etc., at different levels.

### **2.3.3. Research Question 2**

How is the interplay between PECB and GenCB?

This study shows that the interplay between PECB and GenCB is quite limited in general. As stated by Sitarz (1993) "altering consumption patterns is one of humanity's greatest challenges in the quest for environmentally sound and sustainable development" (p. 39).

Considering it is impractical to define a standard scale to quantify the level of interplay across different contexts, this research question aims at providing and analyzing a series of positive and negative examples of interactions.

Overall, this SLR highlights that the interplay is influenced by different drivers depending on the level of the analysis conducted by the scholars (e.g., community, neighborhood, municipal, regional or national level); moreover, it is highly context related. For example, at the neighborhood level, the presence of a pro-environmental organization or the existence of spillover effects usually favors the adoption of innovative waste management measures, and the diffusion of PECB among generic consumer too. Vice versa at the national level, as it happens in Singapore, adequate information and educational campaigns promote the spread of pro-environmental values among the population and, consequently, create optimal conditions for this interplay.

In relation to the community level, Meneses (2009) analyzed the effectiveness of recycling promotion through a block leader. He inferred that there is no difference between cooperative people and non-cooperative ones in terms of reaction to the new recycling information. This result contradicts the classical recycling approach that considers people with a more innovative profile as the ones more receptive in responding to new recycling techniques; nevertheless, his study supports the importance of an information campaign for all consumers to favor behavioral changes. At the micro or local level, Thøgersen (1999), Wonneck and Hobson (2017) and Zhou et al. (2017) showed some examples of positive and negative spillover. For instance, Wonneck and Hobson (2017) inferred that Calgary's recycling pilot program had positive effects on dry recycling, but negative effects on home composting. Rees et al. (2015) analyzed more hidden behavioral mechanisms and highlighted how sense of guilt and shame for human-caused environmental catastrophes "lead to reparative behavioral intentions and actual behavior in the context of intergroup relations" (p. 440).

Moving from the community to a higher level, the legal and institutional framework definitely represents a key element in fostering the pro-environmental sensitivity of all consumers, and promoting the mentioned interplay or the move towards more environmentally friendly behavior. In fact, on the one hand, an efficient legal framework favors the contagious effect of green initiatives and the virtuosity of pro-environmental consumers or ecologist movements; on the other hand, it forces skeptical or reluctant generic consumers to adopt procedures that are already rooted among pro-environmental consumers. Moreover, this framework contributes to the diffusion of the imitation effect; for instance, Agovino et al. (2018) referred to it in terms of “imitation-driven process” (p. 681) and Sabbaghi et al. (2015) included the “behavioral imitation” (p. 306) among the “mediating and moderating variables” of households’ behavior. In fact, it is quite unrealistic to conduct pro-environmental activities in a context with a limited law enforcement and a scarce sense of discipline, as clearly demonstrated in several field studies in Italy (Agovino, Ferrara, et al., 2016). Indeed, some articles describe several examples of ineffective or incomplete governmental interventions (Scafuto & La Barbera, 2016); unfortunately, this situation negatively impacts on both GenCB and PECB. The former tends to not feel responsible for not applying pro-environmental procedures in its daily living, while the latter increases its isolation and frustration in pursuing pro-environmental goals in an unfavorable context.

Nevertheless, there are some rare cases of effective national regulations and law enforcement, as demonstrated by the pro-environmental measures enforced in Singapore. As a matter of fact, Singapore represents a clear and quite unique example of successful institutional pro-environmental management through the widespread implementation of practical governmental measures, enforced at all levels at the proper time. Moreover, this solid institutional framework is reinforced by adequate informational and educational campaigns (Savage & Kong, 1993). This this context in order to understand and possibly explain the reasons for this success: some of them have focused on leadership and government, others on the peculiar Singaporean socio-cultural context, others on Singaporean citizens that are characterized by a strong sense of discipline and a peculiar environmental attitude (Fang et al., 2017; Ma et al., 2015; Savage & Kong, 1993). Most likely, these positive results are motivated by a combination of different factors, like the remarkable awareness of potential environmental problems by Singaporean governmental organizations, the strong commitment in fixing these problems through appropriate law endorsement and enforcement, the implementation of ad hoc cultural and school initiatives, and the diffusion of communitarian values through environmental campaigns. This analysis is also supported by Stearns and Montag (1975) who highlighted the importance of good leadership and governmental quality in steering the polity in order to achieve and maintain a sustainable development.

### **2.3.4. Research Question 3**

What are the factors and conditions (if any) that favor this interplay, or the shift of GenCB towards PECB?

As previously mentioned, the interplay or the shift is significantly influenced by the context, but there is also a plethora of other factors that play a key role in this relationship. In order to untangle this complex knot and better understand the influence of different factors and conditions on consumer behavior in relation to waste management, they are analyzed in the following order:

- Internal (or individual) conditions and factors
- External conditions and factors
- Collective (or socio-demographical) conditions and factors
- Institutional-legal and informational conditions and factors
- Political-ideological conditions and factors
- Economic conditions and factors
- Infrastructural-technological conditions and factors
- Contextual (or situational) conditions and factors

Ideally a deep and objective analysis of human behavior in relation to waste management requires investigating all of the above-mentioned factors and conditions (schematic classification in Appendixes A, B and full list of factors in SM online); actually, this SLR infers that the selected papers generally tend to focus on specific factors and conditions depending on the field of investigation (e.g., social psychology, economics, laws, education).

In general, although this paper does not conduct a meta-analysis of variance of factors, individual, contextual and infrastructural factors turn out to be the best predictors of PECB. In particular, these include: attitude, norms, perceived behavioral control, past behavior and self-identity among individual (or internal) factors; access to services among infrastructural factors; spillovers, proximity effects and past exposure to contamination or ecological disasters among contextual factors. These indications are also supported by the meta-analysis conducted by Geiger et al. (2019).

#### **2.3.4.1. Internal (or Individual) Conditions and Factors**

When scholars consider the individual as a complex set of rational and non-rational thinking, the analysis generally focuses on personal norms (Wang, Guo, et al., 2018), attitudes (Ertz et al., 2016), individual expectations (Piermatteo et al., 2016), intentions (Chen & Tung, 2010), motivations (Dai et al., 2015; Heller & Vatn, 2017) and emotions (Hegtvedt et al., 2019). For example, some authors further investigate the field of feelings and conducts by defining factors like anticipated regret (Graham-Rowe et al., 2015), frugality (Fujii, 2007), minimizing inconvenience (Porpino et al., 2015), lack of priority (Graham-Rowe et al., 2014), perceived seriousness of social and environmental problems (Dagher & Itani, 2014) and perceived policy effectiveness (Wan et al., 2015; L. Xu et al., 2017). These variables play a fundamental role in the interplay between PECB and GenCB because consumer behavior is less rational than expected (Ajzen, 1991). In particular, the mentioned interplay (or shift) is significantly influenced, for example, by the perceived effectiveness of environmental behavior, perceived seriousness of environmental problems, perceived environmental responsibility (Dagher & Itani, 2014), environmental knowledge (Minelgaite & Liobikiene, 2019) and trust in official information, besides the amplifying effects of media (Whitley et al., 2018). It is assumed that a diffused lack of perceived seriousness of environmental problems significantly impacts the interplay (in terms of imitation of PEB by generic consumers) in a negative direction.

Moreover, PECB is clearly affected by lifestyle (Barr & Gilg, 2006; Guo et al., 2017; Sabbaghi et al., 2015). In fact, lifestyle represents a critical element in attaining sustainable development (Guo et al., 2017); for instance, in a society where a hedonistic lifestyle is very diffused, generic consumers definitely display some sort of reluctance in adopting green behaviors, so phenomena like imitation or eco-centric behavior represent quite a rare occurrence.

Another factor that is addressed by some scholars is the stewardship of things (Lane & Watson, 2012). By utilizing the word “stewardship” of things, some authors intend to investigate the strict relation between the individual and things in terms of possession, affection and dependence. Stewardship of things becomes an enabling condition for the interplay between PECB and GenCB when it is related to the common good; in fact, it presupposes a solid type of civics, sense of education and responsibility.

On the reasoned side it is important to also consider factors like the environmental awareness or concern (Bamberg & Moser, 2007; Liu et al., 2009; Morone et al., 2018), consciousness of environmental problems (Fujii, 2006; Guerin et al., 2001), willingness to support policy (Wan et al., 2015), to pay (Caplan et al., 2002; Oliver et al., 2011; Sterner & Bartelings, 1999) and to engage in PEB (Dai et al., 2015; Kiessling et al., 2017). All are pre-conditions favoring both the mentioned interplay and the shift of GenCB towards PECB.

#### **2.3.4.2. Collective (or Socio-Demographical) Conditions and Factors**

Many scholars highlight the importance of social norms and interactions (Agovino et al., 2018; Wang, Guo, et al., 2018). Considering the range of relationships revolving around the individual is huge,

they analyze this type of interaction by selecting different layers to investigate: some focus on the sphere immediately surrounding the individual, like personal and family relationships (Jamieson, 2016); others go beyond this horizon by considering neighboring behavior (Vollmer & Gret-Regamey, 2013; Williams & Dair, 2007); while some others further expand by considering social and economic aspects, like civil involvement (Hadler & Haller, 2011), presence of pro-environmental organizations active at the local level (Guerin et al., 2001), sharing of common values among consumers (Savage & Kong, 1993), presence of activists (Scafuto & La Barbera, 2016) and environmental organizations (Agovino et al., 2018).

In general, the collective level is affected by external or stakeholders' influences (Hou et al., 2014; Wan et al., 2015) that can steer behavior in very different directions; for instance, as mentioned in the previous section, these external actors can shape or alter lifestyles.

Overall, the above-mentioned factors have a significant impact on consumer behavior, especially in the interplay between PECB and GenCB because they create a common substrate on which pro-environmental values can develop.

#### **2.3.4.3. Institutional-Legal and Informational Conditions and Factors**

The interplay between PECB and GenCB, and the mentioned shift are also positively influenced by a favorable institutional and legal framework (Dai et al., 2015; Milovantseva, 2016), sometimes referred to as institutional quality (Agovino, Ferrara, et al., 2016; Hou et al., 2014; Taberero et al., 2015).

The role of the governmental institutions, at all levels (community, municipal, provincial, regional, national and supra-national), is fundamental in promoting participation in recycling (Hansmann et al., 2006), the development of moral responsibility, the spread of environmental values and knowledge, and the dissemination of an ecological worldview (Gottlieb et al., 2013). In fact, a wide spectrum of activities can be organized by official bodies, like encouraging biodiversity (Ziari et al., 2018), sorting behavior (Kirakozian, 2016), promoting pro-environmental campaigns (Agovino et al., 2018) and creating adequate pro-environmental stimuli (Sabbaghi et al., 2015).

In relation to the legal aspects, as previously mentioned, a condition that definitely fosters PEB is represented by law enforcement measures (Barile et al., 2015; Savage & Kong, 1993), besides a well-structured legal apparatus. In fact, the effectiveness of many pro-environmental measures is related to the capability of controlling consumers' waste-related activities and promptly sanctioning those who do not respect the correct procedures. This problem has been addressed by several scholars by studying the perceived behavioral control and the attitude-behavior gap (Alwitt & Berger, 1993; Peattie, 2010; Romero et al., 2018); this gap can be reduced through law enforcement too.

In general, the application of a supportive legal and institutional framework also requires an adequate communication program, so this study points out that the diffusion of PEB is directly influenced by ad hoc informational interventions too (Agovino et al., 2018; Birau & Faure, 2018; Stockli et al., 2018).

#### **2.3.4.4. Political-Ideological Conditions and Factors**

The presence of pro-environmental movements or specific parties may influence the mentioned interplay and shift, in some cases by enforcing it, in others by rejecting an ideology because it belongs to the opposite political party. In fact, Anwar et al. (2019) observed that "different developing nations have started considering "climate change communication" as an integral part of the political campaigns and sustainable development" (p.29946). Furthermore, they highlighted the capability of political elites to mobilize a large percentage of the population and generate concern or awareness on sustainable development issues. Consequently, they include factors such as "trust in politics" and "source credibility" in their models.

Conway and Repke (2019) analyzed some experimental scenarios and measured factors like "Support for Citizen Action on Climate Change", "Contamination", "Right-Wing Authoritarianism", "Social Dominance Orientation" and voting intent for pro-environmental law. They concluded that political

pressure causes psychological contamination with the final effect of the rejection of the governmental actions created for environment preservation and recycling.

In addition to the above-mentioned factors, the environmental consumer orientation is also affected by green skepticism (Zarei & Maleki, 2018), political polarization, partisanship and ideological values (Coffey & Joseph, 2013), party orientation (Neumayer, 2004) and political trust (Zannakis et al., 2015).

#### **2.3.4.5. Economic Conditions and Factors**

The economy, from the local to the supra-national level, certainly influences PECB and its interplay with GenCB. Nowadays there are significant efforts to shift from the classic linear economic model to the “Circular Economy” in order to reduce the depletion of resources and humans’ impact on the environment (Abuabara et al., 2019; Ferronato et al., 2019; Nainggolan et al., 2019). It is clear that the single consumer has a very limited influence on the production process, but its role becomes important during the utilization of a product and its recycling; in fact, through these phases, the individual can somehow influence the production of goods or the provision of services, like in the case of the reverse green supply chain (Couto et al., 2016) or the acceptance of remanufactured goods (Smol et al., 2018). For these reasons, several researches try to understand the consumer attitude and its perception toward bio-waste product (Russo et al., 2019), public awareness towards circular economy (Guo et al., 2017; Liu et al., 2009), and socially responsible consumption (Park & Ha, 2014). In particular, Park and Ha (2014) deem that the diffusion of corporate social responsibility favors the choice of green products or services by all consumers; it follows that the diffusion of this type of responsibility should increase the interaction between pro-environmental consumers and generic ones, or the shift of the latter towards the former.

#### **2.3.4.6. Infrastructural-Technological Conditions and Factors**

The mentioned interplay and shift are definitely influenced, in general, by a favorable infrastructure made of accessible services (Agovino et al., 2018; Tonglet et al., 2004), and specifically, by the efficiency of the local waste management program. There have been many cases where the municipal solid waste has been adequately handled through an efficient municipal recycling program (Campbell et al., 2016), based on quality services, green and financial incentives (Lin Xu et al., 2017), equal sharing of the costs and benefits of recycling (Conke, 2018). In some specific situations the municipalities and the waste management companies have also been able to create opportunities for recycling (Tonglet et al., 2004) and better services (Agovino et al., 2018; Tabernero et al., 2015), favoring the real involvement of consumers in recycling programs (including the most skeptical ones). Unfortunately, there are also several cases of inefficient waste management systems (Massimiliano Agovino et al., 2019; Cembalo et al., 2019).

In this sense, the role and the conditions in which the waste management company and the local institutions operate, represent an enabling factor. For example, the shift towards a more pro-environmental behavior is fostered by maintaining a continuous presence on the ground (in order to continuously support the correct application of waste management measures), encouraging an open communication between providers and users, rewarding virtuous behaviors (Nolan, 2013), and ensuring the respect of the procedures (including a punctual system of sanctions) (Ohnuma et al., 2005).

Lastly, it is important to highlight the role of technology because the great advances in environmental engineering significantly facilitate participation in recycling programs (Mihelcic et al., 2017) and, indirectly, the mentioned interplay and shift.

#### **2.3.4.7. Contextual Conditions and Factors**

In a holistic analysis of the conditions and factors influencing consumer behavior it is mandatory to consider the contextual ones, also known as situational ones (Agovino, Crociata, et al., 2016; Agovino



et al., 2018; McCoy et al., 2018; Taberner et al., 2015), like the proximity effect (M. Agovino et al., 2019; Agovino, Crociata, et al., 2016). These conditions and factors produce significant effects on consumers' behaviors; their inclusion in pro-environmental consumer models represents a real challenge for all scholars. In fact, on the one hand, it is impossible to analyze consumer behavior without considering the context where the consumers live; on the other hand, there are no shared methodologies for accounting for the context in a standardized way. This issue is exacerbated, in some cases, by the presence of unique environmental features (Kießling et al., 2017) or environmental alterations (Da Costa Filho et al., 2017; Varotto & Spagnoli, 2017).

This study infers that situational factors and conditions definitely influence the interplay between PECB and GenCB or the related shift. For example, the presence of a landfill or an incinerator in the proximity of a town causes an enhanced pro-environmental awareness and knowledge, that, in turn, create favorable conditions for the diffusion of activities of pro-environmental associations, and greatly increases the chances of shifting GenCB towards PECB. Other examples to mention are, for instance, living in a circular city (Williams, 2019) or in the vicinity of protected areas, being a member of community gardens (Kim, 2017) or urban mines (Pierron et al., 2017), being involved with projects protecting the cultural and natural heritage (Sacco & Crociata, 2013) or living in very degraded contexts where the standard of living is completely different from advanced economies (Joshi & Seay, 2019; Singh & Raj, 2019).

#### **2.3.5. Research Question 4**

What are the main issues in the research on PECB?

First of all, it has to be clarified that the main issues referred to below are not applicable to all selected papers, although they represent recurring trends in this SLR.

A typical problem is represented by the selection of the key factors necessary to correctly frame the consumer behavior in relation to waste management. Even though scholars are fully aware of the fact that environmental attitude and PEB are the results of many influencing factors, the proposed models are likely to be either too simple (Gifford & Nilsson, 2014), or not generalizable to other situations. In fact, many scholars put a great effort in defining the factors influencing PEB without having the certainty to be able to include all of them; in some cases, they decide to focus their research on very specific aspects of consumer behavior, often context dependent. Although Gifford and Nilsson (2014) individuate an ample and very comprehensive classification made of 18 categories of personal and social factors, many scholars agreed with them when they inferred that “attempting to fully account for variation in environmental concern and pro-environmental behaviour is a seriously complex enterprise” (Gifford & Nilsson, 2014). This leads to the observation that several authors often wrongly assume they are able to include the main influencing factors in their research. At the same time, when scholars champion what they believe to be the most suitable model for describing PEB in a specific context, that model is subjected to the risk of failing when applied to a different context because it lacks the capability of generalization. In addition, the dynamics of contexts further complicate the investigations conducted by scholars (Peattie, 2010).

In addition to the context-dependency of many researches, a recurring critical aspect is the heterogeneity of consumers and recycling situations. While this issue is generally not so evident when investigating defined samples of the population (e.g., university students) or specific activities (e.g., coffee cup disposal in a cafeteria), it becomes more evident in analysis at the national or supra-national level, especially in the case of comparative studies. In these cases, it is more challenging to test the validity of the proposed theory or model; from another standpoint, the heterogeneity of the sample contributes to the generalization and validation of the model.

In addition, the behavioral analysis is further complicated by the behavioral instability of the individual. In fact, as stated by Peattie (2010) “even the greenest of consumers are likely to have types of behavior they treat as exceptions” (p. 215). For example, McDonald and Oke (2018) investigated the differences in behavior (at times, paradoxical too) between the workplace and home,

demonstrating the complex decision-making process of the consumer in the case of changing values, competing priorities and uncontrollable emotions.

A big debate involves the definition of the ideal relationship (e.g., linear/non-linear) among the factors utilized for describing PECB. For instance, it is very difficult to define how the cultural level (Culiberg, 2014; Markle, 2014) or the income of investigated people impact PEB (Hong et al., 1993); in this sense, there is a general tendency, typically in the non-social sciences, to assume a direct relation between these factors, thinking, for instance, that a high cultural level corresponds to an increased sensitivity in sustainable development (Crociata et al., 2015). Actually, real life examples demonstrate that in some cases high education levels or incomes do not necessarily mean a high environmental awareness or a better recycling behavior (Dunlap & Mertig, 1995); for these reasons, some authors assume that this direct relation takes place in specific cases only, like for transformative learning (Marschke & Sinclair, 2009) or in developing nations that just started dealing with environmental issues (Bronfman et al., 2015; Wesley Schultz & Zelezny, 1999).

Most likely, there is a great variety of influencing levels or interconnecting functions among these factors, especially because “many of the factors influence each other through moderation or mediation”, as stated by Gifford and Nilsson (2014); for example, in some cases, the effects of a X factor exclude the effects of a Y factor in a specific context, whereas in another context, or if the factor is considered in isolation, the effects of Y are tangible.

Another recurring critical aspect is related to the fact that many scholars automatically assume that the reported behaviors are in truth the actual behaviors; consequently, many researchers think they are assessing actual behavior while actually they are examining the reported behavior. By doing so, they underestimate the bias in human behavior when answering a questionnaire or a semi-structured/structured interview. Gifford and Nilsson (2014) deemed that this assumption could be quite inaccurate because, considering an increasing share of the population is in favor of protecting the environment, they inferred that “reported behaviour may reflect social desirability as a bias, or reports that are sincere but flawed by memory errors” (p. 151). On the other hand, the manifest impossibility of directly measuring actual behavior leads several scholars to this assumption, that nevertheless, requires a correct definition of the research methodology and related limitations.

In general, this SLR leads to the conclusion that a diffused limitation of the research on PECB is the incapability (or unfeasibility) of defining a holistic framework applicable to different contexts and encompassing, at the same time, variables related to different fields like economics, laws, marketing, sociology, psychology, ecology, biology, energy management, infrastructure and logistics.

## **2.4. Overall Analysis and Discussion of Results**

Concerning the meta-data analysis of selected papers, this SLR provides a clear indication of an increased interest in the subject of investigation in the last decade; this trend is definitely applicable to North America, Europe and a part of Asia. In terms of single countries, the mere analysis of the number of articles highlights the consistent production by nations like USA, United Kingdom, China and Italy. However, after weighing this data with the number of national inhabitants (Figure 31 and Figure 32 in Appendix A), this study provides a more correct interpretation of the phenomenon, so the nations with 10 or more articles per 10 million inhabitants become Lithuania, Denmark, Portugal and Slovenia (noticing that this value is significant only when the country has a substantial number of articles).

Unfortunately, the lack of articles written in English in some areas of the globe does not provide adequate information on other nations and continents; consequently, it does not allow to fully generalize this SLR’s results to the rest of the world. It is also important to note that, in this specific interdisciplinary investigation topic, the limited number of peer-reviewed articles on PECB for some advanced economies does not necessarily imply that these nations are not sensitive to environmental issues, like in the case of Singapore, the Netherlands, Denmark, Norway and Switzerland.

In terms of comparative analysis, the research on PECB in relation to waste management does not normally take advantage of the collation of different national perspectives. In fact, in limited cases only, do scholars investigate the differences among nations (Blöse et al., 2019; Ferronato et al., 2019), whereas this approach could bring new insights to the topic of this SLR.

The analysis of the selected articles also indicates a predominant focus on specific types of waste like household food, electrical and electronic equipment, urban and municipal solid waste. Consequently, the investigations conducted by the scholars generally take place in residential and municipal areas, households, schools, universities, and in some cases, shopping areas and cafeterias; it follows the main focus on family, household and student behavior, besides electronic and green consumers.

Normally, the source of data is represented by ad hoc or online questionnaires, and guided interviews; however, the utilization of existing databases (produced by official polls by governmental organizations or national statistic institutes) is quite common too. In the latter case, the area of investigation tends to expand at the regional or national level; moreover, there is an improvement of sample consistency, which favors more robust analysis and less context-dependent deductions.

In relation to the scientific journals in which this SLR's papers have been published, this study shows a predominance of environmental or socio-psychological journals, like "Environment and Behavior", "Resources, Conservation and Recycling", "Journal of Cleaner Production", "Journal of Environmental Psychology" and "Waste Management". Apart from these publications, some papers are available in journals about marketing, economy, education and geography, but the limited number of manuscripts indicates that pro-environmental issues are not a common topic in such journals.

In terms of contents, this SLR highlights a diffused commitment among scholars in understanding and accounting for the influence of the huge plethora of factors affecting consumer behavior with the intent of applying a multi-disciplinary approach. Among these efforts, it is worth mentioning that Zhang et al. (2011) proposed a model based on a complete analysis of possible influences spanning from political factors to environmental ones, including economic, social, technological and legal factors.

The complexities and difficulties in discovering and explaining the interconnections among these factors are demonstrated by the heterogeneous approaches adopted by subject matter experts for the sake of defining the most holistic framework. In fact, in some cases, the outcomes are characterized by a predominant focus on socio-economical aspects, while in others they are focused on social psychology, management, public policy or law. Overall, considering the field of investigation of this SLR is related to human behavior and the understanding of its antecedents, the predominant approach is socio psychological.

For this reason, this review shows a common trend whereby the focus defaults to attitudes, norms, intentions, emotions and conceptualization of the attitude-behavior gap (Romero et al., 2018) or the intention-behavior gap (Echegaray & Hansstein, 2017), emphasizing the idea that human actions are always somehow different from the planned course of action, besides being strongly influenced by the context. The theoretical framework underlying this approach is mainly based on the works of Ajzen and Fishbein (Ajzen, 1980; Ajzen & Fishbein, 1970; Fishbein & Ajzen, 1977) and Schwartz (1977), namely the TRA and the TPB for the former, and the NAM theory for the latter. The Value-Belief-Norm theory proposed by Stern (2000) could be considered an evolution of the NAM theory because it includes some key factors, like awareness of consequences, ascription of responsibilities and personal norms, already addressed by the former theory.

The detailed analysis of the theoretical frameworks indicates that the TPB is definitely the most utilized. Although its definition dates back to 1991 (Ajzen, 1991), many scholars affirm that the TPB still represents a valid framework to understand human behavior, and an adequate mean to set up intervention measures. Furthermore, some authors created their own models by expanding the original TPB (also known as the "extended TPB models") in order to include all the factors applicable to the specific context of investigation. For this reason, they further break down typical factors considered in the TPB, like attitude, subjective norms and perceived behavioral control, with the intention of catching further sides of human behavior. Just to name some examples, Taylor and Todd



(Taylor & Todd, 1995a, 1995b) proposed the integrated waste management model, characterized by the subdivision of the three mentioned basic factors into smaller components: attitude is divided into personal relative advantages, social relative advantages and complexity; subjective norms are divided into internal normative beliefs and external normative beliefs; and perceived behavioral control is divided into self-efficacy and facilitating conditions. Ulhasanah and Goto (2018) also divided intention into separation intention and feeling intention.

Other theoretical frameworks are also quite diffused, like the NAM and the VBN theory; however, there is no consensus on the ideal theory or model to apply, especially in the light of the heterogeneity of contexts, backgrounds, samples and research aims. In fact, this SLR highlights that the concept of PECB and GenCB are differently framed depending on the type of approach utilized by the scholar; for instance, studies on GenCB are mainly focused on economic or marketing aspects, while the ones on PECB generally encompass sustainable development, ecology and other related fields. Nevertheless, in recent years, some scholars have tried to conduct more holistic analyses of consumer behavior through the inclusion of economic, legal or institutional aspects with encouraging results. For example, Ulhasanah and Goto (2018) defined a predictive model based on the TPB with the addition of some specific factors like the role of government and law enforcement. Their model is applied to the behaviors of the Indonesian citizens of Pandang city in relation to municipal solid waste management, in order to understand the factors influencing citizens' behaviors and acceptance of a new waste management system. At the end of their study, the authors argued that the roles of the local government and law enforcement are very important for improving the citizens environmental knowledge and determining the acceptance of the new system.

This SLR also highlights how contested is the definition of factors influencing PECB. In addition to the classic socio-economic and demographical factors, like income, gender, age, social class, lifestyle, education and economic convenience, there are typical socio-psychological variables, like social and personal norms, personality, perceptions, motivations, willingness and sense of responsibility. In any case, the above-mentioned factors are not sufficient to fully understand the complexity of PECB. In fact, as previously explained, it is essential to consider situational factors because, for instance, the presence of an incinerator in the area of investigation or other proximity effects (M. Agovino et al., 2019) directly influence local inhabitants' behavior, their sensitivity and knowledge on environmental issues, regardless of their income, class or education (Agovino, Crociata, et al., 2016). Socio-cultural or political factors could also affect PECB, like the presence of activists or environmental organizations (Jaca et al., 2018), the diffusion of a specific ideology or the trust in politics (Anwar et al., 2019). Moreover, PECB is not only determined by local factors like physical geography and spatial constraints (Savage & Kong, 1993), it also depends on the quality of the institutional-legal framework and the level of law enforcement, as demonstrated by Savage and Kong (1993) who evaluated leadership and institutional culture in Singapore, or Lin Xu et al. (2017) who adopted government-related factors.

These examples clearly indicate how complex the analysis of consumer behavior is in the specific field of waste management, and the challenges associated with classification of heterogeneous factors. Consequently, besides expanding and combining theoretical models, scholars also proposed different approaches and categorizations to extricate themselves in this intricate situation. For instance, several authors opted for the classification of factors in two main categories: internal (or personal) and external (Kollmuss & Agyeman, 2002); the latter are divided into cultural, organizational and infrastructural (Middlemiss, 2010), or institutional, economic, social and cultural (Kollmuss & Agyeman, 2002) depending on the type of approach. Hence, to correctly frame the analysis of PECB, this SLR offers an ample classification of these factors in Appendixes A, B and SM online.

This SLR also addresses a quite underestimated aspect of consumer behavior: the interplay between PECB and GenCB, and the shift of GenCB towards PECB. In fact, the reciprocal influence of one type of consumer on the other and vice versa contributes to the enhanced understanding of human behavior; unfortunately, this interaction is quite limited and strongly influenced by the context. Just

to mention an example of the factors influencing this interplay, the legal framework represents a favorable condition for improving the environmental sensitivity of consumer behavior and, in turn, the interplay between PECB and GenCB.

This SLR presents some limitations. In addition to the previously mentioned exclusion of papers not written in English and the consequent loss of potentially relevant literature in other languages, the search is conducted in Web of Science, Science Direct and EBSCO, without the inclusion of grey literature and other databases; consequently, future studies may consider expanding the collection of manuscripts to other databases. Nevertheless, the robust body of primary literature offers a wide and trustworthy data set, allowing to identify the majority of factors and conditions influencing PECB and its interrelation with GenCB, apart from the current gaps in literature. Another limitation is the level of definition of the search query that, although quite expanded and detailed, cannot guarantee the inclusion of all applicable papers because of the existence of synonyms, acronyms and words with different interpretations. Moreover, as stated in Section 2.1.3, this SLR does not analyze the behavior of minors and their education, workplaces and sales practices; in the latter case, the study of the purchase phase would allow to further understand the impact of consumer behavior on waste management during the selection of the good and its acquisition. In fact, the reduction of waste starts from the knowledge of the product and the selection of low-impact packaging (with the support of adequate education and information campaigns). Lastly, although all papers are rigorously selected through specific inclusion/exclusion criteria and an extraction protocol, the literature has not been quality assessed and the inferences of authors are potentially subject to biases, also considering the investigation of very different fields.

## 2.5. Conclusions

This SLR, besides providing a valuable summary of the academic literature on a complex and interdisciplinary topic, addresses different perspectives on adult consumer behavior in relation to waste management, highlighting relevant issues, and offering a possible classification of the myriad of factors and conditions influencing PECB. Moreover, through the selection of ad hoc research questions, it provides valuable insights into the conceptual framework and the interplay between PECB and GenCB, an aspect underestimated in academic research.

This study is also beneficial to scholars (with background not rooted in social psychology) who decide to investigate or understand consumer behavior in relation to waste management. They may overcome the difficulties in determining the key factors defining consumer behavior by referring to our analysis of conditions and factors. In fact, nowadays, research on marketing of consumer products, or the production of a good for the consumer market, cannot ignore the analysis of related waste and its impact on consumer behavior. In these cases, the proposed classification of factors and the ample framing of available behavioral theories and models may help researchers in setting up their studies in the most convenient way to catch the hidden mechanisms and peculiarities of human behavior. Moreover, scholars may find some useful examples of integration of behavioral theories, which offer the possibility of further understanding recycling behavior.

This SLR also highlights several limitations of current research on PECB about waste management and offers some possible solutions. First of all, this review recognizes how, in the latter years, studies on consumer behaviors have broadened their research horizons (compared to some twenty or thirty years ago) by including new factors and attempting to correlate them although they belong to different fields (Danish et al., 2019). Nevertheless, the call for deeper and cross-boundary investigations remain topical, keeping in mind that the final goal is to understand and, hopefully, improve human behavior. In this sense, the academic research should expand its intervention studies from typical areas like universities and neighborhoods, to wider sectors of the population; moreover, it should foster a more holistic framework and comparative analysis. In fact, the real challenge for scholars conducting research on consumer behavior is to investigate the real world for possible similarities among different populations, and generalize theories and models currently confined in specific fields.

In any case, the research should not forget to analyze the effectiveness of the intervention measures adopted by governments and institutions through ad hoc experimental studies, in order to evaluate and promote more responsible and respectful behaviors. In fact, traditionally, academia plays the role of testing procedures, new materials or products through robust and reproducible methodologies, leading their application in the real world on a larger scale.

In addition, this SLR shows that a very contested area is represented by the capability of accounting for all applicable factors when trying to understand and interpret human behavior: the interaction between reasoned aspects and non-reasoned ones is very complex, and it often reveals unexpected relations and motivations. At the same time, the analysis of human behavior is inseparable from the investigation of the context in which the individual lives and interacts. It follows the need to persevere in the interdisciplinary approach in order to unveil as much as possible these hidden mechanisms influencing human behavior. For these reasons, all theories and models need to undergo a continuous testing in heterogeneous sectors to prove their strength, robustness and universality.

This SLR also reveals that in several researches there is a predominance of a specific approach (e.g., sociological, psychological, environmental, legal), normally influenced (and limited) by the authors' background; for example, studies focusing on socio-psychological factors have shown a partial or inexistent interest for infrastructural and legal issues, which could clearly help in explaining some aspects of human behavior under specific conditions. Similarly, economic studies tend to consider the individual as a rational actor maximizing his/her profit or interest. In general, the analysis of human behavior is influenced and biased by the different sectorial perspective adopted by the scholar. Consequently, the capability of accounting for all applicable factors remains the key for the success of the proposed models.

This critical aspect leads to the need to create a real interdisciplinary research team when analyzing human behavior and its impact on other people or the surrounding environment. A wide-open approach on social, economic, psychological, legal, institutional, political, infrastructural and technological issues would definitely favor the correct analysis of PECB, its interplay with GenCB, and a deeper understanding of the factors characterizing this interplay.

At the same time, another concomitant challenge is represented by the definition of the right level of granularity (e.g., micro versus macro scale). In fact, an excessive level of details inevitably leads to the risk of focusing on specific sectors (like psychology, marketing, laws), whereas a generic model, although being more applicable to different contexts, does not allow to shine a light on the nuance of human behavior.

**Supplementary Materials:** The following is available online at <http://www.mdpi.com/2071-1050/12/11/4452/s1> or refer to Appendixes A and B of this thesis. Excel spreadsheet including data extraction table (Tab 4) and further tables and figures in tabs 1–14.

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## **Chapter 3: Recycling Behavior: Mapping Knowledge Domain through Bibliometrics and Text Mining**

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## **Abstract**

In recent years, the research on human behavior in relation to waste management has increased at an exponential rate. At the same time, the expanding academic literature on this topic makes it more difficult to understand the main areas of interest, the leading institutions and authors, the possible interconnections among different disciplines, and the gaps. This paper maps knowledge domain on recycling behavior through bibliometric analysis and text mining in order to identify current trends, research networks and hot topics. 2061 articles between 1975 and 2020 from three different databases are examined with an interdisciplinary approach.

The findings reveal that 60% of papers have been published between 2015 and 2020, and this topic is of global interest. Leading countries are mainly located in Europe, North America and Commonwealth; however, China and Malaysia are also assuming a driving role. Bibliometrics and text mining provide the intellectual configuration of the knowledge on recycling behavior; co-word analysis individuates conceptual sub-domains in food waste, determinants of recycling behavior, waste management system, waste electrical and electronic equipment (WEEE), higher-level education, plastic bags, and local government. Overall, waste management and related human behavior represent a universal challenge requiring a structured and interdisciplinary approach at all levels (individual, institutions, industry, academia). Lastly, this paper offers some suggestions for future research such as smart city design, sensor network system, consumer responsabilization, the adoption of a more comprehensive view of the areas of investigation through the holistic analysis of all stakeholders.

## **Keywords**

Recycling behavior; mapping knowledge domain (MKD); bibliometric analysis; systematic literature review (SLR); waste management; text mining

### 3.1. Introduction

Recycling behavior constitutes an important area of investigation in numerous disciplines and remains highly topical for several reasons including the depletion of natural resources, the challenges in correctly handling waste, the complexity of human behavior, and the influence of media. This behavior is analyzed from different perspectives like the points of view of consumers, producers, retailers, service providers, organizations and public administrations. The consumer and household contributions to recycling activities, although apparently intangible, is actually significant; in fact, Tseng et al. (2018) infer that “human behavior is a strategic domain because of the enduring effects of both poor and good recycling habits” (p. 367). Moreover, the success of governmental measures for waste reduction is highly dependent on consumer behavior.

In particular, the research about recycling behavior continually attracts the attention of numerous practitioners, scholars, officials, managers, politicians, law makers, psychologists, sociologists, etc. This type of research ranges from the economic aspects to the ecological implications, from marketing to psychological studies, thus providing a “branch of alternative research and an opportunity for a complementary investigation” (Concari et al., 2020, p. 1). At the same time, the expanding academic literature on this topic makes it harder to understand the main areas of interests, the leading institutions and authors, possible interconnections among different disciplines, and the gaps too.

In this respect, mapping the knowledge domain through a bibliometric analysis of the academic literature definitely helps in identifying current trends, research networks and relevant topics, especially considering that papers on recycling behavior keep growing at an exponential rate (Concari et al., 2020). Therefore, studies conducted a couple of years ago may not be able to capture new threads or recent collaborative networks. Although bibliometric analyses are based on quantitative and rigorous approaches, they can improve the findings of a systematic literature review (SLR) by further analyzing the literature characteristics on a specific topic. Furthermore, they are valuable tools to assess the performances of institutions, journals or scholars. If supported by a solid text mining, they can also offer new insights on the field of investigation.

This paper analyses recycling behavior with an interdisciplinary approach through the utilization of different databases in order to find possible interconnections among apparently different fields. In fact, although some authors have performed bibliometric analysis on waste management behavior in recent years, the focus is on specific aspects or sectors like sustainable food research (Popescu et al., 2019), socially responsible consumer behavior (Nova-Reyes et al., 2020), waste electrical and electronic equipment (WEEE) (L. M. Zhang et al., 2019), the application of a behavioral theory (Si et al., 2019), environmental economics (Ma & Stern, 2006). In other cases, the area of investigation is very generic and goes beyond waste management; for example, the study of sustainable behavior (Wang et al., 2019) involves different pro-environmental activities like energy saving, transportation, besides waste management. Moreover, several bibliometric analyses extract their papers from a single database (X. Li et al., 2019; Phulwani et al., 2020) or a single journal (Wang et al., 2019), therefore they may lack some important information from other sources. This paper follows the need to fill these gaps by mapping knowledge domain and creating opportunities for new research lines; therefore, it offers a clear and updated framework on the research on recycling behavior to scholars, especially considering the exponential growth of the academic literature on this topic. More specifically, it highlights the temporal and spatial distribution of the academic production on recycling behavior through a wide-open approach; it indicates the most influential authors and journals; it reveals the conceptual structure of the knowledge on recycling behavior through mapping knowledge domain (MKD). Moreover, it explains the interdisciplinary nature of recycling behavior, and it highlights some challenges and techniques for an effective text mining. Lastly, this manuscript, while providing a significant contribution to the analysis of the studies on recycling behavior, offers some quite unexplored strands for future research.

This paper is divided into six sections and integrated by supplementary material (SM). The next section defines the conceptual framework; the following sections explain how data have been

collected and analyzed. The results are discussed in the fifth section; also, future challenges and gaps are identified. The last section draws some conclusions.

### 3.2. Literature review

The research on recycling behavior dates back to the 1970s. Some authors as Webster (1975) consider this behavior as a part of the wider socially conscious behavior or ecologically conscious behavior; others as Betts (1973) analyze the recycling activities and their implications on the overall depletion of resources. In particular, Betts applies a systemic conceptual view of the recycling problem by breaking it down into three systems: production-consumption, material-energy, disposal. Consequently, he identifies economic, technological and behavioral factors.

In general, the literature review of recycling behavior shows that, since the earliest stages, most of the authors have focused directly on the socio-psychological aspects of this behavior and on specific types of waste like food (Arbuthnot & Lingg, 1975) and newspapers (Reid et al., 1976). In fact, acknowledging that the research on recycling behavior is highly influenced by the scholar's background, in the 1970s, 1980s, 1990s, it is deeply rooted in social psychology; moreover, the studies are characterized by a limited interdisciplinarity. Arbuthnot (1977) and de Young (1986) analyze attitudinal and personality variables, awareness and intention; Oskamp (1983) highlights the role of psychologists and other social analysts in helping the conversion to a more sustainable world. The academic research in the 1990s is led by Oskamp et al. (1991), de Young (1986), McCarty and Shrum (1994), Thøgersen (1999), Schultz (1995), Stern et al. (1995), who focus on attitude change, interventions, norms, perceptions, beliefs, expected utility, education, and public participation. The study of the determinants of recycling behavior are mainly based on Ajzen (1980)'s theory of reasoned action (TRA) and the subsequent theory of planned behavior (Ajzen, 1991); nevertheless, other scholars apply Schwartz (1977)'s Norm Activation Model (NAM) and Stern (1999)'s Value Belief Norms (VBN) model. In the previous millennium the leading journal is *Environment and Behavior*, followed by other sources from the psychological and marketing fields like the *Journal of Applied Social Psychology*, *Advances in Consumer Research*, *Psychology and Marketing*, *Journal of Environmental Psychology*. The analysis of recycling behavior takes mainly place at the household level (Oskamp et al., 1998; Taylor & Todd, 1995a) and in universities (Ludwig et al., 1998). Overall, until the mid-1990s, the academic research is mainly centered in the UK and the USA.

In the third millennium new aspects of recycling behavior emerge, like the effects of media on recycling behavior, WEEE, circular economy (CE), life cycle assessment (LCA). These topics indicate, on the one hand, the specific focus on new types of waste, and on the other hand, the application of a more interdisciplinary approach to waste management. In the former, scholars analyze mobiles, batteries and plastic packaging, whereas in the latter, waste management is considered in terms of strategy, extended producer responsibility (Sun et al., 2015), "food loss and waste" management and greenhouse gas emissions (Aldaco et al., 2020), supply chain (Wohner et al., 2019), product stewardship schemes (Blake et al., 2019), etc. In particular, Suckling and Lee (2017) try to integrate the environmental and social aspects in LCA; Wohner et al. (2019) investigate the environmental impact of product packaging. In several cases, the conceptual framework expands from the socio-psychological field to the economic and institutional sector; for example, Turaga et al. (2019) introduce the concept of "producer responsibility organizations" to make the producer more responsible for its environmental impact, through the involvement of Government and technology.

In this context, the application of bibliometric methods and mapping knowledge domain represents quite a recent approach; in fact, the bibliometric analysis on environmental behavior has mainly occurred in the last five years. In some cases, bibliometric articles focus on a specific database or journal (Wang et al., 2019), in others on the application of a specific theory, like Si et al. (2019) applying TPB to environmental science. In general, scholars apply bibliometrics to specific types of waste or sectors; in the former case, they study food waste (Popescu et al., 2019) or WEEE (L. M.



Zhang et al., 2019); in the latter, they analyze reverse logistics for end-of-life products (Campos et al., 2017), and circular economy applied to municipal solid waste (Tsai et al., 2020).

Despite the limited timeframe, the application of bibliometric techniques and MKD have already proven to be successful in providing useful insights in the field of sustainable development (X. Li et al., 2019; Phulwani et al., 2020; Si et al., 2019). For example, Nova-Reyes et al. (2020) investigate the intellectual structure of socially responsible consumer behavior (SRCB) and they find that in the last few years, SRCB has developed as a separate topic, no longer addressed through corporate social responsibility, as in the past.

Overall, in the field of recycling behavior, the predominant approach is grounded in sociology and psychology. Scholars often apply Ajzen, Schwartz and Stern's behavioral theories and models to better understand and predict human behavior. This qualitative approach is integrated by quantitative analyses like SLRs, bibliometrics and, recently, MKD, which offer the possibility of showing trends and gaps, leading authors and organizations, and potential areas for future research, thus complementing field studies and meta-analyses.

### **3.2.1. Research Questions**

This paper provides some useful insights on human behavior in relation to waste management by addressing three research questions as follows:

1. How is the analysis of recycling behavior evolving?
2. What is the intellectual configuration of the knowledge on recycling behavior?
3. What are the main areas of interest and the possible gaps in the literature about recycling behavior?

The first research question aims at defining the volume and the geographical distribution of papers on recycling behavior throughout the years; moreover, it intends to highlight possible trends in terms of growth, and leading countries or journals Udomsap and Hallinger (2020). The second question aims at individuating the scholars and the papers which have emerged in this field and influenced the research on recycling behavior by discovering their nature, relevance and evolution; in practical terms, it defines their impact on the academic literature through conceptual mapping. The third question highlights the topics getting more attention among scholars, and the sectors less investigated, in order to suggest areas of future investigation.

## **3.3. Methods and Data**

### **3.3.1. Methodology**

A typical bibliometric analysis is applied to the selected data in order to answer the research questions focusing on the evolution of recycling behavior, its intellectual configuration, trends and gaps through an interdisciplinary approach.

The selection of an appropriate database represents an important aspect and it is still a debated point (Mongeon & Paul-Hus, 2016). Large databases are traditionally used (e.g., Scopus, Emerald, Web of Science, ACM, IEEE) (da Silva et al., 2012), but there is no consensus on the most adequate. In any case, Boyack and Klavans (2010) infer that a "high coverage is necessary to allow for accurate portfolio analysis" (p. 2402), therefore this paper adopts three databases (Web of Science, Scopus, EBSCO), especially considering that these databases include different scientific journals and focus on non-identical geographic areas (Biesbroek et al., 2013). Moreover, it adopts a broad scope of papers categories because it aims at an interdisciplinary understanding of adult recycling behavior (with the exclusion of some specific situations or activities like handling of hazardous waste, nuclear sites, national parks, industrial processes, as specified in SM). Consequently, all disciplines somehow involved with human behavior are investigated; thus, besides psychology, education, and sociology, this study also analyses papers from fields such as engineering, economics, law, marketing, nutrition.

In terms of procedural steps, this paper is based on a collection phase, followed by an analytical phase aiming at MKD, also known as science mapping analysis (Cobo et al., 2011), through bibliometrics and text mining.



The collection phase applies the systematic review methodology (Petticrew & Roberts, 2006) to reduce research biases and prevent loss of essential information; it adopts the “Preferred Reporting Items for Systematic Reviews and Meta-Analyses” (PRISMA) methodology (Liberati et al., 2009; Moher et al., 2009), in order to apply a rigorous and reproducible approach for collecting papers (SM).

In this paper, the initial steps suggested by Petticrew and Roberts (2006) for SLRs are performed before executing the typical bibliometric analysis: after the definition of the research questions and the selection of the necessary studies (to answer the research questions), the papers are searched through an ad hoc search query, then they are selected according to the inclusion and exclusion criteria based on topic, time, type of papers, language (SM). In the case of a SLR, this collection phase is normally followed by the appraisal of the included studies; in this paper it actually sets up the subsequent knowledge mapping through bibliometric analysis and text mining.

A rigorous collection phase definitely influences the quality of the data and lays the groundwork for the subsequent analysis. As clearly described by de Carvalho et al. (2020) and Nobre and Tavares (2017), the proper selection of the keywords to utilize for the search query is an important step for the correct analysis of the selected topic. Actually, this aspect is often underestimated in several SLRs and bibliometric analysis, although it contributes to a more rigorous investigation. This paper has applied several iterations of key term list identification to define a solid selection query made of terms related to waste management and recycling behavior (SM).

According to Cobo et al. (2011), science mapping analysis is generally organized as follows:

- Data retrieval
- Preprocessing
- Network extraction
- Normalization
- Mapping
- Analysis
- Visualization
- Interpretation

Data retrieval is based on the initial steps of the SLR; the preprocessing step aims at making the data ready for the subsequent analysis by detecting and removing duplicates (SLR performs this activity too), or correcting errors like a misspelled author’s name or journal title. Network extraction selects the data depending on the unit of analysis (e.g., author, keyword, journal) through citation, co-citation, bibliographic coupling (SM). The normalization step takes place after the definition of the network; it is a mathematical process which applies similarity measures (e.g., Jaccard’s index) to the relations (also known as edges) between the nodes (Cobo et al., 2011). The analysis phase applies specific techniques to the previously created map in order to perform a network, temporal or geospatial analysis. The visualization phase applies different techniques to better understand and interpret the output. Lastly, the analyst has to interpret these maps to extract useful and actionable information to support the managerial decision-making process or to guide future research.

### **3.3.2. Data Collection**

The data extraction initially selected 15315 papers from Web of Science, 4366 from Science Direct and 1491 from EBSCO. After applying the category exclusion criteria, merging these papers and removing duplicates (please note that EBSCO automatically removes duplicates), 6857 papers constitute the primary body of literature. After revision of titles, abstracts and keywords, the body reduces to 2106 papers; the subsequent check of the texts brings down the body to 2061 papers (Figure 10), based on the PRISMA flow diagram) (Liberati et al., 2009).

In relation to the selection of an appropriate analytical tool, several software applications are available on the market, namely CiteSpace, Vantage Point, IN-SPIRE, VOSviewer, SciMAT (Cobo et al., 2011, 2012). The selection of VOSviewer is due to several reasons, for instance the utilization of a friendly user visualization platform, and the harmonization of “mapping and clustering of bibliometric networks” (Waltman et al., 2010) thanks to a very efficient user-graphic interface (Cobo

et al., 2011). Also, the selection of SciMAT offers the possibility to analyze the evolution of the clusters of research through the years thanks to the strategic diagram and the cluster network, besides the overlapping and evolution maps.

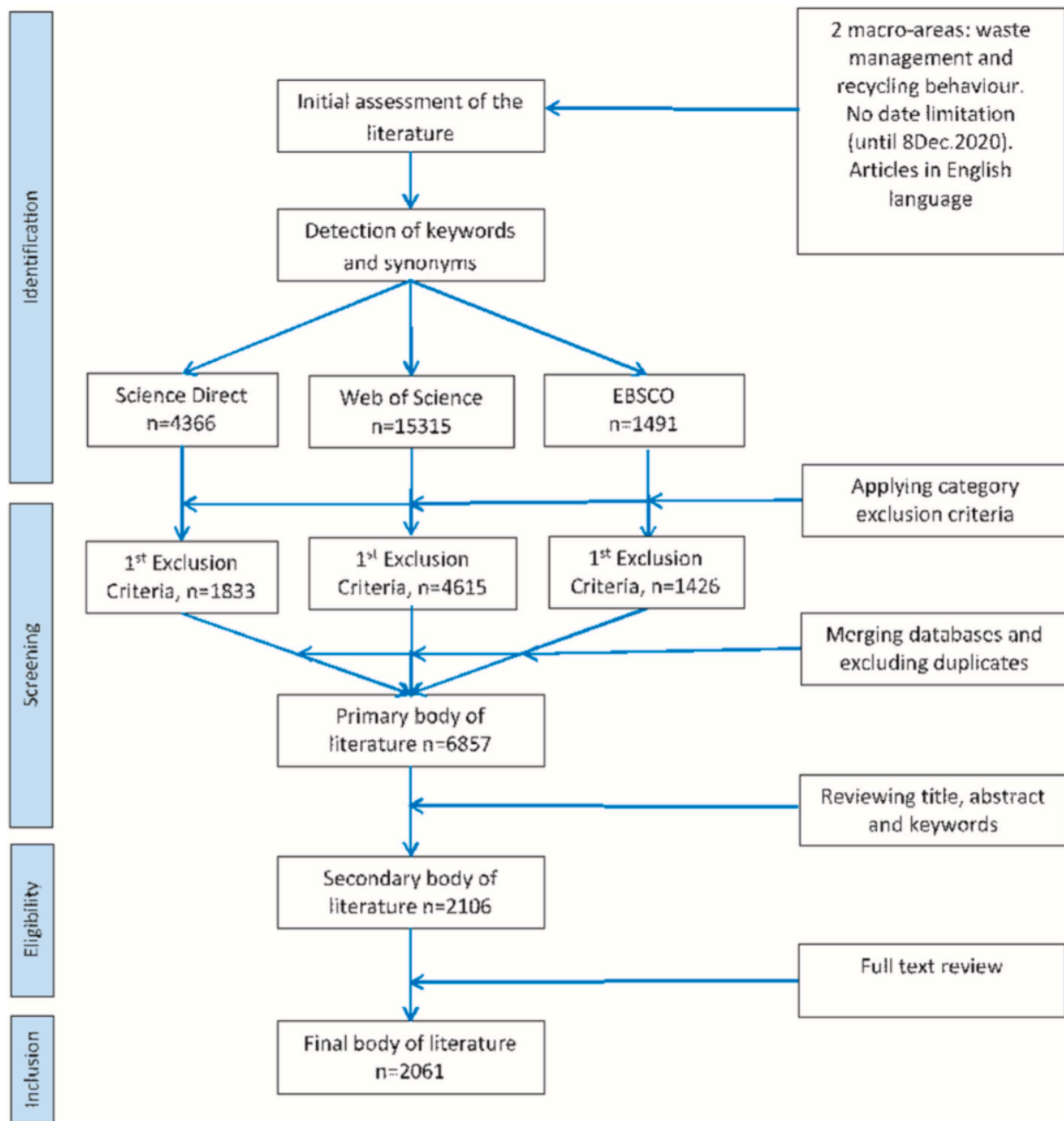


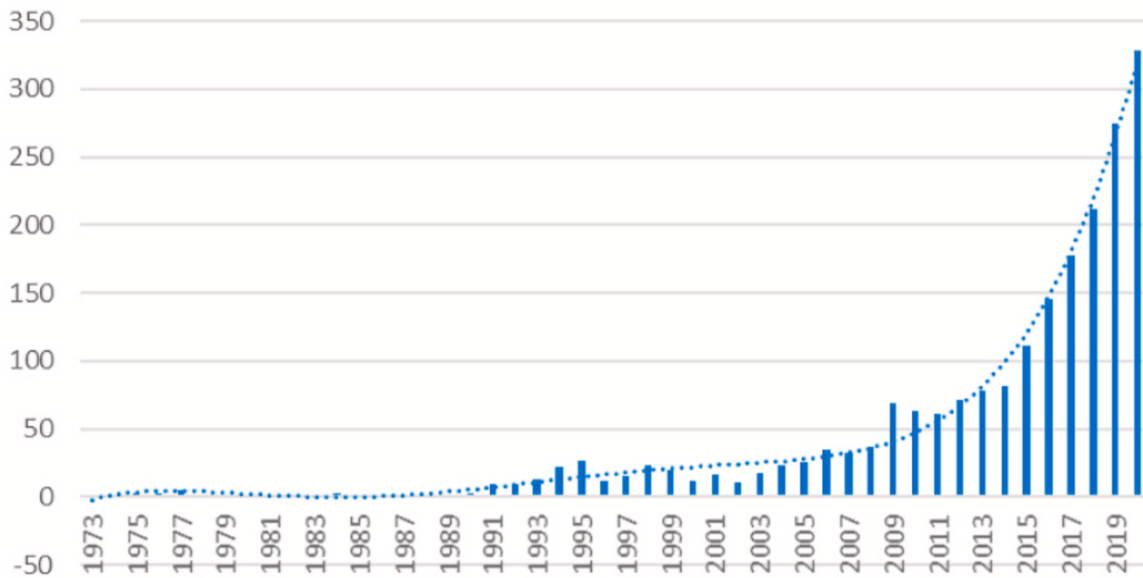
Figure 10. Data collection process.

### 3.4. Results

#### 3.4.1. Research Question 1

Descriptive statistics show the dimension of the phenomenon in terms of number of papers, their growth trajectory and the geographical distribution of authors (Udomsap & Hallinger, 2020). The analysis of the number of papers per year shows a tangible production of academic articles in the 1990s, followed by a quite steady increase in the last two decades, and an exponential growth in the last five years (Figure 11 and SM). The interest on recycling behavior in the 1990s is also influenced by the development of pro-environmental sensitivity at a world-wide level, thanks to several international events organized by the United Nations, such as the Earth Summit in Brazil in 1992,

and the signature of international agreements, like the “Agenda 21”, the convention on biological diversity (Concari et al., 2020). In 2000 the United Nations adopt the Millennium Declaration leading to the “Millennium Development Goals” (succeeded by the “Sustainable Development Goals” in 2016). Subsequently, numerous international organizations endorse the “Earth Charter”; at the same time, the European Union enforces new rules for waste management at the National level, thus contributing to development of environmental studies. Furthermore, the evident consequences of intense and nefarious human activities, like heavy pollution, resource depletion, and loss of biodiversity favor the development of deeper analysis of the human impact on the environment.



**Figure 11.** Number of papers per year with trend polynomial dotted line.

Overall, the analysis of the primary sources indicates a predominance of environmental and social sciences (Table 3). The first five journals account for approximately 35% of the selected papers, whereas the remaining papers are distributed among more than 100 journals, indicating that recycling behavior represents a topic of interest for many other journals. The most productive journal in relation to recycling behavior is *Resource, Conservation and Recycling* with 217 articles, contributing 10.53% to the selected literature; the second one is *Waste Management* with 157 articles, representing 7.62%; the third one is the *Journal of Cleaner Production* with 156 articles, contributing to 7.57% of the selected papers; the fourth one is *Sustainability* with 112 articles, representing 5.43%; the fifth one is *Environment and Behavior* with 87 articles, contributing 4.22%.

**Table 3.** Primary source journals.

Rank	Journal	No. of Articles	Percentage
1	Resources, Conservation and Recycling	217	10.53
2	Waste Management	157	7.62
3	Journal of Cleaner Production	156	7.57
4	Sustainability	112	5.43
5	Environment and Behavior	87	4.22
6	Journal of Environmental Psychology	52	2.52
7	Waste Management & Research	46	2.23
8	Journal of Environmental Management	34	1.65
9	Ecological Economics	32	1.55
10	International Journal of Consumer Studies	29	1.41

The analysis of the yearly production shows a significant growth in the latter years for the top four journals, with the exception of *Environment and Behavior* which concentrates its articles on recycling behavior in the 1990s and 2000s (Figure 12).



**Figure 12.** Top 5 journals (number of articles per year).

A cross-subject analysis of the main journals highlights that recycling behavior is investigated not only in environmental sciences and social sciences, but also in studies related to economics, management, business, marketing, energy, engineering, agriculture, biology, education, medicine, nutrition, etc. It follows a significant level of interdisciplinarity for articles investigating human behavior in relation to waste management.

The geographical analysis provides useful information in relation to leading nations and to the evolution of these countries throughout the years. The number of citations per nation indicates a predominance of European, North American and Commonwealth countries, besides People's Republic of China (PRC) and Malaysia (Table 4).

**Table 4.** Number of citations and articles per country.

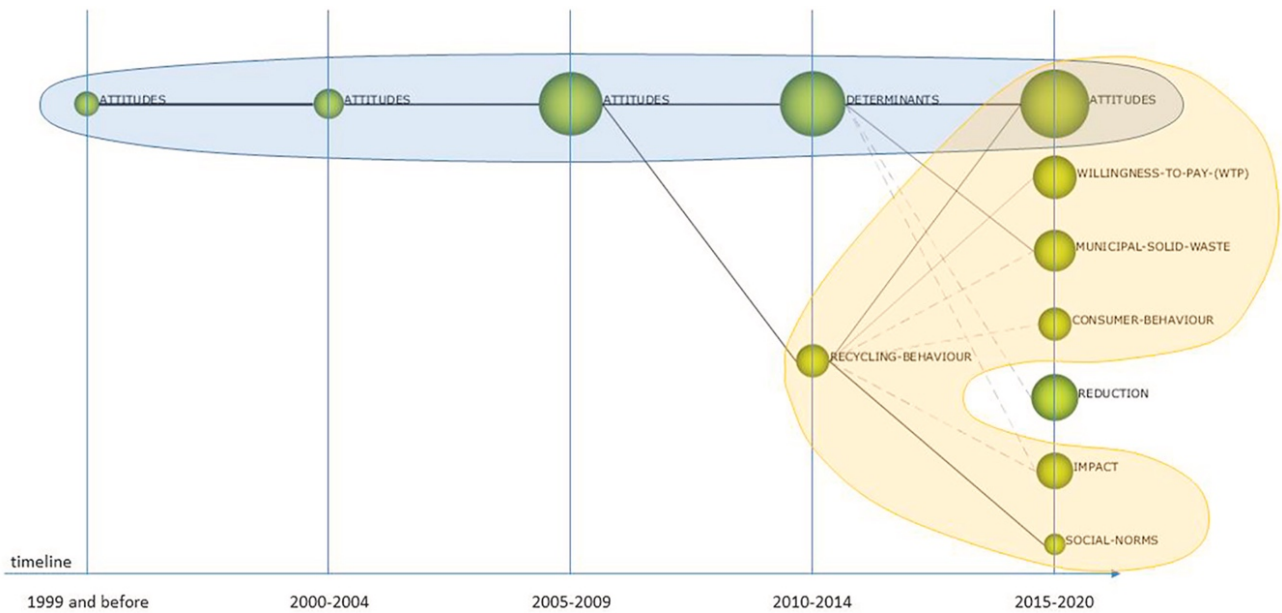
Rank	Nation	No. of Citations	No. of Articles
1	England	6664	173
2	USA	6311	206
3	PRC	3390	211
4	Sweden	2595	61
5	The Netherlands	2277	48
6	Germany	2250	55
7	Italy	2210	113
8	Canada	1357	68
9	Malaysia	1054	58
10	Spain	1025	48

In order to obtain a better-defined picture, the study of the number of articles per country needs to be integrated by other types of analysis, like citations, co-authorship or network visualization (SM). In fact, although England does not have the highest number of articles on recycling behavior (173 compared to 206 for the USA and 211 for PRC), its articles are the most cited ones, indicating the predominant influence of this country in this field. At the same time, countries with less than 100 articles, like Sweden and The Netherlands, are highly cited.

The network visualization of VOSviewer of the citations by country gives an immediate indication of the main national clusters (Figure 13), the size of a circle and its label is proportional to its weight, the lines between circles represent their links, the distance between two circles shows their relatedness). The clusters are centered in: PRC (red), USA (yellow), England and Italy (blue),

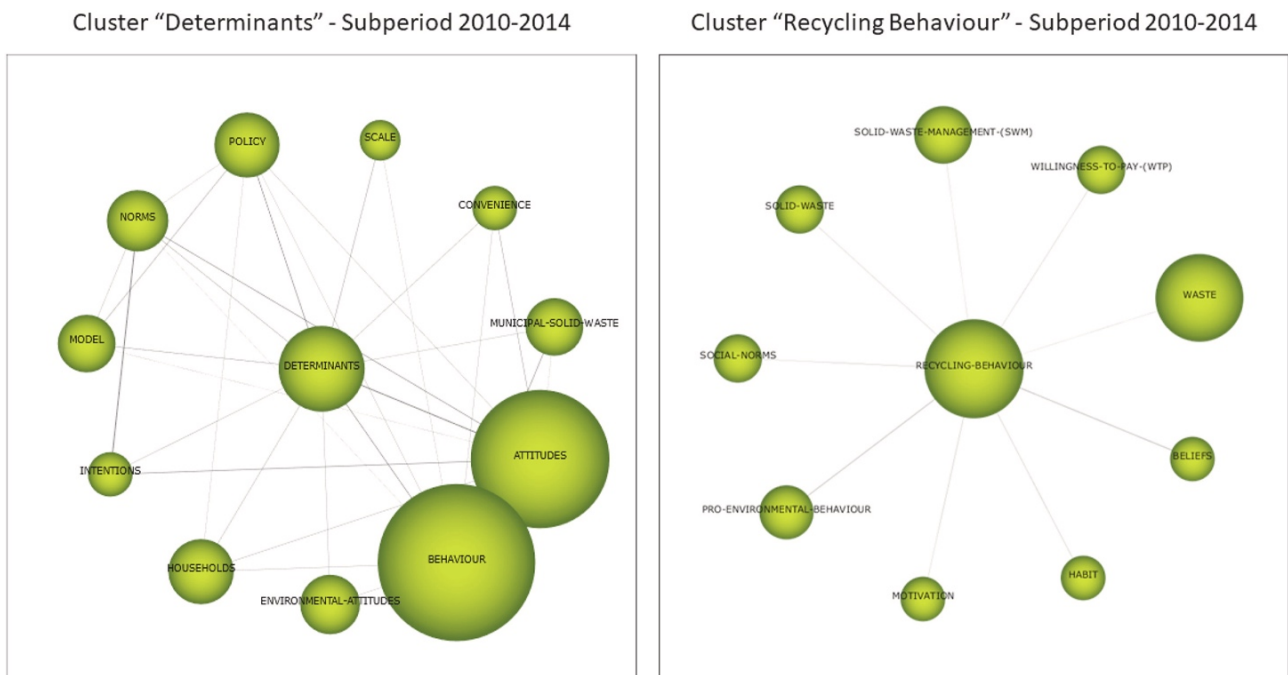






**Figure 14.** Evolution map of the clusters (Longitudinal view of SciMAT).

A closer analysis of the subperiod 2010-2014 indicates that the cluster “determinants” is actually made of several subclusters, mainly represented by “Attitudes” and “Behavior” (Figure 15– left side); this evidence clearly confirms that the concept of “Attitude” remains pivotal throughout the years. At the same time, the appearance of the new cluster on “recycling behavior” indicates that this type of behavior becomes an important field of investigation (Figure 15 – right side). In the subperiod 2015-2020 the further expansion of studies in this field leads to new clusters like “Willingness-to-pay (WTP)”, “Municipal Solid Waste” and “Social Norms” (light orange shaded area in Figure 14). These clusters indicate a sort of unity and consistency in the socio-psychological research strand throughout the years.



**Figure 15.** Clusters views of subperiod 2010–2014 (SciMAT).

In relation to the “attitude” theme, the evolution of the academic research really connects to the number of published papers and their citation impact, especially in the last 10/15 years, which are characterized by an exponential growth of articles (as indicated by the sphere dimension).

### 3.4.2. Research Question 2

The second research question intends to reveal the knowledge base of recycling behavior through the identification of key authors and papers, and their relationship. In fact, Zupic and Čater (2015) infer that “the knowledge base of a field is the set of articles most cited by the current research” (p. 438), also known as the intellectual base (Persson, 1994).

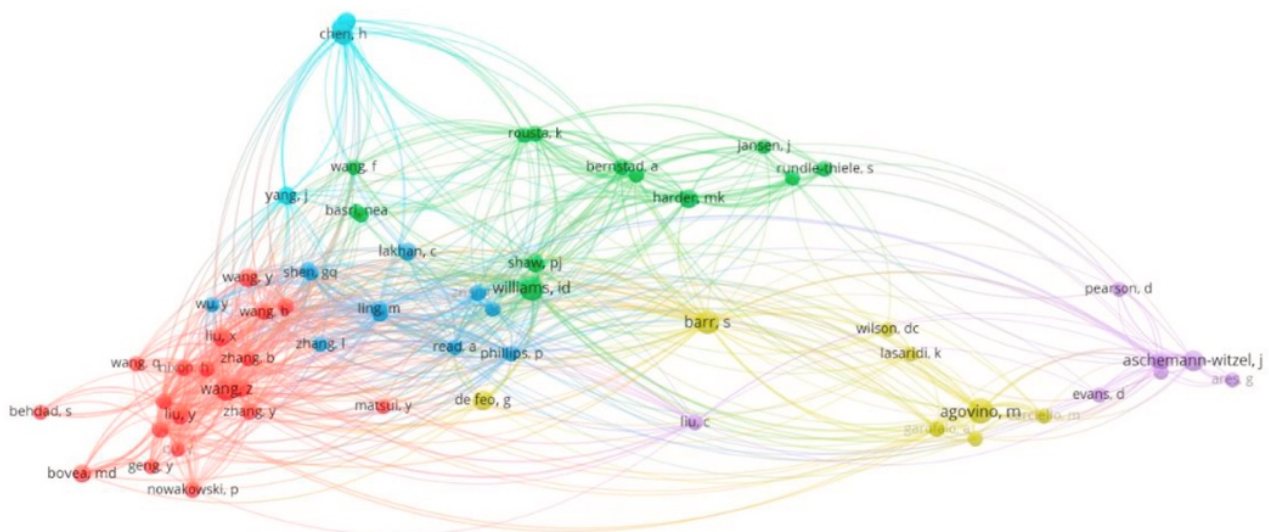
The authorship analysis investigates the number of articles per authors; it provides an immediate indication of the most productive authors in the field of recycling behavior. These authors are Barr, S. with 16 articles, Agovino, M. with 14 articles, Williams, I. D. with 13 articles, Aschemann-Witzel, J., Chen, H. and Oskamp, S. with 11 articles each (Table 5).

**Table 5.** Most productive and cited authors.

Rank	Authors	No. of Articles	No. of Citations
1	Barr, S.	16	1161
2	Agovino, M.	14	190
3	Williams, I. D.	13	522
4	Aschemann-Witzel, J.	11	363
5	Chen, H.	11	49
6	Oskamp, S.	11	638
7	De Feo, G.	9	171
8	Thøgersen, J.	9	154
9	Chen, F. Y.	8	34
10	Bernstad, A.	7	354

Actually, this type of analysis does not provide indications on the influence of an author on other scholars, or possible collaboration patterns among authors; in this regard, the citation analysis is helpful in understanding the most prominent authors.

The connection network among these authors is visible in Figure 16 (each node is labelled with the author’s name and its size represents the number of times it is cited). In this case VOSviewer identifies some clusters centered on Aschemann-Witzel, J. (purple colour), Barr, S. (yellow), Williams, I. D. (green), Chen, H. (cyan), Lakhan, C. (blue), Wang, Z. (red).



**Figure 16.** Citation of authors (network view, minimum 5 citations per author - VOSviewer).

The collaboration network is also defined by the co-authorship analysis, which is based on the frequency of different authors in the same paper. VOSviewer individuates numerous clusters (Figure 17): the main ones are Chen., H. and Wang, Y.; while others stand out quite clearly, namely Barr, S., Agovino, M., Aschemann-Witzel, J., De Feo, G., Williams, I. D. A careful analysis of the temporal dimension (as per color scale of Figure 17, blue for 1990, green 2010, yellow 2020) helps in understanding the changes in co-authorship network throughout the years. In fact, clusters like McCarthy, J., or Vining, J. are collocated in the early 1990s, whereas Barr, S. and Phillips, P. in the 2000s, and Chen., H. and Wang, Y. in the last decade.

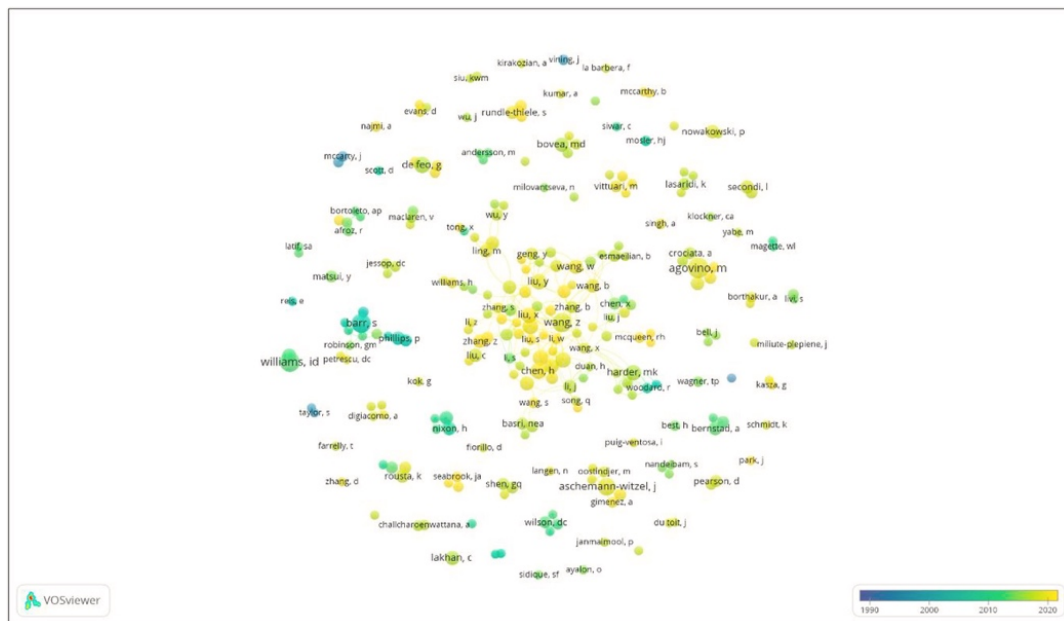


Figure 17. Co-authorship analysis (minimum 3 papers per author - VOSviewer).

The co-citation of cited authors depicts a different framework of authors, because it highlights the most influential authors to be co-cited. The dimension of the circles in Figure 18 indicates that Ajzen, J. and Barr, S. are the most co-cited authors; in addition, Figure 18 shows the influence of Aschemann-Witzel, J., Schultz, P. W., Graham-Rowe, E., Vining, J., Stern, P. C., Saphores J. D. M. in the literature on recycling behavior. The co-citation analysis clearly confirms Ajzen’s prominence in this field, thanks to his extensive works on the TRA and the TPB.

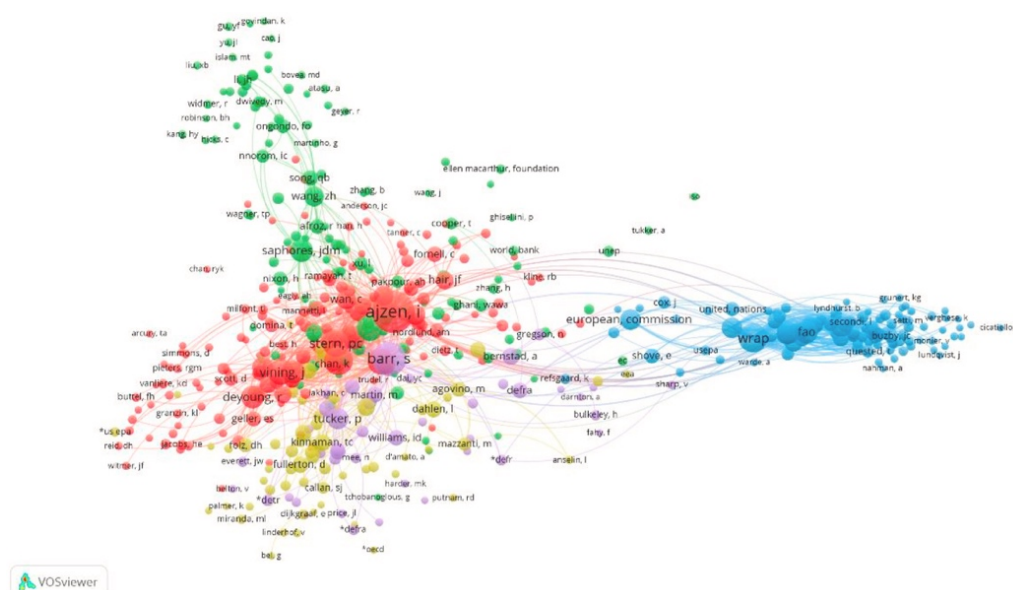
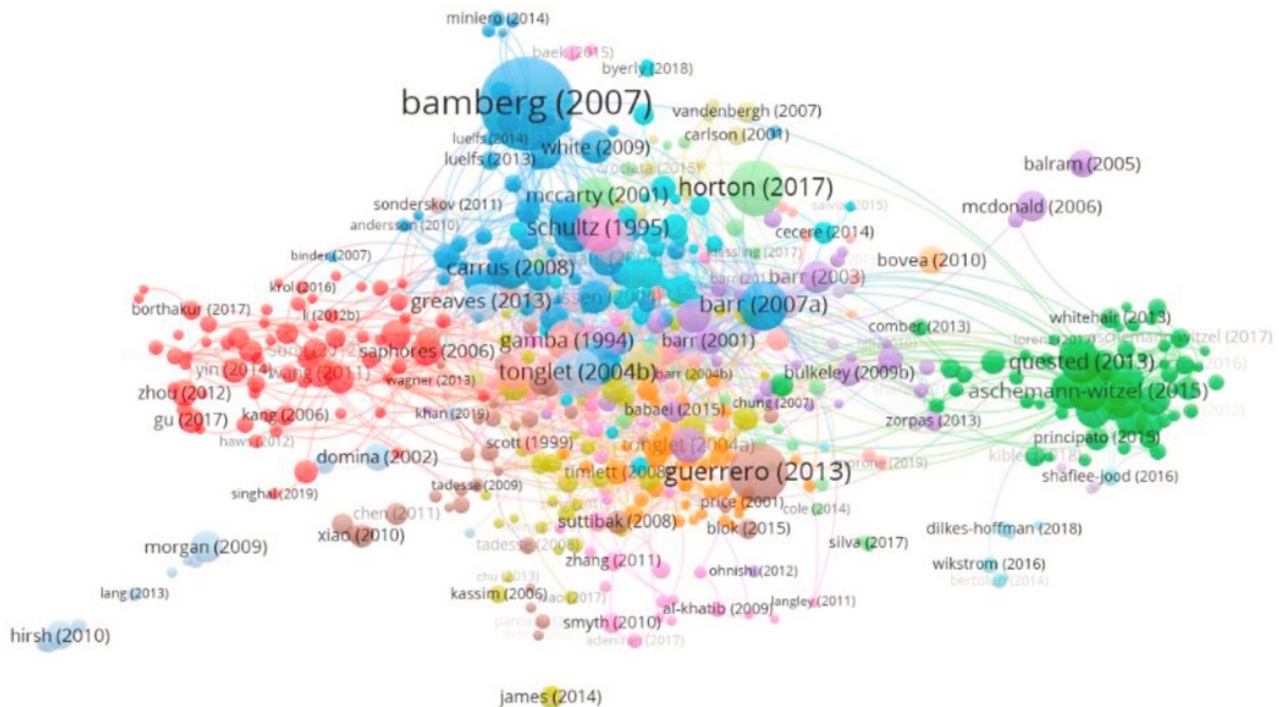


Figure 18. Co-citation of cited authors (minimum 20 citations - VOSviewer).



The analysis of the most cited papers reveals several clusters as indicated in Figure 19 (the top 10 cited papers are displayed in Table 6, and further analysis on SM). The azure blue cluster focuses on household behavior in relation to waste management and the conceptual framework of environmental behavior. The most cited paper is Bamberg and Moser (2007)'s meta-analysis of factors influencing responsible environmental behavior through the application of the NAM and the TPB. This cluster also includes Barr (2007)'s paper on the study of the role of psychological factors, situational features and environmental values in determining waste management behaviors.



**Figure 19.** Citations of papers (minimum of 15 citations per paper; papers are labelled by their author's name and year - VOSviewer).

The brown cluster is characterized by numerous citations of Guerrero et al. (2013)'s analysis of the solid waste management challenges in developing countries. This cluster of papers addresses some issues related to solid waste management through a wider approach in comparison to the diffused socio-psychological approach. For example, Blok et al. (2015)'s paper investigates both the sustainable production and consumption.

The dark green cluster is associated with Quested et al. (2013)'s and Aschemann-Witzel et al. (2015)'s papers on food waste behavior.

The light green cluster focuses on environmental planning, conservation of natural resources and risk awareness. The leading papers are by Horton et al. (2017) on microplastics in non-marine environments, and by Oskamp (1995) on the application of social psychology to prevent ecological disaster.

The red cluster is associated with Saphores et al. (2006)'s paper on e-waste recycling.

The yellow-to-green cluster is characterized by papers on the collective dimension of recycling behavior, as public participation and community activities. The leading papers are by Ramayah et al. (2012) on green movements and social norms, Pakpour et al. (2014) on educational activities and public campaigns, McDonald and Ball (1998) on public contribution.

The violet cluster features the pro-environmental consumer lifestyle including sustainable consumption and strategies for sustainability; typical papers by McDonald et al. (2006) and Barr (2003).

**Table 6.** Most cited papers.

Rank	Articles	Authors	Year	No. of Citations
1	Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behaviour	Bamberg, S., Möser, G	2007	1310
2	Solid waste management challenges for cities in developing countries	Guerrero, L. A., Maas, G., Hogland, W.	2013	527
3	Microplastics in freshwater and terrestrial environments: Evaluating the current understanding to identify the knowledge gaps and future research priorities	Horton, A., Walton, A., Spurgeon, D. J., Lahive, E., Svendsen, C.	2017	463
4	Determining the drivers for householder pro-environmental behaviour: waste minimisation compared to recycling	Tonglet, M., Phillips, P. S., Bates, M. P.	2004	363
5	Factors influencing environmental attitudes and behaviors: A UK case study of household waste management	Barr, S.	2007	353
6	Who recycles and when? A review of personal and situational factors	Schultz, P. W., Oskamp, S., Mainieri, T.	1995	334
7	The recycling of solid wastes: Personal values, value orientations, and attitudes about recycling as antecedents of recycling behavior	McCarty, J. A., Shrum, L. J.	1994	279
8	The use (and abuse) of the new environmental paradigm scale over the last 30 years: A meta-analysis	Hawcroft, L. J., Milfont, T. L.	2010	268
9	Emotions, habits and rational choices in ecological behaviours: The case of recycling and use of public transportation	Carrus, G., Passafaro, P., Bonnes, M.	2008	263
10	Factors Influencing Community Residents' Participation in Commingled Curbside Recycling Programs	Gamba, R. J., Oskamp, S.	1994	258

Another cluster of papers focuses on household recycling, related policies and tariffs with articles by Hage et al. (2009) and Sidique et al. (2010).

The ice blue cluster addresses personality traits and the convenience of recycling. In this cluster the most diffused approach to analyze the determinants of recycling behavior is again Ajzen's TPB (Greaves et al., 2013; Tonglet et al., 2004).

A minor cluster focuses on separate waste collection considering the local and spatial dimension of recycling behavior; the leading papers are Martin et al. (2006)'s study on the role of local authorities and ethnic minorities, and Agovino, Crociata, et al. (2016)'s spatial analysis.

### 3.4.3. Research Question 3

The previous analysis of citations, co-citations of authors and papers is integrated by the analysis of topics in order to correctly map the knowledge on recycling behavior. The co-word analysis in VOSviewer offers the possibility of gaining further insights on the area of investigation; furthermore, by changing the thresholds of co-occurrence of keywords, different clusters become visible (SM). In addition, the strategic view in SciMAT allows to define the relevant research areas, and to understand the way they changed throughout the years.

In VOSviewer the co-word analysis (with a threshold of minimum 50 keywords co-occurrences in titles and abstracts) shows that the most recurring terms are food waste, recycling, attitude, consumer, system, intention, food, collection, product, consumption, resident, city (However, the analyses of the relevance of the words (calculated by VOSviewer for each term by combining its frequency and representativity) reveal a slightly different situation in which subjective norms, TPB and planned behavior are the most relevant words (Table 8). In fact, the use of relevance scores allows the exclusion of frequent general terms (e.g., methods, results) which are not representative of any specific topic.

Table 7).

However, the analyses of the relevance of the words (calculated by VOSviewer for each term by combining its frequency and representativity) reveal a slightly different situation in which subjective norms, TPB and planned behavior are the most relevant words (Table 8). In fact, the use of relevance scores allows the exclusion of frequent general terms (e.g., methods, results) which are not representative of any specific topic.

**Table 7.** Co-word analysis (with a threshold of minimum 50 co-occurrences in titles and abstracts).

Rank	Terms
1	Food waste
2	Recycling
3	Attitude
4	Consumer
5	System
6	Intention
7	Food
8	Collection
9	Product
10	Consumption
11	Resident
12	City

**Table 8.** Co-word analysis: relevance of the words (minimum threshold of 50 keywords).

Rank	Term
1	Subjective Norms
2	TPB
3	Planned behavior
4	Food
5	Household Food Waste (HFW)
6	Food waste reduction
7	Packaging
8	Consumer behavior
9	Environmental impact
10	SEM (Structural Equation Modeling)
11	Food waste
12	Intention

It follows a focus on the determinants of recycling behavior and the theoretical frameworks, quite often based on Ajzen's TPB. Also, food production, packaging and the related waste remain pivotal. The co-word analysis of title and abstracts defines three main clusters: the red one is centered on the words: recycling, systems, collection; the green one: food waste, consumer, food, product; the blue one: attitude, intention (Figure 20).

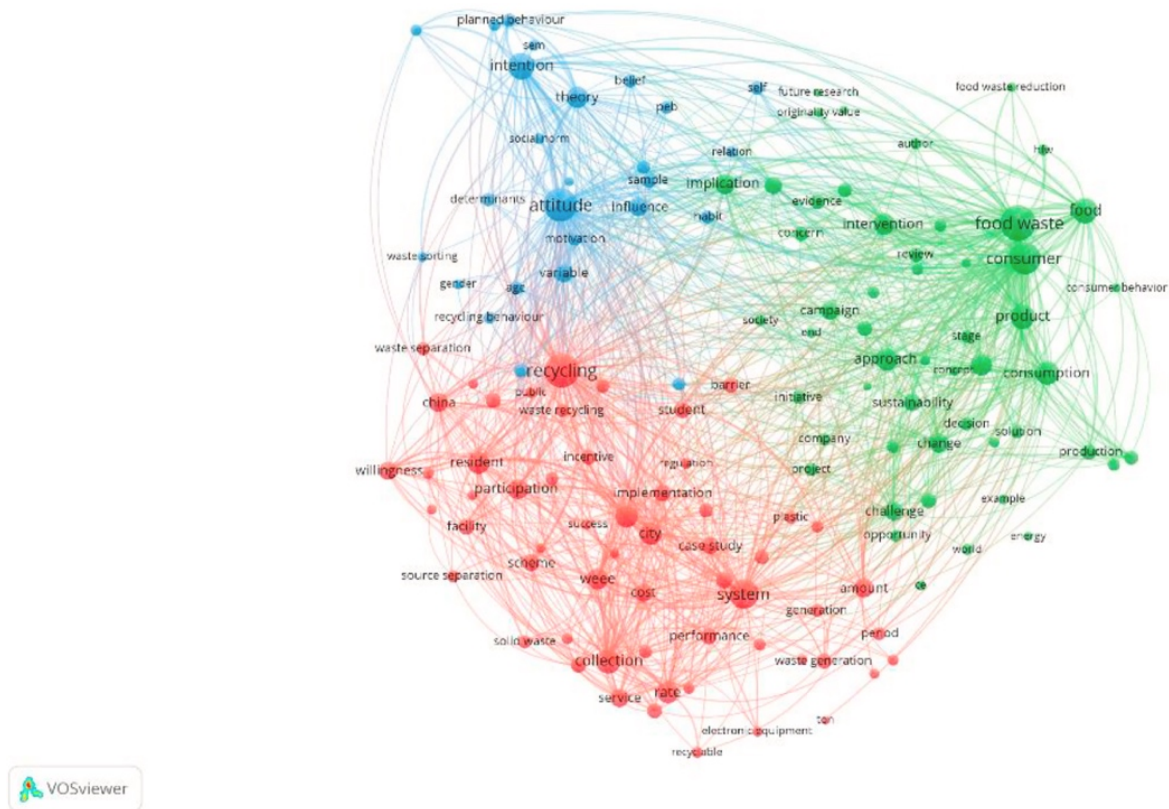
Specifically, the red cluster focuses on recycling as a waste management system; in fact, it is characterized by keywords like collection, separation, performance, rate, waste generation/separation, solid waste management (SWM), system, scheme, participation, citizen, public, service, local authority, municipality, region, regulation, implementation (of corrective measures). Moreover, it includes keywords related to cost, quantity, facilities and types of waste.

The green cluster is characterized by the keywords: food and related declinations, like production, consumption, food waste reduction, household food waste. This cluster analyses the entire process involving food from the production phase (including the design phase), through the packaging and the consumption, to the reduction and prevention of food waste; consequently, it also addresses companies and campaign, CE, sustainable development and climate change, society, challenges and opportunities, energy and future research.

The blue cluster is centered on attitude and intention; in fact, it focuses on the determinants of recycling behavior like social and subjective norms, motivation, habits, beliefs, and environmental

concerns, besides typical socio-demographic factors like age, gender and income. Consequently, this cluster focuses on theories, especially TPB, supporting the socio-psychological analysis of human behavior.

It is worth noticing that the analysis of words and keywords does not really lead to the identification of specific types of recycling behavior, like “sorting behavior”, “collection behavior”, “composting behavior”; in fact, they are also mentioned in a very limited number of articles. Actually, this paper highlights the predominance of specific keywords like “waste sorting” and “waste separation”, which often indicate specific steps of the waste management process, not necessarily types of behavior.



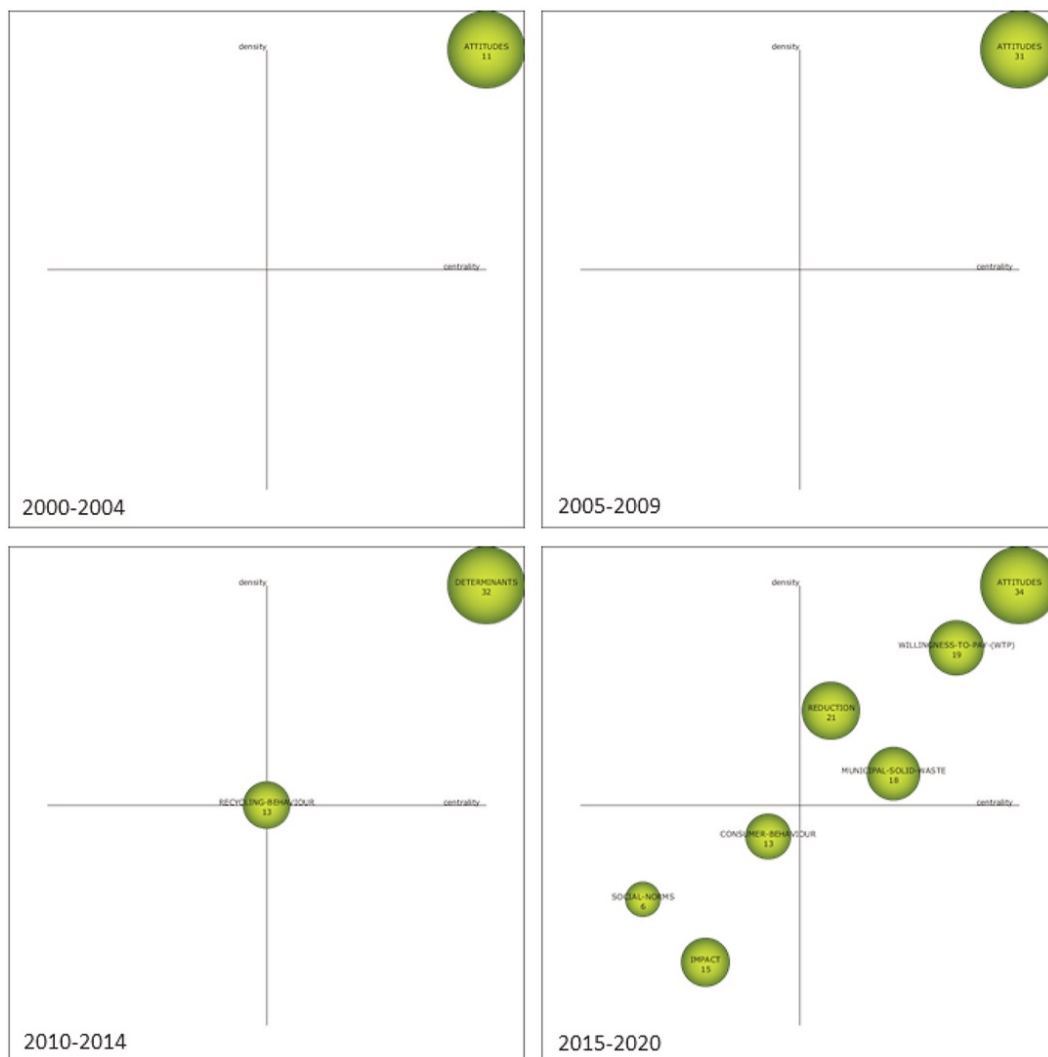
**Figure 20.** Co-word analysis (minimum 50 citations - VOSviewer).

The strategical diagram of SciMAT depicts the themes and their evolution throughout the selected timeframes. The clusters (or themes) are positioned in relation to their centrality and density: the former defines the level of interaction among the themes, the latter the level of interaction between the keywords characterizing the specific topic. As stated by Nova-Reyes et al. (2020) the former measures “the strength of external links that exist among clusters” (p. 4), giving an indication of “the importance of a theme in the development of the entire field of research under analysis” (p. 4); whereas the latter measures the “strength of the internal links between keywords that describe this research topic” (p. 4), giving an indication of “the degree to which the topic under study has been developed” (p. 4). Therefore, the upper right quadrant displays central and developed themes, the lower right quadrant central and undeveloped themes, the lower left quadrant peripheral and undeveloped themes, the upper left quadrant peripheral and developed themes (Callon et al., 1991).

Figure 21 describes the evolution of themes throughout specific time periods as follows: 2000-2004, 2005-2009, 2010-2014, 2015-2020 (the period “1999 and before” is not reported in Figure 21 because the main theme is only “attitude”, as it happens for 2000-2004 and 2005-2009). “Attitude” clearly represents a central and developed theme since 1970’s; in the last decade “willingness-to-pay” (WTP), “reduction” and “municipal solid waste” (MSW) are central and developed as well. The

expansion of these research topics is supported by a greater focus on interventions at the local (municipal) level in recent years, both from the final user perspective and the service provider. In fact, scholars frequently analyze the impact of corrective measures on citizens in terms of quality and cost for the service (e.g., “willingness-to-pay” for a better management of waste). At the same time, the difficulties in handling waste force public institutions and researchers to look for possible ways of reducing waste as e-design, LCA analysis, optimization of packaging, etc.

In the period 2015-2020, topics like “consumer behavior”, “social norms” and “impact” are underdeveloped and peripheral. The analysis of keywords shows that “consumer behavior” has progressively been replaced by more specific terms in relation to waste management, like “(waste) sorting behavior”, “household waste sorting”, “pro-environmental behavior”. Similarly, the keyword “impact” has been integrated with more specific words, like “ecological impact”, “environmental impact (analysis)”, “economic analysis”, “social impact”, “nutritional impact”. In particular, “environmental impact analysis” is gradually becoming an important area of interest, although it does not currently represent a main cluster. The keyword “social norms”, although representing a quite constant presence in the selected literature, is often declined in different forms to better fit the theoretical framework or model adopted by the authors (e.g., TRA, TPB, VBN, NAM); in fact, the selected papers often utilize keywords like “subjective norms”, “personal norms”, “descriptive norms”, “injunctive norms”, “moral norms”.



**Figure 21.** Strategical view per time period with h-index (SciMAT).

A further analysis of keywords and words frequency in the text of the selected literature (SM) indicates that technological aspects influencing recycling behavior are not fully exploited or



frequently investigated. In fact, in spite of the recognized benefits of Internet of Things (IoT) in our daily activities, IoT is mentioned in 8 selected articles between 2018 and 2020. Among them it is worth mentioning Esmailian et al. (2020) who analyze the “design of incentive mechanisms and tokenization to promote consumer green behavior” (p. 1); moreover, they focus on improving the traceability of product lifecycle and the sustainability of the supply chain network. They conclude that, besides the need for the enhancement of LCA methods and a “novel data-driven decision-making architecture” (p. 13), it is essential to investigate the human-machine interaction to fully value the human capital.

In the case of environmental engineering, the related literature highlights the potential of IoT or sensor network system in enhancing waste management, especially during the disposal and collection phases. For example, nowadays the food supply chain offers the possibility to enhance the inventory management, optimizing the line and tracking the waste (Aung & Chang, 2014); Jagtap and Rahimifard (2019) analyze possible ways to reduce food waste by manufacturing digitalization. In this MKD, the articles with a social or psychological approach do not actually dig into the impact of technology on recycling behavior except in a few recent cases (Jiang et al., 2020; Wang et al., 2019; A. Zhang et al., 2019). Nowadays, technology offers the possibility to monitor consumer behavior including food waste or waste dumping behavior. In the first case, Esmailian et al. (2018) propose an “IoT-enabled waste management framework for smart and sustainable cities with particular emphasis on connecting waste management practices to the whole product life-cycle” (p. 14). In the second case, Jiang et al. (2020) define an analytical framework to study household dumping behavior taking advantage of IoT and data mining.

Similarly, the topic of recycling behavior in smart and circular cities needs further attention by Academia, think tanks and governments; in fact, it shows up in a limited number of papers, namely 8 between 2016 and 2020. Also, the term big data appears in the text of only 8 articles (this figure goes down to 3 if considering titles, abstracts and keywords only). Clearly, pandemics and COVID-19 show up in a few articles in 2020 only (except 2 cases in previous years in which pandemic is mentioned).

Other topics deserving further attention are the impact of social media on recycling behavior, the effects of spillovers, the relationship between recycling behavior at home and at work, efficient WEEE recycling, socio-psychological factors limiting smartphones recycling, on-line recycling, transition to CE, intention to use single-use plastic bags, effect of pandemic on household recycling behavior, young consumers, intergenerational transmission of recycling habits and behaviors, stakeholders engagement to improve recycling behavior.

### **3.5. Discussion of Results**

Through the application of the bibliometrics techniques and text mining, this paper documents the overall evolution of the research on recycling behavior since the early 1970s. This type of analysis becomes important when the academic literature increases in terms of volume, geographic distribution, authorship and thematic areas. This section interprets the overall findings, analyses the consequent implications, provides some suggestions for future research and highlights the limitations of this research.

#### **3.5.1. Interpretation of the Findings**

This bibliometric analysis is based on a solid literature review including different databases which complement each other. The final body of literature is made up of 2061 papers on recycling behavior, published between 1973 and 2020 and indexed by the selected databases. The temporal analysis of these papers clearly documents a barely tangible production until the late 1980s, followed by an intermediate phase until the mid-2000s with no more than approximately 30 articles per year; afterwards, an exponential growth leads to an explosion of research documenting the diffused interest in all environmental issues and sustainable development in the latter decades (including recycling

behavior). Indeed, approximately 60% of the papers have been published between 2015 and 2020, leading to the conclusion of a highly dynamic production on recycling behavior with an evolving knowledge base.

The geographical analysis of the body of literature demonstrates that the topic of recycling behavior represents a global phenomenon. In fact, besides the numerous European, North American and Commonwealth countries, other regions are expanding their literature; in particular, China represents a leading nation in the studies on environmental sciences, and specifically on waste management and recycling behavior. This trend is also confirmed by the co-word analysis of titles and abstracts, which indicates China as a common keyword in this field. In addition, Malaysia, Iran, Turkey, Taiwan, Vietnam, Japan and Indonesia play a leading role in their geographic area. At the same time, this diffused interest indicates that waste management and the study of the related human behavior represent a universal and pressing challenge requiring a structured approach at all levels (government, institutions, academia, citizens).

The analysis of the source of papers highlights a significant predominance of journals dealing with environmental sciences, sociology and psychology, namely *Resources, Conservation and Recycling, Waste Management, Journal of Cleaner Production, Sustainability and Environment and Behavior*. A minor percentage of articles comes from heterogeneous disciplines like nutrition, education, engineering, law, economics, marketing, namely *Appetite, Education Sciences, International Journal of Production Research, Law & Society Review, Economic Systems Research, Journal of Business Ethics, Journal of Marketing*. On the one hand it means that environmental sciences represent a consolidated area of investigation with new journals contributing to the environmental research in the last two decades, like the *International Journal of Environmental Research and Public Health, Environment, Development and Sustainability, the International Journal of Environment and Sustainable Development*. On the other hand, the study of recycling behavior needs to include the analysis of the legal and institutional framework, the cultural factors, managerial aspects, etc. In fact, although the journals (investigating recycling behavior) not belonging to the environmental sciences represent a limited percentage, their exclusion would bias the results of the research, especially from the interdisciplinary point of view.

The analysis of authorship and co-authorship provides clear indications on the most influential authors throughout the years. Until the mid-2000s, considering also the limited literature on recycling behavior, the leading authors are quite defined, namely Barr (2003), McCarty and Shrum (1994), Phillips et al. (2002), Vining and Ebreo (1990), Oskamp et al. (1991), Taylor and Todd (1995a), Bamberg and Moser (2007). Moreover, they mainly operate in Europe and North America, and in a less favorable condition for the exchange of information in comparison with nowadays (e.g., limited diffusion of electronic journals). The following period presents a plethora of leading authors around the world, taking advantage of the facilitated exchange of information; furthermore, many nations develop their own solid knowledge on waste management and recycling behavior, thus offering many subject matter experts through academia, public institutions, and think tanks. For example, China is currently a leading nation in this sector, as demonstrated by its numerous scholars like Wang, Guo, et al. (2018); Italy, as well, presents many highly cited authors like Agovino, Crociata, et al. (2016). It is worth noticing that the authorship analysis is also influenced by the contingent research trends; for instance, the consistent academic production by Aschemann-Witzel (between (2015) and (2020)) focuses on a topical subject like food waste.

The co-word analysis indicates specific areas of interest, namely food waste, determinants of recycling behavior (e.g., attitude, intentions), waste management system, WEEE, plastic bag and local government. The document analysis highlights some recurring topics as well: household behavior and conceptual framework, SWM, food waste behavior, environmental planning and risk awareness, e-waste recycling, public participation and community activities, pro-environmental consumer lifestyle (including sustainable consumption and strategies for sustainability), household recycling and related policies (including tariffs), personality traits and the convenience of recycling, spatial and local dimension of SWM. These topics also indicate that the academic research



investigates specific locations like households, residential and municipal areas, universities and schools.

Overall, these examples demonstrate that the correct interpretation of findings requires a combined analysis of the articles, authors and keywords, in order to identify the main strands of a research area. In this sense, science mapping offers a unique opportunity for visualizing the conceptual structure of recycling behavior (Udomsap & Hallinger, 2020); in fact, Zupic and Čater (2015) infer that “science mapping aims to reveal the structure and dynamics of scientific fields” (p. 431).

It is also worth noting that papers characterized by numerous references have a stronger influence in bibliographic coupling (Vogel & Güttel, 2013); consequently, SLRs, bibliometric papers and meta-analysis reach a higher network centrality than typical articles based on specific case studies; similarly, papers with a limited number of cited references result less influential or tend to be eliminated (Mura et al., 2018).

Lastly, in terms of theoretical framework this study confirms the applicability of TPB to recycling behavior. Numerous papers apply TPB and its extended forms to different situations with positive results; other models like NAM and VBN also show their effectiveness in predicting and analyzing recycling behavior, but starting from different assumptions.

### **3.5.2. Suggestions for Future Research**

Mapping knowledge domain also provides some opportunities for individuating future areas of investigations in relation to both the wider field of recycling behavior and some specific topics of interest.

The former requires the adoption of a more comprehensive view of the areas of investigation; for example, the holistic analysis of all stakeholders (including their goals, motivations, involvement) may favor the individuation of the applicable factors and their interrelations, besides the implementation of adequate and effective intervention measures. As already mentioned, the correct analysis of a household recycling behavior has to include the detailed study of the context and the external factors, which are often grouped all together as a single or non-significant variable, therefore underestimated in quantitative and qualitative terms. In fact, the correct analysis of recycling behavior cannot exclude aspects like the effects of the infrastructural, legal and institutional framework, the recycling scheme (including rewards and fines), the eco-design of products, the production and the purchase phases, and the product life cycle. On this matter, some papers investigating LCA (Suckling & Lee, 2015) have proved to offer the possibility of integrating the analysis of consumer behavior and the retailer perspective with the aim of better understanding consumers' needs, providing a more efficient service to the final user, and recovering materials for further utilization. Other recent papers investigate organizational and managerial aspects of recycling like the “organizational citizenship behavior for the environment” (Liu et al., 2021, p. 290), the green organization identity, and the pro-environmental posture of managers and industry through the analysis of corporate social responsibility (Ciocirlan et al., 2020). Moreover, these studies appear to be fragmented, therefore future research should further consider, for example, the need to include the analysis of the production phase and the legal framework to further integrate the aggregated knowledge and better understand consumer behavior. In fact, recycling behavior is definitely influenced by a favorable framework motivating and facilitating recycling, rewarding citizens, and offering low-impact packaging options.

The latter is represented, for instance, by the investigation of topics related to technological advances which may influence recycling behavior in the years to come, like environmental IoT (Hart & Martinez, 2015), smart waste management (A. Zhang et al., 2019), waste segregation through image processing (Sartipi, 2020), sensor network system, smart cities design, information communication technology, big data and social media. In this context, technology may improve the consumers' awareness of the impact of their actions on the environment, or the quality and efficiency of recycling, and indirectly the motivation to recycle. In fact, IoT has already proven its beneficial effects on the production and selling of goods, through enhanced operational effectiveness, reduced

costs and risks, transparency and flexibility (Kamble et al., 2019). These effects are already influencing consumer purchase behavior, but they impact recycling behavior too.

Other topics deserving further attention are packaging of food, the relationship between pro-environmental behavior and the utilization of bitcoin, circular cities, consumer responsibility on reducing its environmental impact, re-use/re-utilization, consumerism, product obsolescence (Dermody et al., 2020), and effects of COVID-19 pandemic on recycling behavior. Specifically, the research should focus more on consumer responsibilities (Soneryd & Ugglå, 2015) and its pro-active role in waste management through possible consumer-driven interventions; in this case the analysis presupposes the existence of an enhanced awareness of the environmental impact on the consumer side, and an extended producer responsibility and product stewardship on the other side (Blake et al., 2019).

On the conceptual side, future research may benefit from the application of new theoretical frameworks or integrated forms of the existing ones; in fact, although TPB is the dominating paradigm in the study on recycling behavior since its definition in 1991, Ajzen and Kruglanski (2019) have recently developed the theory of reasoned goal pursuit (TRGP) by integrating TPB and the goal system theory (GST). TRGP, which is lacking application to recycling behavioral studies, may provide further insights on human behavior by integrating the individual's goals into the TPB construct. At the same time, the predominant socio-psychological approach, clearly motivated by the focus on human behavior, calls for the integration of other models from disciplines like economics, management, marketing, and public government.

Furthermore, this paper highlights the existence of alternative areas of investigations like the comparative analysis of metropolitan and rural areas or different Nations or regions; in fact, a limited number of scholars apply a comparative approach in their studies. Agovino, Crociata, et al. (2016) and Crociata et al. (2016) analyze and compare waste management for some Italian regions and discover the existence of spatial factors influencing it. Purcell and Magette (2009) investigate the spatial variability of biodegradable municipal waste generation; Zambezi et al. (2021) the spatial differences in litter amounts. In any case, the spatial analysis of different types of waste remains quite unexplored, therefore the research may benefit from the application of this approach to other areas of investigation or geographic locations, building on Ferronato et al. (2020) and Blose et al. (2019)'s research, which shows how comparative analysis at the regional or national level bring new insights on this topic. Moreover, few authors have addressed the analysis of recycling behavior at work and home; therefore, further investigations in this sector may help in better understanding the determinants of human behavior, in particular the influence of external factors and organizational values.

Considering this paper evidences a predominant interest on specific actors like households, university students and electronic consumers, it would be useful to expand the area of investigation to other types of consumers or stakeholders in order to better understand their behavior and benefit from the application of successful intervention measures in other sectors.

Future research should also address the need for a clear definition of the taxonomy of waste management behavior. For example, some scholars consider composting as an integral part of recycling; others distinguish composting from recycling, and re-use from recycling. Some scholars distinguish the public and private dimension of this behavior; others talk about recycling of reusable materials (Lee & Paik, 2011) or products, which may actually be considered re-use or re-utilization. Phulwani et al. (2020) consider recycling as a "type of private sphere pro-environmental behavior" (p. 17). Moreover, the definition of recycling behavior is clearly influenced by the socio-cultural background, the legal and institutional framework, the context, workplace versus domestic environment, recycling schemes, the economic system, etc.; therefore, a shared definition of the taxonomy may prove to be challenging.

Lastly, although MKD offers useful insights on the topic of investigation, it cannot provide further information on qualitative aspects like the efficacy of TPB in predicting recycling behavior or the adequacy of intervention measures to improve household recycling. Therefore, a meta-analysis may

offer a better understanding of these aspects and integrate the outcomes of bibliometrics and text mining, besides being better suited for a quality assessment of literature.

### 3.5.3. Limitations

This bibliometric analysis presents some types of limitations. The selected literature is written only in English, therefore the final body of literature cannot capture all existing research networks and current trends. For example, some areas of the globe are characterized by a notable production of papers in Spanish or Arabic only; thus, a correct geographical or authorship analysis would require the inclusion of these papers too. Consequently, some findings require a further careful analysis before being generalized. In addition, the authors opted for the analysis of peer-reviewed papers only, however the inclusion of books, book chapters, conference proceedings and grey literature may offer the possibility of capturing recent trends in relation to recycling behavior. Moreover, the selection of 3 different databases does not automatically guarantee the full coverage of the existing academic production of peer-reviewed articles in English; therefore, future research may consider the inclusion of papers in other languages and other databases to prevent the exclusion of potentially relevant papers.

Although the search query has been carefully defined and it covers a solid array of keywords, the risk of exclusion of applicable terms still remains, especially considering the evolution of keywords throughout the years and the existence of acronyms or synonyms. In addition, this study does not assess the quality of the selected papers, because this procedure would require the definition of criteria which may not be applicable to all involved disciplines. Considering this manuscript aims at a holistic analysis of the topic of investigation, the specific inclusion and exclusion criteria are deemed suitable for the correct selection of the final body of literature. Actually, dos Santos and Rausch (2009) in do Nascimento et al. (2019) infer that “bibliometrics as a method has the advantage of softening the elements of judgements and generating quantitative results that tend to be the sum of many small judgements and judgements made by several people” (p. 292).

This paper does not address some types of behavior or people, like minors, managers and retailers; therefore, it does not investigate topics like managerial practices and corporate social responsibility, which may deserve some attention in order to have a holistic understanding of recycling behavior, both from the consumer side and the producer (or service provider) side. The authors recognize that a full understanding of recycling behavior requires the analysis of all stakeholders, their motivations, their driving factors, and the context too.

### 3.6. Conclusions

This paper analyses the academic production on recycling behavior through a bibliometric and text mining approach; it provides a clear and updated picture of the structure of knowledge in this specific sector by demonstrating its salience and its evolution throughout the years. The inclusion of the three databases (Web of Science, Science Direct and EBSCO) leads to the selection of a final robust body of literature with a trustworthy dataset, which allows the identification of key aspects and gaps. In fact, this paper provides a substantial contribution to the literature on recycling behavior by mapping peer-reviewed articles available on the mentioned databases, individuating trends and gaps, and making suggestions for future research. In particular this paper identifies topical areas like food waste and related behavior, packaging, determinants of recycling behavior, WEEE and e-waste recycling, SWM, household recycling. It also highlights a new strand of investigation by providing a valuable and updated overview of the literature on recycling behavior. Consequently, it is beneficial to scholars approaching the field of recycling behavior for the first time, or looking for further insights on this matter or filling in gaps. In fact, while revealing some limitations of the existing research, it proposes several suggestions for future studies, such as a more comprehensive analysis of recycling behavior integrating the final user and producer perspectives, or the potential of environmental IoT and smart waste management. Further analysis of food packaging is required to promote the adoption

of successful measures at the governmental and industrial level, and to increase consumer awareness of its role on sustainable development. Also, peculiar behaviors (e.g., re-use) or standard behavior under specific circumstances (e.g., recycling during the pandemic) require further investigation because their studies may unveil the importance of some underestimated factors, therefore leading to more tailored interventions. In this regard, the application of integrated forms of consolidated theoretical framework, like the combination of TPB and GST into TRGP, may increase the capability of investigating and predicting recycling behavior through the analysis of goals and motivations (besides the TRGP antecedents of intention).

This paper also highlights that, although recycling behavior keeps attracting the attention of scholars from different disciplines, the research is often fragmented or confined in specific sectors, for instance social psychology, marketing or environmental engineering. This manuscript recognizes the predominant approach rooted in social psychology and the influence of scholars' background. It follows the need for further investigation at an interdisciplinary level considering the exigency to improve waste management at all levels, and to make the consumer more involved in sustainable development and more conscious of its environmental impact. In this regard, the establishment of interdisciplinary research teams would greatly benefit from future research on this matter, and favor the integration of different theoretical approaches from heterogeneous disciplines in the same framework. In this context, a clear definition of taxonomy represents a key element to foster an integrated approach on this matter.

Lastly, considering this paper points out that the growth trajectory of the literature on recycling behavior predicts a significant increase in size in academic production in the years to come, any current MKD on recycling behavior will require future regular re-assessments to be able to capture new trends and gaps, with the support of an ad hoc SLR and meta-analysis.

### **Author Contributions**

Research design, methodology and data collection, data analysis and interpretation, A.C.; data validation, A.C., G.K. and P. M.; writing—original draft preparation, A.C.; writing—review, G.K. and P.M.; supervision, G.K. and P.M. All authors have read and agreed to the published version of the manuscript.

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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.

### **Supplementary Data in Appendixes**

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jenvman.2021.114160> (after the declaration of competing interest) or in Appendixes C, D and E of this thesis.

# **Chapter 4: The Role of Goal Pursuit and Habits in the Prediction of Waste Separation Behavior through an Extended “Theory of Planned Behavior” (TPB) Model**

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**EMBARGOED**

## **Chapter 5: Investigating the Role of Goals and Motivation on Waste Separation Behavior Through the Lens of the Theory of Reasoned Goal Pursuit**

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**Abstract**

Nowadays the prediction and change of waste-related behaviors represent a key topic for scholars and policy makers. The theoretical mainstays applied to waste separation behavior, such as the Theory of Planned Behavior (TPB), the Norm Activation Model and the Value Belief Norm, do not include the construct of goal in their formulation. Other goal-focused theories, such as the Goal Systems Theory (GST), lacks applications on separation behavior. Recently Ajzen and Kruglanski (2019) have proposed the Theory of Reasoned Goal Pursuit (TRGP) which combines TPB and GST. Considering TRGP has the potential to offer further insights on human behavior and, to our knowledge, there is no application of TRGP to recycling behavior yet, this paper analyses waste separation behavior of households in Maastricht and Zwolle (The Netherlands) under the lens of TRGP. Although waste separation behavior represents a kind of habitual behavior, this paper highlights the influence of goals and motivation on intention to separate waste. Furthermore, it offers some indications to promote behavior change and some suggestions for future research directions.

**Keywords**

Waste separation behavior; recycling; theory of reasoned goal pursuit; theory of planned behavior; goal systems theory; the Netherlands; waste collection; pro-environmental behavior; structural equation modeling; confirmatory factor analysis



## 5.1. Introduction

The analysis of the academic papers on pro-environmental behavior in the last years indicates that waste recycling behavior remains topical. The prediction and change of waste-related behaviors, like separation, reduction, re-utilization, represent a key topic for scholars, scientist, politicians, waste service providers and policymakers. Some researchers are more focused on the reasoned part of human behavior like intention, attitude, norms, awareness of consequences, ascription of responsibility, personal values, beliefs (McCarty & Shrum, 2001); whereas others highlight the importance of less volitional predictors of waste-related behaviors like habits (Cheung et al., 1999; Lavelle et al., 2015) or emotions (Carrus et al., 2008). Contextually, we recognize that, in the specific field of waste-related behavior, the constructs of goal and motivation are actually not sufficiently addressed in combination with the typical precursors of behavior like intention and norms. Looking at the theoretical mainstays applied to recycling behavior, the Theory of Planned Behavior (TPB; Ajzen, 1991) and its predecessor, the Theory of Reasoned Action (TRA; Ajzen & Fishbein, 1970), the Norm Activation Model (NAM; Schwartz, 1977) and the Value Belief Norm (VBN) Theory (Stern, 2000) do not include the construct of “goal” in their formulation. Although TPB has proved to be a robust framework to explain pro-environmental behaviors (D. Li et al., 2019; Miafodzyeva & Brandt, 2013) at different levels (e.g., managerial, household, consumer), Perugini and Bagozzi (2001) move a step forward by adding desire and anticipated emotions to the TPB framework. Certainly, human behavior is goal-driven as well, and several theories have offered frameworks to give the right emphasis to this important precursor of behavior, for example the Goal Setting Theory (Latham & Locke, 1979) and the Goal Systems Theory (GST; Kruglanski et al., 2015; Kruglanski et al., 2002). Recently, Ajzen and Kruglanski (2019) have proposed the Theory of Reasoned Goal Pursuit (TRGP) which combines TPB and the GST. The TRGP has the potential to offer further insights on human behavior and as, to our knowledge, there is no application of TRGP to recycling behavior yet, this paper analyses waste separation behavior of the households in Maastricht and Zwolle (the Netherlands) under the lens of TRGP. Acknowledging that TPB has been successfully tested in different contexts (Carmi et al., 2015), this paper aims at both understanding the effect of the inclusion of the goals and motivation among the TPB precursors, and at offering valid suggestions to policy makers and service providers in the definition of effective waste management measures at the household level. Although waste separation behavior represents a kind of habitual behavior, driven by consolidated waste management procedure in many advanced economies, we expect not only to corroborate the validity of the typical TPB constructs in explaining waste sorting behavior, but also to verify the enhanced predictive capability of TRGP for this type of habitual behavior.

## 5.2. Literature Review and Theoretical Framework

The TPB (Ajzen, 1991) represents the most diffused framework for analyzing recycling behavior (Yuriev et al., 2020). This theory can be considered the evolution of the TRA (Ajzen & Fishbein, 1970); both of them analyze and predict social behavior through “a set of hierarchically linked constructs” (Barr, 2004, p. 233). Intention is the immediate predictor of behavior, whereas attitude, subjective norms and perceived behavioral control (PBC) (the latter in the case of TPB only) are the precursors of intention. Intention “represents the person’s motivation in the sense of his or her conscious plan to exert effort to carry out a behavior” (Eagly & Chaiken, 1993, p. 168). It is influenced, in turn, by attitude, which measure “the degree to which a person has a favorable or unfavorable evaluation or appraisal of the behavior in question” (Ajzen, 1991, p. 188); in very simple words, this construct measures how much an individual aspires to perform a specific behavior. Numerous studies have proven the direct relationship between attitude and intention; in fact, a positive attitude toward the behavior reinforce the intention to perform the behavior. Among the precursors of intention, attitude usually represents the most influential. Another precursor is subjective norms which represent “the perceived social pressure to perform or not to perform the behavior” (Ajzen, 1991, p. 188). In fact, this construct measures the influence of the society or

“important others” (e.g., parents, partner) on the individual, who usually adheres to norms and needs social recognition. In relation to recycling behavior, several studies have confirmed the importance of norms in predicting intention and behavior, however at a lower level compared to attitude both at the individual level (Wang et al., 2020) and at the organizational level (Botetzagias et al., 2015; Khan et al., 2020). The third precursor of intention, PBC, measures “the perceived ease or difficulty of performing the behavior” (Ajzen, 1991, p. 188). This construct considers both the capacity and the autonomy of the individual of performing the behavior. Furthermore, Ajzen and Fishbein consider the direct and unmediated effect of PBC on behavior. An overall analysis of this construct in scientific papers indicates that the level of influence of PBC on recycling intention and behavior is significant, even though we may notice different levels of significance among case studies (Liao & Li, 2019; Nigbur et al., 2010; Wang et al., 2020).

Although the original TPB framework has been successfully applied to recycling behavior, numerous scholars have added constructs to make it better fit to specific situations, for example, past behavior, emotions, habits and desire. In particular, the model of goal directed behavior (MGB; Perugini & Bagozzi, 2001) enriches TPB by adding positive and negative anticipated emotions, past behavior (frequency) and desire to the typical TPB constructs.

At present, the suitability of TPB for fully understanding and predicting pro-environmental behavior is still undergoing numerous tests. In this regard, it is worth recalling Staats (2003) who concludes that “the [TPB] model will perform best when the behavior under consideration is very reasoned, or very planned. That is, the more attention is given to consciously considering all the relevant factors (behavioral, normative and control beliefs) the better will be the prediction” (p. 185).

Consequently, Staats distinguishes between the application of TPB to important decisions with long-term and irreversible effects, versus behaviors with less stable relationships among components (e.g., attitude and related beliefs).

Another well diffused framework for analyzing recycling behavior is the Norm Activation Model (NAM) and the Value Belief Norm (VBN). NAM has been proposed by Schwartz (1977) assuming that the activation of personal norms strongly influences human behavior; in turns, personal norms are activated by ascription of responsibility and awareness of consequences. The VBN by Stern (2000) builds on NAM by integrating the concepts of biospheric, altruistic and egoistic values; moreover, it gives further centrality to the individual with the intent of “advancing theories of environmentally significant individual behavior” (Stern, 2000, p. 407). Yuan et al. (2016) apply VBN to the consumer intention to exchange electronic products.

Some authors have also investigated the reasons for selecting a specific framework. It is worth recalling Bamberg and Moser (2007) who explain the selection of a reasoned choice approach (TRA or TPB) with researchers’ need to focus on the individual’s self-interests. On the contrary, scholars more interested in pro-social behavior opt for a framework based on NAM or VBN.

The mentioned meta-analysis and systematic literature reviews also show that goal constructs have actually never been fully and directly considered in the study of recycling behavior (Concari et al., 2020; Concari et al., 2022). First, it is worth recalling some theoretical frameworks focusing on goals. Latham and Locke (1979)’s “Goal Setting Theory” focuses on the individual setting their personal goals to satisfy their personal needs. So far, this theory lacks applications to household behavior.

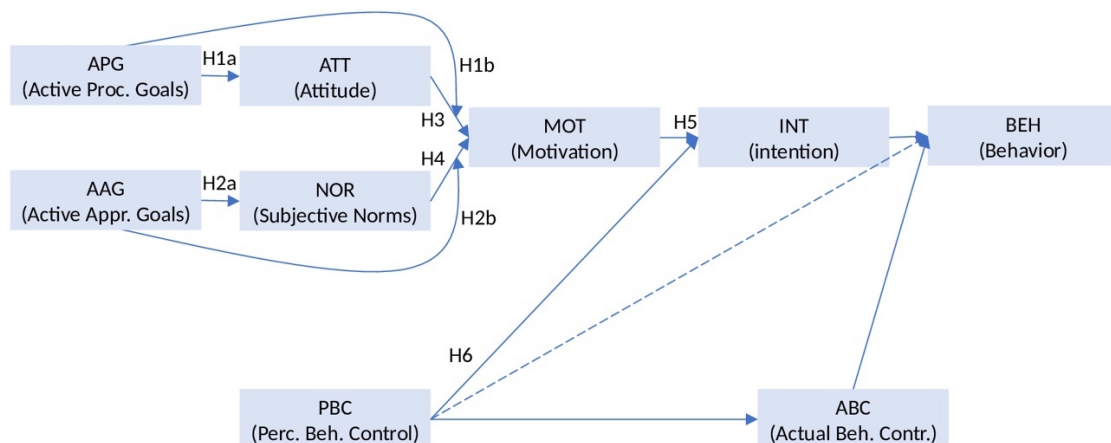
The GST (Kruglanski et al., 2002) considers goals as the motivators of action, being “a mental representation whose contents are of motivational significance” (Kruglanski, 1996, p. 599). Given that goals are dynamics and can be reached in different ways, Kruglanski et al. (2015) focus on the means to reach these goals as well, and define the concept of “multifinality”, “equifinality” and “counterfinality”. Kruglanski (1996) considers goals as “a desirable future state of affairs one intends to attain through action” (p. 600); in fact, goals are defined in terms of desirability, attainability and accessibility. Consequently, “only contextually available means can be considered for selection, and among these available means the most salient, vivid, and accessible will win out” (Bargh et al., 2010, p. 280). Overall, the GST postulates that goal systems have motivational and cognitive properties (Kruglanski et al., 2002). Unfortunately, in the academic literature there is a very limited number of

papers applying this theoretical framework to pro-environmental behavior, in particular to recycling behavior. Nielsen (2017) proposes a theoretical analysis of environmental behaviors in terms of goal setting and striving; Devezer et al. (2014) analyze the effect of goal failure and the importance on environmental friendly behaviors; Corrégé et al. (2018) study the effect of priming goals through social norms to improve energy-efficient behavior.

Quite recently Ajzen and Kruglanski (2019) combine TPB and GST into the TRGP to expand the predictive capabilities of their respective original frameworks: “whereas the TPB is a bottom-up approach that centers on the behavior as a point of reference, the GST represents a top-down approach in which the goals drive (and hence explain) the behavior undertaken in their service” (Ajzen & Kruglanski, 2019, p. 777). Acknowledging the great utility of TPB in analyzing different types of behavior, they concur that “the TPB’s behavior focus omits an important consideration, namely that behaviors are usually performed in the service of certain goals” (Ajzen & Kruglanski, 2019, p. 777). In the current case study, recycling may be undertaken to promote the higher-level goal of environmental protection; moreover, this goal has to be sufficiently desirable and attainable to start recycling. Therefore, TRGP adds goals and motivation to the typical TPB constructs in order to improve the understanding and predictability of human behavior. In particular, Ajzen and Kruglanski (2019) posit that some TPB precursors of intention are driven by goals: active procurement goals (APG) influence attitude, whereas active approval goals (AAG) influence subjective norms. The activation of a procurement goal makes the individual consider the possibility of achieving this goal; in our case, if individuals deem environmental protection very important for their daily life, their attitude towards recycling become relevant. Similarly, for AAG which indicate the personal aim at gaining the approval of “important others”; in this case study, if individuals consider recycling as an important way to get approval of significant social referents, their subjective norms become relevant. Furthermore, Ajzen and Kruglanski (2019) posit that “motivation” is the immediate predictor of intention; as such, motivation constitutes the desire to perform a behavior in order to achieve one or more active goals.

In line with the TRGP, our hypotheses are as follows (Figure 24):

- H1a<sub>APG-ATT</sub>**. Active procurement goal (APG) positively affects attitude (ATT)
- H1b<sub>APG-MOT</sub>**. Active procurement goal (APG) positively affects motivation (MOT)
- H2a<sub>AAG-NOR</sub>**. Active approval goal (AAG) positively affects subjective norms (NOR)
- H2b<sub>AAG-MOT</sub>**. Active approval goal (AAG) positively affects motivation (MOT)
- H3<sub>ATT-MOT</sub>**. Attitude (ATT) positively affects motivation (MOT)
- H4<sub>NOR-MOT</sub>**. Subjective norms (NOR) positively affect motivation (MOT)
- H5<sub>MOT-INT</sub>**. Motivation positively affects waste sorting intention (INT)
- H6<sub>PBC-INT</sub>**. PBC positively affects waste sorting intention (INT)



**Figure 24.** Research framework – Hypotheses testing.

## 5.3. Methodology

### 5.3.1. Research Design

This paper is based on a research process made of four subsequential steps (Zhang et al., 2021). First, it reviews the applicable literature in order to analyze the theoretical frameworks applied to separation behavior and the related constructs; then it proposes the hypotheses testing the TRGP (Section 5.2). Second, it defines a questionnaire (based on these hypotheses) through an initial eliciting questionnaire, followed by the pre-test on a limited sample, and finally the distribution of the survey with an adequate sample size (N) (Section 5.3). Third, it applies Structural Equation Modeling (SEM) via a two-stage procedure (Anderson & Gerbing, 1988; Morrison et al., 2017): initial assessment of the measurement model through Confirmatory Factor Analysis (CFA), subsequent assessment of both measurement and structural models, and hypothesis testing (Section 5.4). Fourth, it discusses the results (Section 5.5), it proposes some suggestions for interventionists and future research, and it highlights main limitations (Section 5.6).

In relation to the second step, this study applies a quantitative research method to investigate the application of the TRGP to waste sorting behavior (Strydom, 2018) in Maastricht and Zwolle (the Netherlands). The data were collected between March and July 2020. Considering that the research took place during COVID-19 pandemic, the questionnaires were distributed on-line.

### 5.3.2. Structure of Questionnaire, Constructs and Measures

The questionnaire is made of different parts analyzing socio-demographical aspects (gender, education, employment status, type of dwelling, age range, number of people living in the household), socio-psychological factors (TRGP constructs, including active goals and important referents), separation knowledge and barriers. All questions are based on a 7-point Likert scale or multiple-choice answers; most of items utilize already validated scales; further information on constructs and measures are available in the supplementary material (SM).

All participants have been informed about the purpose of the study and the research has been conducted in an ethically correct manner in accordance with local statutory requirements (e.g., no personal identifiable data have been requested to respondents, no discrimination of gender or race).

### 5.3.3. Data Collection and Analysis

Different approaches and software are available to calculate the minimum sample size (e.g., Slovin's formula (SM), "G\*Power" software which offers different types of statistical tests). A statistical power analysis performed with G\*Power 3.1 (Faul et al., 2009) indicates a minimum sample size of 191 respondents (with significance criterion 0.05, power 0.80 (Cohen, 1992), effect size 0.20).

A total of 223 respondents participated to the on-line questionnaire and 208 questionnaires were adequately filled out for the subsequent analysis. Data are analyzed with IBM Statistical Package for Social Sciences (SPSS) 26 and IBM AMOS 28 in order to perform descriptive statistics and SEM (Khan et al., 2021; Morrison et al., 2017). SEM allows a thorough testing of variables relationship (through multiple regression) and the analysis of the model measurement errors (Kline, 2011). The 2-step analysis aims at first testing the model validity and reliability, followed by the assessment of the measurement and structural models to verify the predictive capabilities of TRGP in relation to separation behavior (Ling et al., 2018; Mondéjar-Jiménez et al., 2016).

## 5.4. Results

### 5.4.1. Descriptive Statistics

The demographic sample consisted of 63.9% respondents ( $n=133$ ) from Zwolle and 36.1% ( $n=75$ ) from Maastricht. The sample shows a slight predominance of the age range 25 to 34 (27.4%), followed by a quite uniform distribution of the age ranges 35 to 44 (16.8%), 18 to 24 (15.4%), 45 to

54 (15.4%), 55 to 64 (13.9%); the sample at or above 65-year-old is poorly represented. Other socio-demographic parameters have been investigated and results are shown in SM.

In relation to the education level of the sample, in both towns the largest portion holds a university degree, whereas a smaller portion attended the high school or holds an associate degree, and a very limited number of respondents ( $n=3$ ) has an elementary education only. Therefore, the education level of the sample is quite high. The occupation status is quite different between the two towns: whereas in Maastricht there is a clear predominance of students compared to employees, in Zwolle the employees are significantly predominant. Regardless of these differences, data still show a reasonably normal distribution. The following analysis of data is based on the exclusion of cases pairwise and some extreme outliers.

#### 5.4.2. Statistical Analysis

A CFA based on the maximum likelihood estimation is performed with the software IBM AMOS 28 to assess the measurement model fit before proceeding to hypothesis testing. The maximum likelihood estimation (covariance-based SEM) is preferred to partial least square SEM considering this research is not exploratory and it rather focuses on understanding the relationships among constructs (Khan et al., 2020; Wetzels et al., 2009).

The goodness of the measures is assessed in terms of indicator loadings, reliability and validity; in turn, the analysis of validity is made of construct validity and convergent validity. In this study indicator loadings are generally above the normal cutoff point of .700, although some indicators (APG2, AAG3, ATT2, NOR1) are in the range .500 and .700 (Table 13). In this case they are acceptable considering average variance extracted (AVE) is above .500 (Khan et al., 2020), although they require careful scrutiny. The scale score reliability measures the internal consistency through the diffused Cronbach's alpha ( $\alpha$ ), which represents the "expected correlation between an actual test and a hypothetical alternative form of the same length" (Carmines & Zeller, 1979, p. 45). The analysis of Cronbach's  $\alpha$  coefficient (Cronbach, 1951) shows that all values are acceptable being above .500, although several authors like Nunnally and Bernstein (1978) suggest above .700. It is worth recalling Pallant (2020) who warns researchers that "Cronbach alpha values are, however, quite sensitive to the number of items in the scale" (p. 135), therefore we may expect values as low as .5 in scales made of very few items. Different approaches are also available for investigating scale reliability; Morrison et al. (2017) integrate Cronbach's  $\alpha$  analysis with the study of the indicator reliability (IR) or the composite reliability (CR), which is based on IR. IR is the "proportion of variance in each measured variable that is accounted for by the latent factor it supposedly represents" (Morrison et al., 2017, p. 1334); ideal values are above .39 (O'Rourke & Hatcher, 2013). Therefore, we conclude that the internal consistency of all items is within acceptable limits although some indicators (AAG3, NOR1) are borderline (Taber, 2018) (Table 13).

Convergent validity is measured by AVE; its cut-off value is .500 (Fornell & Larcker, 1981); therefore, all latent variables meet this requirement.

The discriminant validity verifies that the constructs are different from each other. We apply the Fornell-Larcker criterion (Fornell & Larcker, 1981), which states that discriminant validity is adequate when the square root of AVE ( $\sqrt{AVE}$ ) per each construct is greater than the correlations with the other related constructs (Lin & Guan, 2021). Table 58 of SM confirms that this criterion is verified for this case study.

Although some items present borderline values, we conclude that the measurement model is acceptable.

The model shows a root mean square error of approximation (RMSEA) of .116 (RMSEA LO 90%=.103, HI 90%=.128), which is normally out of tolerance, however it can be considered as a sufficient value for small size of the sample N. In fact, Chen et al. (2008) "demonstrate that there is no empirical support for the use of .05 or .10 as universal cutoff values to determine adequate model fit. The means of the sampling distributions of the RMSEA are related to the size of the sample, the type of the model, and the degree of misspecification" (p. 476).

**Table 13.** Constructs and related indicators.

Constructs	Indicator Code	Indicators	Loadings	Cronbach's $\alpha$	Indicator Reliability	Average Variance Extracted
<b>Active Procurement Goal (APG)</b>	APG1	A clean(er) world is important to me	.801	.669	.641	.539
	APG2	I can contribute to a cleaner world by separating waste accurately on a daily basis	.661		.437	
<b>Active approval Goal (AAG)</b>	AAG3	To me, it is important if people around me approve my waste separation	.520	.624	.270	.529
	AAG4	I am supported in separating waste accurately on a daily basis by my important referent	.888		.789	
<b>Attitude (ATT)</b>	ATT1	My waste separation on a daily basis for the next 3 months is good/bad	.748	.744	.560	.506
	ATT2	My waste separation on a daily basis for the next 3 months is pleasant/unpleasant	.637		.406	
	ATT3	My waste separation on a daily basis for the next 3 months is useful/useless	.744		.554	
<b>Subjective Norms (NOR)</b>	NOR1	The most important person/group of people to me separates waste accurately on a daily basis	.539	.662	.291	.567
	NOR2	The most important person/group of people to me think that I should accurately separate waste on a daily basis	.918		.843	
<b>Motivation (MOT)</b>	MOT1	I am motivated to separate my waste accurately	.897	.816	.805	.621
	MOT2	Do you desire to separate waste accurately?	.770		.593	
<b>Perceived Behavioral Control (PBC)</b>	PBC1	If I wanted to, I am confident that I can accurately separate waste on a daily basis	.738	.762	.545	.621
	PBC2	It is my own conscious decision to accurately separate my waste on a daily basis	.835		.697	
<b>Intention (INT)</b>	INT1	I expect to separate my waste accurately on a daily basis	.806	.898	.650	.673
	INT2	I will separate my waste accurately on a daily basis	.792		.627	
	INT3	I intend to separate my waste accurately on a daily basis	.861		.741	

Taasoobshirazi and Wang (2016) also recommend researchers to be cautious with RMSEA values when dealing with limited samples; furthermore, “TLI [Tucker-Lewis index] and RMSEA indices reward for model parsimony and penalize for model complexity” (Perugini & Bagozzi, 2001, p. 87). The CHI SQUARE test is 3.787; we usually aim for a value of 3.0 or below (Kline, 2011), however Schumacker and Lomax (2004) accept values as high as 5.0, therefore we consider the model sufficiently fit considering the limited sample.

The analysis of hypotheses is presented in Table 14.



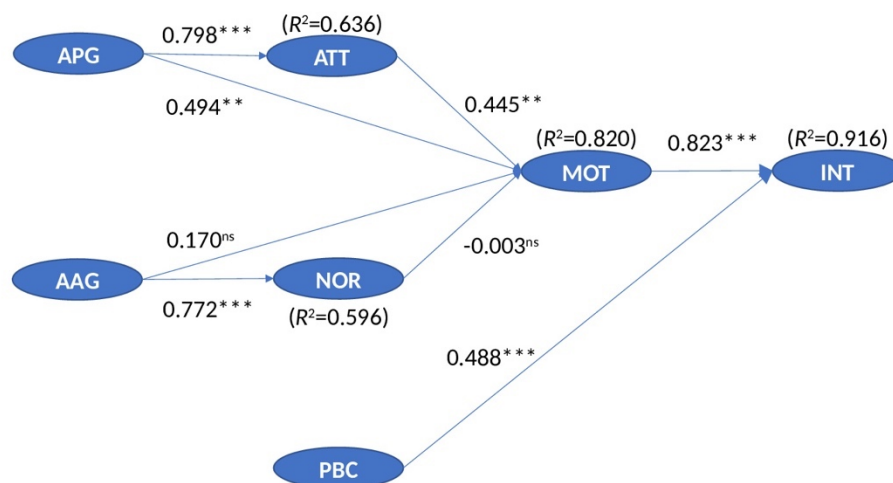
**Table 14.** Structural Equation Modeling (SEM) – Hypotheses testing.

Hypothesis	Predictor	Dependent variable	<i>p</i> -value	<i>t</i> -value	$\beta$ (beta)	95% CI	Hypothesis Acceptance
H1a	APG (Active Procurement Goal)	ATT (R <sup>2</sup> =0.636)	***	7.413	.798	[.617, .943]	Accepted
H1b	APG (Active Procurement Goal)	MOT (R <sup>2</sup> =0.820)	.002	3.212	.494	[.072, .953]	Rejected
H2a	AAG (Active Approval Goal)	NOR (R <sup>2</sup> =0.596)	***	3.337	.772	[.642, .879]	Accepted
H2b	AAG (Active Approval Goal)	MOT (R <sup>2</sup> =0.820)	.297	1.049	.170	[.065, .370]	Rejected
H3	ATT (Attitude)	MOT (R <sup>2</sup> =0.820)	.003	3.070	.445	[.132, .851]	Accepted
H4	NOR (Subjective Norms)	MOT (R <sup>2</sup> =0.820)	.982	-.024	-.003	[-.195, .225]	Rejected
H5	MOT (Motivation)	INT (R <sup>2</sup> =0.916)	***	10.855	.823	[.640, .927]	Accepted
H6	PBC (Perceived Behavioral Control)	INT (R <sup>2</sup> =0.916)	***	7.448	.488	[.201, .729]	Accepted

Note. \*\*\*=*p*-value<.001. Confidence Intervals (CI) are based on 2000 sample bootstrapping procedure at 95% significance level.

Table 14 clearly indicates that goals positively influence attitude and subjective norms at a statistically significant level; specifically, APG positively influences attitude to separate,  $\beta=.798$ ,  $p<.001$ , 95% CI=[.617, .943], whereas AAG positively influences subjective norms  $\beta=.772$ ,  $p<.001$ , 95% CI=[.642, .879]. Therefore, the hypotheses H1a and H2a are accepted. The situation is different in relation to the impact of goals on motivation; in fact, APG positively influences motivation at a statistically significant level ( $\beta=.494$ ,  $p=.002$ , 95% CI=[.072, .953]), whereas AAG do not influence motivation at a statistically significant level ( $\beta=.170$ ,  $p=.297$ , 95% CI=[.065, .370]). Therefore, hypothesis H1b is accepted and H2b is rejected.

The antecedents of motivation show different types of influence: attitude has a positive influence on motivation at a statistically significant level ( $\beta=0.445$ ,  $p=0.003$ , 95% CI=[.132, .851]), whereas subjective norms have no statistically significant effect on motivation ( $\beta=-0.003$ ,  $p=0.982$ , 95% CI=[-.195, .225]). Therefore, hypothesis H3 is accepted and hypothesis H4 is rejected.



**Figure 25.** Theory of Reasoned Goal Pursuit (TRGP) Model – Structural Equation Modeling (SEM) estimation results ( $\beta$  and R<sup>2</sup>).

Note. \*\*=*p*<.005, \*\*\*=*p*<.001, ns=non-significant; all path coefficients are standardized.



The antecedents of intentions influence the precursor of behavior at a statistically significant level; particularly, motivation which has a strong positive effect on intention ( $\beta=0.823, p<.001, 95\% \text{ CI}=[.640, .927]$ ). PBC shows an appreciable and positive effect on intention as well ( $\beta=0.488, p<.001, 95\% \text{ CI}=[.201, .729]$ ). Therefore, hypotheses H5 and H6 are accepted.

Furthermore, the model explains high levels of variance, namely 63.6% of variance in attitude ( $R^2=.636$ ), 59.6% in subjective norms ( $R^2=.596$ ), especially 82.0% in motivation ( $R^2=0.820$ ) and 91.6% in intention ( $R^2=0.916$ ) (Figure 25). In terms of effect size (measured with Cohen's D method), values indicate that the strength of the relationship between APG and motivation is strong (.67), between APG and motivation is moderate (.17), whereas the intensity of the relationships between AAG and motivation, or subjective norms and motivation are weak (respectively, .07 and 0.06).

### 5.4.3. Group Analysis

Being said that the analysis of beta coefficients is based on a limited sample for each city ( $n=75$  for Maastricht and  $n=133$  for Zwolle), Table 15 shows the different effects of predictors on dependent variables for the cities of Zwolle and Maastricht (when values in both cities reach a statistically significant level). Analyzing the specific predictors on Table 15, APG in Maastricht have a stronger positive effect on attitude than in Zwolle ( $\Delta\beta=+0.107$ ), respectively  $\beta=.875 (p<.001, \text{ CI}=[.643, .989])$  and  $\beta=.768 (p<.001, \text{ CI}=[.512, .983])$ . Similarly, motivation in Maastricht has a stronger positive effect on intention than in Zwolle ( $\Delta\beta=+0.244$ ), respectively  $\beta=.972 (p<.001, \text{ CI}=[.822, 1.000])$  and  $\beta=.728 (p<.001, \text{ CI}=[.552, .905])$ .

**Table 15.** Comparison of beta coefficient ( $\beta$ ) for Zwolle and Maastricht (when values in both cities are at a significant level).

Predictor	Dependent Variable	Maastricht $\beta$ (beta) & probability $p$	95% CI	t-value	Zwolle $\beta$ (beta) & probability $p$	95% CI	t-value	Difference $\Delta\beta$
APG (Active Procurement Goal)	ATT (Attitude)	.875***	[.643, .989]	5.677	.768***	[.512, .983]	5.23	+0.107
MOT (Motivation)	INT (Intention)	.972***	[.822, 1.000]	9.947	.728***	[.552, .905]	7.96	+0.244

Note. \*\*\*= $p$ -value<.001, \*= $p$ -value<.05. Confidence Intervals (CI) are based on 2000 sample bootstrapping procedure at 95% significance level.

## 5.5. Discussion

Building on Ajzen and Kruglanski (2019)'s consideration that "because most behaviors are goal-driven, their initiation presupposes the prior activation of one or more goals for which the behaviors in question serve as a means" (p. 777), some researchers might object that recycling behavior is not really goal-driven. We admit that there are other volitional activities requiring strong concentration and determination to succeed; furthermore, nowadays recycling is a mandatory activity in many advanced economies. Therefore, one might think that no significant goal (or no goal at all) drives separation behavior. On the other hand, people living in advanced economies have developed an enhanced environmental awareness and sensitivity. Moreover, numerous studies demonstrate that repetitive behaviors may arouse some volitional mechanisms under specific circumstances during their execution. Ajzen and Kruglanski (2019) infer that "routine behavior of this kind is not necessarily unintentional, although it may occur spontaneously, without a conscious intention" (p. 781). Consequently, in the above-mentioned specific context, separating waste is goal-driven as well, therefore we expect a strong positive correlation among specific personal goals and other precursors of behaviors. Also, in specific conditions, motivation does arouse intention to perform a specific behavior; in fact, having the intention to separate does not automatically imply that the individual is

going to perform waste separation. Therefore, we expect that the goal construct ultimately influences intention through its immediate precursor, namely motivation, which, in turn, is influenced by the typical TPB constructs of attitude and subjective norms. In this regard, it is also worth noticing that previous studies on recycling behavior in many advanced economy cities (Knussen et al., 2004; Mondéjar-Jiménez et al., 2016) evidence the higher influence of attitude on intention compared to subjective norms, hence we anticipate a similar outcome in our case as well.

This paper actually shows that APG have a significant effect on motivation to recycle and indirectly on intention. In fact, APG shows a positive and strong statistically significant impact on attitude ( $\beta=.798, p<.001, 95\% \text{ CI}=[.617, .943]$ ) and motivation ( $\beta=.494, p=.002, 95\% \text{ CI}=[.072, .953]$ ). The situation is different for AAG. In fact, AAG strongly and positively influences subjective norms at a statistically significant level ( $\beta=.772, p<.001, 95\% \text{ CI}=[.642, .879]$ ), but AAG does not show the same level of influence on motivation as it happens for APG on attitude; moreover, AAG influence on motivation is statistically insignificant ( $\beta=.170, p=.297, 95\% \text{ CI}=[.065, .370]$ ). Similarly, attitude shows a positive and statistically significant influence on motivation ( $\beta=0.445, p=0.003, 95\% \text{ CI}=[.132, .851]$ ), whereas subjective norms do not influence motivation at a statistically significant level ( $\beta=-0.003, p=0.982, 95\% \text{ CI}=[-.195, .225]$ ). These results may seem contradictory, but they are actually in line with our expectations for the above-mentioned generic reasons and for more specific arguments, explained below.

First, the construct of APG is somehow interconnected with attitude and, similarly, for AAG with subjective norms. In fact, Ajzen and Kruglanski (2019) state that “activation of one or more procurement goals leads to consideration of behavioral options capable of attaining those goals. It follows that attitudes toward one or more behavioral options become relevant only in the context of active goals” (p. 779). Moreover, the outcomes deriving from both AAG and APG have a predominant effect (“privileged status”) respectively, in the genesis of attitudes and subjective norms. Therefore, a strong behavioral or normative belief can significantly polarize, attitude or subjective norms, regardless of the total effect of other existing beliefs which are dormant or not salient at that time. This aspect represents a significant change from TPB and “stands in partial contrast to the compensatory nature of the expectance-value model of attitude in which behavioral beliefs of varying strength and valence can compensate for each other, and each product of belief strength times outcome evaluation is given equal weight” (Ajzen & Kruglanski, 2019, p. 799).

Another key factor to consider is the overall stability of the environmental protection goals related to recycling and, specifically, to the separation activity at the household level, which normally takes place in quite standard conditions (e.g., visual cues, smell, position of bins).

Moreover, although highly volitional behaviors are, presumably, significantly goal-driven, less volitional or habitual behaviors are still driven by some goals; actually, Ajzen and Kruglanski (2019) clearly state that “habitual behavior is typically goal-driven” (p. 781). These goals may be less vivid because less persistent or latent, but they may be invigorated by contingent and contextual occurrences, like the action to remove the food from the plastic container before throwing it in the correct bins. This simple and repetitive action may make you quickly think to the possibility of reducing plastic or paper waste by utilizing reusable packaging. These ordinary examples support Ajzen and Kruglanski (2019)’s assertion that “a strong habit may support some active goals” (p. 781). In addition, the results of our questionnaire show that the great majority of participants consider environmental protection as a medium to high importance goal.

As expected, our results confirm that, in the case of separation behavior, AAG do not reach the level of importance of APG. If we have a closer look at the social context, we realize that a correct and diligent waste separation behavior does not significantly contribute to the individual’s social recognition, especially in the case of a diffused conviction of poor recycling services or lack of sanctioning for improper separation. Therefore, the limited approval by the social group of reference is sufficient not to promote approval goals, which in turns do not directly contribute to motivation ( $\beta=.170, p=.297, 95\% \text{ CI}=[.065, .370]$ ), nor indirectly through subjective norms.

The analysis of the effect of motivation on intention confirms that motivation is the immediate precursor of intention. This new construct represents a step forward for TPB; in fact, TRGP introduces a construct that measure the desirability and attainability of a goal. In this regard, Ajzen and Kruglanski (2019) highlight that “action is unlikely to be initiated unless the goal is sufficiently desirable and its perceived likelihood of attainment exceeds a certain threshold level” (p. 777). In fact, they explain that, although an individual may have a positive attitude toward recycling, and he/she feels the social pressure to recycle, the individual does not automatically form the intention to recycle nor perform recycling. To do that, the individual definitely needs to understand that separating waste is a mean to achieve one or more active goals such as environmental ones. It is also worth mentioning that environmental motivation does not fluctuate over time and it is directly related to recycling behavior (Otto et al., 2018); these aspects clearly favor the application of TRGP to recycling behavior.

In line with our expectations and with the TPB, PBC represents a key construct when analyzing recycling intention and behavior. Our paper confirms the key role of PBC on intention as well ( $\beta=0.488$ ,  $p<.001$ , 95% CI=[.201, .729]), and it also indicate that PBC is not influenced by goals because this construct “refers to people’s expectancy that their attempts to execute the behavior will be successful” (Ajzen & Kruglanski, 2019, p. 780). At the same time, the perceived individual ability expressed through PBC enables the possibility of attaining one or more (procurement or approval) goals.

Looking at the precursors of motivation, the effect of norms on motivation is not comparable with the effect of attitude on the same construct. This outcome is in accordance with our expectations because in this recycling context the effects of social norms is quite limited, whereas attitude to recycle represents a key factor.

In any case, this TRGP model displays high levels of  $R^2$  for attitude (63.6%), norms (59.6%) and, especially, motivation (82.0%) and intention (91.6%), indicating the significant predictive validity of this framework when applied to separation behavior.

The comparative analysis between Zwolle and Maastricht aims at understanding different behaviors and the peculiarities of the relationship among constructs. Unfortunately, not all relationships reach an acceptable level of statistical significance, primarily because of the limited sample. Nevertheless, our results indicate that the influence of APG on attitude is slightly higher in Maastricht than in Zwolle ( $\Delta\beta=+0.107$ ); similarly, motivation has a higher impact on intention in Maastricht than in Zwolle ( $\Delta\beta=+0.244$ ). These differences may derive from a higher propensity for APG (related to recycling) for citizens in Maastricht; in turn, this higher propensity may be because Maastricht has implemented more effective educational campaigns or recycling programs. In this regard, a more detailed and holistic comparative analysis (including the structure of goals) might help in capturing possible differences, barriers and criticalities.

## 5.6. Conclusions

This paper investigates the effectiveness of the TRGP in explaining waste separation behavior at the household level in two medium-size cities in the Netherlands, where recycling represents a well-established procedure. Moreover, this paper represents a seminal application of TRGP in the field of environmental behaviors, thus contributing to a new line of research on recycling behavior.

The results of this study indicate that integrating the goal construct within TPB improves the explanatory power of TPB and supports the validity of TRGP as a framework for analyzing recycling behavior. We concur with Ajzen and Kruglanski (2019) that this addition makes “explicit what hitherto was only implicit in TPB-guided behavioral explorations” (p. 777). TRGP moves a step forward from TPB by acknowledging that “behaviors are usually performed in the service of certain goals” (Ajzen & Kruglanski, 2019, p. 777). Considering waste separation at the household level usually takes place in a stable context and in a repetitive manner, at a first approach we may expect a limited influence of goals on the intention to separate. Actually, the effects of APG are actually statistically significant both on recycling attitude and motivation. Consequently, this paper highlights

that TRGP exhibits a strong explanatory power for behavior not under full volitional control as well, as in the case of habitual behaviors. Moreover, the results indicate that motivation represents a very reliable proxy of intention to separate; in fact, the construct of motivation is able to improve the predictive capabilities of TPB by explaining why a strong intention to recycle does not automatically form the recycling behavior unless it is supported by adequate motivation. Specifically, having the intention to separate does not automatically implies that the individual is going to perform waste separation. At the same time, if an individual has a positive attitude toward recycling and he/she feels the social pressure to perform recycling, the individual does not automatically form the intention to recycle unless he/she has the motivation to achieve an active goal. Therefore, as expected, our findings support the addition of active goals and motivation as precursors of intention; in particular, in the case of waste separation, the construct of APG enhances the predictability of separation intention.

Furthermore, our comparative analysis between the two cities helps understanding the peculiarities of the respondents, indicating that a correct analysis of the individual behavior presupposes the familiarity with the context of investigation by the researcher.

### **5.6.1. Implications and Policy Suggestions**

The outcomes of this case study provide useful indications to interventionists about effective measures to promote behavior changes to improve waste separation. The key role of goals and motivation calls for more targeted interventions. It becomes essential to activate the applicable goals and means; in fact, empirical studies indicate that “when a goal is activated, competing goals are inhibited” (Kruglanski & Szumowska, 2020, p. 1266), and similarly for means. Waste service providers, municipalities and higher institutions should aim at developing persuasive communication (Hamilton et al., 2022) and promoting high level goals. As explained by Kruglanski and Szumowska (2020), “treating habits as instances of goal-directed behavior also has important implications for the possibility of changing habits and uprooting ones that are undesirable or harmful” (p. 1266). This statement particularly applies to recycling behavior which is often characterized by improper separation routines. In this case, interventionists should first identify the goals serving the correct behavior (Kruglanski et al., 2002), define the alternative behavior and pair it with the desired goals in order to create an expectancy that the alternative behavior serves the goals in a more effective way (Kruglanski & Szumowska, 2020).

Although this paper highlights the importance of APG, interventionists should promote AAG as well. In this case the spectrum of intervention is quite wide because it ranges from the family dimension to the society level, including schools and workplace. Promotion of approval goals should be pursued in combination with the enhancement of subjective norms by encouraging the approval of “important others” or by fostering social recognition (Hamilton et al., 2022). Clearly, these interventions have to be tailored depending on socio-demographic characteristics as age, because elders require different measures from youngsters (SM).

### **5.6.2. Future Research Directions**

This paper offers some suggestions for future research directions.

Considering TRGP extends the range of applications of TPB (Ajzen & Kruglanski, 2019), it would be useful to test the predictive capability of TRGP in different contexts. As inferred by Fishbein and Ajzen (2011) when defending the TPB solidity, a solid theoretical framework has to undergo the test of generalization.

Furthermore, TRGP may not represent a theoretical end state, thus scholars are invited to further explore this theoretical framework with possible additions or modifications. In fact, (Ajzen, 2015) states that “there is nothing in the TPB to preclude addition of new predictors. Indeed, the TPB was developed by adding perceived behavioural control to the original theory of reasoned action” (p. 2). In any case, these modifications need to be well justified, including the sufficiency assumptions (Fishbein & Ajzen, 2011).

A comparative analysis between similar samples of population from different cities may offer the possibility of better understanding recycling behavior and the effectiveness of recycling procedures. Furthermore, a multi-group analysis of the sample based on socio-demographics characteristics (e.g., age, income) may help defining more targeted interventions.

Moreover, this paper highlights the importance of conducting a correct analysis of active goals, in particular when dealing with habitual behaviors. In fact, habits may conceal the real presence of goals and lead to the wrong conclusion of lack of pertinent active goals. Researchers should also carefully consider the intrinsic limitations of questionnaires when analyzing active goals not adequately elicited by the method of investigation.

### **5.6.3. Limitations**

We also acknowledge some limitations in our study.

Measures are not taken from actual behavior, but they are based on self-reported behavior. Therefore, data based on real observation may provide different outcomes from data coming from reported behavior (Ali & Ahmad, 2016). The limited sample exposes collected data and related scales to the risk of internal inconsistency, high RMSEA, low CFI (Comparative Fit Index) and similar indexes. In addition, our sample may be biased by the COVID-19 pandemic and the predominance of the age range 25-34. Therefore, this sample does not entirely represent the population of the two cities in relation to the age of respondents. Lastly, although Otto et al. (2018) report that environmental motivation is a pretty stable factor, there is the real risk that the fluctuations of goals and motivation are not adequately captured during the data collection phase.

## **Chapter 6 – Conclusions**

The reduction of waste and the reutilization of valuable resources are key aspects of our daily life. Many developed economies are currently struggling to reduce their waste and many developing economies have to start seriously dealing with waste-related issues. Acknowledging that these issues have to be addressed at all level (e.g., individual, societal, managerial, industrial, governmental) with a structured and harmonized approach, it must be recognized that the role of human beings remains pivotal. In fact, all types of remedial actions aiming at waste reduction, re-utilization, minimization, etc., involve the individual in terms of thorough understanding of the critical situation, sensitivity to environmental issues, personal contribution to waste reduction and resource saving. The increasing amount of scientific literature on recycling behavior confirms the growing attention on waste-related issues, the importance of understanding human behavior, the effort on defining and implementing effective measures to tackle the problem of waste management and resource saving. This thesis addresses these topics in a rigorous and reproducible manner through the lens of a specific framework based on the TPB and through the subsequent TRGP. The compilative structure of this thesis sheds light on waste separation behavior starting from the analysis of the existing literature to arrive at a deeper understanding of this behavior through the application of the mentioned frameworks to real case studies. By doing so, this thesis contributes to the body of knowledge on waste separation behavior by applying an extended form of TPB, testing the recent TRGP with a seminal case study, offering some suggestions for future research and proposing some forms of interventions to promote waste separation behavior. As previously explained, the objectives of this study are addressed through specific research questions which are analyzed in the following text. Through the analysis of the main theoretical frameworks and empirical research on citizens in a couple of EU towns, this chapter presents the most significant findings of this thesis starting from answering each RQ. Furthermore, it examines the contributions to the existing theories and practices; then, it provides some recommendations for action and future research. Finally, it recaps the main limitations of this thesis (previously described in detail in the preceding chapters) and it ends with some concluding remarks.

## 6.1. Answering Research Questions and Summary of Key Findings

This section analyzes the characteristics and peculiarities of waste separation behavior by answering four RQs; in particular, it highlights and explains the key roles of some constructs such as habits, motivation and goals and their influence on separation intention. Table 16 recaps the main findings for each research question.

**Table 16.** Research questions and key findings.

RQ1	Considering waste separation behavior is very repetitive, what is the role of habits on this behavior? If habits impact separation behavior, what is the level of influence on separation intention?	Chapter(s)
Key Findings	The proposed extended TPB model highlights the key role of habits (besides environmental motivation and the typical TPB predictors of intentions, namely attitude, subjective norms and PBC)	4
	There is a strong influence of habits on the intention to separate waste both directly ( $\beta=0.225$ ) and mainly indirectly through PBC ( $\beta=0.620$ ) and attitude ( $\beta=0.381$ ). Therefore, the total (direct and indirect) effect of habits on intention is very strong.	4
	TPB may benefit of the addition of habits when analyzing repetitive behavior with a very limited control by the individual such as waste separation behavior (both through direct effect and indirect effects)	4
RQ2	Does motivation influence the intention to separate waste? If so, what is the level of influence of environmental motivation on separation intention?	Chapter(s)
Key Findings	The proposed extended TPB model highlights the significant role of environmental motivation (besides habits, attitude, subjective norms and PBC) on the intention to separate waste	4
	The typical TPB precursors of intention may not be sufficient for action initiation	5



	The TRGP model assigns a key role to motivation. In Chapter 5 case study, motivation significantly influences intention to separate ( $\beta=0.823$ ). The TRGP model exhibits high level of variance for attitude, subjective norms, motivation and intention.	5
	Motivation is a dynamic construct influenced by several factors such as the magnitude of goal, its desirability and its attainability, which fluctuate through time and because of different contexts	4, 5
	Although recycling activities are usually mandatory for citizens in advanced economies, motivation plays a key role in promoting separation behavior	4, 5
RQ3	Is separation behavior goal-driven? What is the level of influence of goals on separation intention?	Chapter(s)
Key Findings	Separation behavior is goal-driven although it may seem not to be influenced by goals. This habitual behavior arouses some sort of volitional mechanisms under specific circumstances (e.g., visual cues, smell, standard position of bins) during its execution	4, 5
	Environmental protection usually represents a medium to high priority goal for the respondents of the sample. This goal is overall stable.	4, 5
	Active goals influence attitude, subjective norms and motivation. In turn, motivation positively influences intention to separate waste ( $\beta=0.823$ ). Specifically, APGs significantly influence attitude ( $\beta=0.798$ ) and motivation ( $\beta=0.494$ ), whereas AAGs influence subjective norms ( $\beta=0.772$ ), but AAGs do not influence motivation at a statistically significant level. Therefore, APGs have a higher impact on motivation than AAGs.	5
	The typical TPB precursors of intention may not be sufficient for action initiation, and intention to separate does not automatically activate separation behavior. The activation of one or more goals and motivation make it possible.	4, 5
	Although recycling activities are usually mandatory for citizens in advanced economies, goals still play a key role in promoting separation behavior	4, 5
	The TRGP model exhibits high levels of variance	5
	APG and AAG have a privileged status in the genesis of attitude and subjective norms (differently from the compensatory approach of the expectancy-value model in which all terms have the same weight)	5
RQ4	Are there other constructs (compatible with the TPB framework) which can improve the understanding of waste separation behavior?	Chapter(s)
Key Findings	The proposed extended TPB model highlights the marginal (or statistically insignificant) role of past behavior and “functionality of waste bins” on the typical TPB precursors	4
	Past behavior does not reach the same level of significance as habits; nevertheless, past behavior has some influence on PBC ( $\beta=-0.199$ )	4
	Chapter 4 findings on past behavior are aligned with Fishbein and Ajzen’s conviction that “the effect of past behavior on intention should be mediated by the theory’s three main predictors” (Fishbein & Ajzen, 2011, p. 289)	4
	Past behavior does not have to be confused with behavior. In the existing literature past behavior is sometimes interpreted as current behavior (in discordance with TPB principles)	4
	Although the academic literature confirms that contextual factors influence pro-environmental behavior, the effect of the “functionality of waste bins” (e.g., difficulties for Roman inhabitants to put their waste into the road bins) is accounted for by other typical TPB constructs. In fact, the “functionality of waste bins” directly influences habits ( $\beta=0.165$ ), which in turn influence PBC, intention, attitude	2, 3, 4

### 6.1.1. Research Question 1

The findings of Chapter 4 indicate that, in a stable context and for routine activities such as waste separation, the influence of habits on waste separation intention is significant. This chapter points out that waste separation activities, especially at the household level, are usually under limited volitional

control; for example, when an individual has to throw his/her waste in the kitchen bins, he/she automatically starts routine procedures of waste separation in a similar way as it happens for other daily repetitive actions (e.g., fastening seat belts before driving a car). Although some scholars, while comparing different theoretical frameworks, highlight that TPB is more appropriate for analyzing volitional behaviors, this thesis shows that the proposed extended TPB model of Chapter 4 is effective in understanding and predicting less volitional behavior such as waste separation. In fact, not only the typical TPB predictors show high levels of correlation and variance (intention  $R^2=0.757$ , attitude  $R^2=0.457$ , PBC  $R^2=0.507$ ) but also habits and environmental motivation are characterized by high values (habits  $R^2=0.439$ ,  $\beta_{EMTV-ATT}=0.318$ ,  $\beta_{EMTV-HABIT}=0.642$ ; please refer to Table 16 or Table 11 for all  $\beta$  values). Furthermore, the addition of habits in the TPB framework is in line with the TPB principles because this construct meets the five criteria (e.g., compatibility) specified by Fishbein and Ajzen (please refer to the discussion section of Chapter 4 for the analysis of these criteria).

### 6.1.2. Research Question 2

The findings of Chapter 4 and 5 indicate that motivation is a precursor of intention to separate waste. Specifically, in Chapter 4 environmental motivation is added to the TPB framework as an additional construct, whereas in Chapter 5 motivation is the immediate proxy of intention (as defined in the TRGP framework). In both cases high values of correlation and variance indicate the great influence of motivation. It is worth noticing that the case study in Chapter 4 interprets environmental motivation in a more extensive way than Chapter 5 and in tight conjunction with environmental goals; whereas the case study in Chapter 5 clearly distinguishes the goal in itself (e.g., APG, AAG) and the motivation to act in order to reach the goal. Therefore, it separately considers the desirability and the importance of goals. Both models (extended TPB in Chapter 4 and TRGP in Chapter 5) express high level of variance, in particular in the case of TRGP: In terms of figures, the extended TPB model in Chapter 4 explains 45.7% of the variance in attitude, 19.2% in subjective norms, 50.7% in PBC and 75.7% in intention; the TRGP model in Chapter 5 explains 63.6% in attitude, 59.6% in subjective norms, 82.0% in motivation and 91.6% in intention.

### 6.1.3. Research Question 3

This thesis concludes that separation behavior is goal-driven although repetitive behavior may appear not to be influenced by goals. This peculiar habitual behavior arouses some sort of volitional mechanisms under specific and typical circumstances which are manifest during the execution phase. For example, while a person separates waste in the kitchen during the daily meal preparation, numerous factors contribute to the activation or revamping of the goal thanks to the visual cues, the smell, the standard position of bins, etc. On the contrary, other daily volitional activities require more determination and concentration to succeed; nevertheless, having the intention to act does not automatically imply that a person is going to perform that behavior. In any case, “routine behavior of this kind is not necessarily unintentional, although it may occur spontaneously, without a conscious intention” (Ajzen & Kruglanski, 2019, p. 781).

The case study in Chapter 4 also highlights that goals must be active to produce their effect on behavior and its proxies; moreover, Chapter 4 analyzes the different influence of active procurement goals and active approval goals respectively on attitude and subjective norms (besides the final influence on motivation). In fact, Ajzen and Kruglanski (2019) infer that “activation of one or more procurement goals leads to consideration of behavioral options capable to attaining those goals” (p. 779). As expected, the case study shows a lower influence of AAG and subjective norms (on the precursors of behavior) than APG and attitude on the same constructs. This situation is due to several reasons such as the fact that nowadays waste separation is a mandatory activity in advanced economies, therefore people have somehow accepted recycling procedures, and it has become a routine activity. In addition, people living in these economies have developed an enhanced environmental awareness and they presume that neighbors and friends perform waste separation on a regular basis.

An innovative aspect of the TRGP framework is that APGs and AAGs have a predominant effect on attitude and subjective norms respectively, and both of them on motivation. In partial contrast with TPB, Ajzen and Fishbein recognize that a strong behavioral or normative belief can respectively steer attitude or subjective norms regardless of the combined effect of other beliefs. Therefore, APGs and AAGs have “privileged status” on “dormant” beliefs in a specific time frame or context. As above mentioned, some environmental goals may be latent unless specifically addressed or recalled; in fact, they become active in specific conditions, for example while a person removes the plastic container of the food and throws the packaging in the correct waste container. At that time a person may also think about the possibility of utilizing reusable packaging or about the high cost of waste management services. Therefore, the case studies in Chapter 4 and 5 are aligned with Ajzen and Kruglanski (2019)’s inference that “a strong habit may support some active goals” (p. 871).

#### **6.1.4. Research Question 4**

RQ4 analyzes the role of some constructs, often addressed in academic papers on waste separation behavior. The findings in Chapter 4 indicate that other constructs may have a direct or indirect effect on the typical TPB constructs, however their effect may be included in these typical TPB constructs. For example, past behavior has some influence on PBC ( $\beta=-0.199$ ), in line with Fishbein and Ajzen (2011)’s inference that “the effect of past behavior on intention should be mediated by the theory’s three major predictors” (p. 289). Similarly happens to the “functionality of road waste bins” which influences habits ( $\beta=0.165$ ), which in turn influence PBC, intention, attitude. It is worth stressing that these findings do not lead to the conclusion that contextual factors are of limited importance. Actually, they deserve attention because they contribute to the understanding of apparently hidden but important mechanisms impacting human behavior. It is also worth mentioning that Fishbein and Ajzen open up to the possibility of integrating their theory with other constructs as long they satisfy some specific criteria such as the principle of compatibility or causality (as stated by Fishbein and Ajzen (2011) “a causal factor determining intention and action”, p. 282). In any case these influencing mechanisms have to be correctly analyzed through the lens of the selected theory. In this regard, RQ4 also highlights the importance of correctly defining constructs in order to avoid misunderstanding or deductions not in line with the theoretical framework. In fact, sometimes it happens that the academic literature confuses the construct of past behavior with behavior in discordance with the TPB principles.

## **6.2. Contributions**

This thesis contributes to the existing body of knowledge on pro-environmental behavior in general and, specifically, on waste separation behavior. The contribution is both theoretical and empirical in content, therefore the next sections are going to separately describe the theoretical and methodological contributions at first, and the empirical contributions based on the findings from the previous chapters right after.

### **6.2.1. Contributions to Theory, Methodology and Academic Research**

Chapter 2 contributes to the existing body of knowledge on pro-environmental behavior. The SLR methodology and the holistic analysis of Chapter 2 allow to define a valuable summary of the academic literature on pro-environmental consumer behavior in relation to waste management at an interdisciplinary level. This study investigates relevant issues about this type of behavior and proposes a useful classification of the myriad of factors and conditions influencing pro-environmental behavior. In fact, it helps scholars and practitioners of different disciplines to extricate themselves in the complex field of waste-related behavior by offering a useful guide for understanding the main theoretical frameworks, concepts, factors and conditions related to this topic. For example, a researcher focusing on marketing of consumer products can benefit the understanding of socio-psychological aspects of the consumer, especially considering that the final user produces waste after

utilizing a product. For this and other reasons, scholars are offered a valuable taxonomy and classification of conditions and factors determining PECB; this classification encompasses all academic papers produced until 2020.

In particular, Chapter 2 points out trends and gaps in the existing research on pro-environmental behavior in relation to waste management. For example, it highlights leading nations and journals in the research on PECB; also, it points out weak areas in current studies such as the exiguous number of interdisciplinary investigations or comparative analysis, and the limited research on the effectiveness of the intervention measures adopted by governments and institutions. It is worth noticing that, in relation to the analysis of the academic production and differently from other SLRs, chapter 2 applies a specific methodology to better understand the evolution of the research. In fact, it weighs the number of articles with the number of national inhabitants in order to provide a more correct interpretation of the phenomenon. This methodology allows to highlight leading nations with a reduced population; for example, Chapter 2 findings bring up different nations (e.g., Lithuania, Denmark, Portugal and Slovenia) from the ones with the highest production in absolute terms (e.g., USA, Great Britain, PRC, Italy, Canada). In addition, Chapter 2 highlights the importance of applying a rigorous and reproducible approach for the selection and analysis of the database. In fact, Chapter 2 offers a valuable example of methodological rigor by defining in detail the concepts and keywords for the search query, the inclusion and exclusion criteria and the data extraction protocol.

In terms of contents, Chapter 2 also analyzes a quite underestimated topic in the academic literature: the interplay between PECB and GenCB. In particular, RQ2 of Chapter 2 points out that this interplay is quite limited, and it is highly context dependent. The analysis of this topic at different levels indicates that the presence of pro-environmental organizations and spillover effects create a supportive environment to correctly apply the existing waste management procedures or easily introduce new ones. Moreover, at the national level, a supportive legal and educational framework is essential to favor this interplay; this is clearly the case of Singapore where pro-environmental measures proved to be effective (Savage & Kong, 1993). This topic will be further addressed in the recommendations section as well.

Chapter 3 defines the conceptual mapping of studies on recycling behavior through bibliometric analysis and text mining; it identifies current trends, the existing research network and hot topics by analyzing 2061 articles produced between 1975 and 2020 from three different databases. Besides highlighting leading nations and the intellectual configuration of knowledge on recycling behavior, it points out conceptual sub-domains such as determinants of recycling behavior, food waste, WEEE and waste management system. A deep analysis of keywords and words frequency points out that technological aspects influencing recycling behavior are not fully exploited (e.g., IoT, smart cities). For example, technological advances offer the possibility to better monitor consumer behavior in terms of purchase and waste dumping, therefore they can contribute to a better understanding of the actual recycling behavior. Contextually, a better measurement of the construct of actual behavior would also favor the correct application of TPB and TRGP, consequently this construct would not be biased as it happens in the case of self-reported measures.

Similarly to Chapter 2, Chapter 3 applies a rigorous science mapping methodology through the steps of data retrieval, pre-processing, network extraction, normalization, mapping, analysis, visualization and interpretation (Cobo et al., 2011). By doing so, Chapter 3 exploits the full potential of science mapping to visualize and understand the conceptual structure of recycling behavior (Udomsap & Hallinger, 2020), including finding out the dynamics of the field (Zupic & Čater, 2015) and revealing future areas of investigations.

Moreover, Chapter 2 and 3 highlight that the full understanding of pro-environmental behaviors requires a holistic approach both from the stakeholders' point of view and in terms of analysis of factors and conditions, through comparative analysis as well. In fact, these chapters also indicate that the value of the comparative analysis of different stakeholders' perspectives is often underestimated, although very beneficial. In relation to the advantages coming from the analysis of all stakeholders, the application of TPB on the managerial level offers the possibility of better understanding the

relationship between managers and workers, or corporate social responsibility. Furthermore, this holistic approach may contribute to the individuation of new key constructs and to the implementation of effective intervention measures.

Chapter 4 also contributes to the body of literature on recycling behavior by showing the benefits of adding the constructs of habits and environmental motivation to the TPB framework. These additional constructs are still aligned with the TPB principles and do not represent a redundancy of the typical TPB predictors of behavior. Actually, the construct of habits highlights some peculiarities of separation behavior such as its repetitive nature. Moreover, the introduction of the construct of environmental motivation in the proposed extended TPB model supports Ajzen and Kruglanski (2019)'s claim that the typical TPB predictors may not be sufficient to activate behavior.

Although this Chapter introduces the concept of motivation in an extensive way and in conjunction with environmental goals (therefore in a different way from Chapter 5), it captures both the key role of motivation and the fact that a habitual behavior such as waste separation is goal-driven as well. In fact, motivation has the capability to spark the intention to perform the behavior, whereas attitude and subjective norms alone may not be enough for doing that. In addition, this case study shows that separating waste may achieve one or more goals, such as the environmental ones.

Chapter 5 represents, to the author's knowledge, the first application of TRGP to waste-related behaviors (as of September 2022). After the first absolute application of TRGP to physical activity in the academic papers in English language (Hamilton et al., 2022), this chapter represents a seminal study in the field of pro-environmental behavior. The findings highlight the importance of active goals and motivation in addition to the typical TPB predictors; in particular, APGs have a predominant effect on the precursors of intention compared to AAGs. In this regard, it is worth noting that the "marginal" role of AAGs is probably due to the specific contextual situation of respondents who are not significantly influenced by "important others" (in relation to their waste separation).

In general, the outcomes of the application of TRGP to separation intention in Rome indicates high levels of correlation and variance for the constructs, therefore they support the validity of the TRGP model in the study of recycling behavior. In particular, Chapter 5 demonstrates that TRGP shows a strong explanatory capability for behavior not under full volitional control such as routine behaviors; moreover, the findings support Ajzen and Fishbein's proposition that motivation is a valid and immediate proxy of intention to separate.

Furthermore, Chapters 4 and 5 highlight some cases of inappropriate definition of scales to measure some constructs in the academic literature. For example, at times, when applying TPB, behavior is confused with past behavior (Cho, 2019; Fan et al., 2019; Khan et al., 2020; L. Xu et al., 2017). Actually, the measurement of behavior cannot take place when the sample is initially queried about TPB predictors of behavior; at that time, asking questions about recycling frequency and quantity refers to past behavior only. As explained by Fishbein and Ajzen (2011), in order to correctly measure self-reported behavior, the participants have to be recontacted after three months from the administration of the initial questionnaire (or a specific time compatible with the behavioral criterion), so they can be queried whether they performed that behavior or not during the last three months (or the applicable timeframe). In other occasions, behavior is confused with beliefs or personal satisfaction (Kechagias & Dimitriadis, 2019), or with awareness and planning (Mondejar-Jimenez et al., 2016). At times, different measures of the items which define the same construct are mixed; for example, Strydom (2018) combines overall average frequency of recycling, quantities of specific types of waste and "taking responsibility for recycling in the household" (p. 5). These issues may lead to incorrect findings or deductions not in line with the theoretical framework of reference; therefore, a correct definition of the way to measure the constructs is paramount. This thesis also provides its own contribution to clarifying the difference between past behavior and habits; moreover, it offers a specific way to measure habits by investigating triggering factors as well.

Chapters 4 and 5 also highlight the importance of applying the correct methodological steps in the preparation of a questionnaire, in particular the utilization of an eliciting questionnaire. This type of

questionnaire represents a key step for understanding the different types of goals and their overall architecture in an unbiased way.

Lastly, Chapter 5 points out the importance of executing a holistic and proper analysis of active goals; contextually, it warns researchers of the difficulties of unveiling goals in the case of habitual behavior. For example, a superficial analysis may not reveal the real presence of a goal, consequently the researcher may conclude that the behavior is not driven by any active goal. Furthermore, Chapter 5 draws attention to the limitations of the final questionnaire when active goals are not adequately elicited by the investigation method. In fact, while the respondents answer the questionnaire, it is almost impossible to recreate the same environment in which waste separation normally takes place. For example, if we think about the preparation of meals in our kitchen (including the dumping of food leftovers in the waste bins), this environment is characterized by specific visual cues, peculiar smells, and standard bins position inside the house. Furthermore, performing the action of waste separation in this specific environment triggers mechanisms which automatically activate one or more goals. As previously explained, the action of separating the plastic packaging from the food may make the individual think about the importance of eco-packaging; similarly, by watching the plastic bin getting frequently filled up by plastic material, the individual may think about the huge production of plastic and the pollution caused by plastic bottles and packaging, then he/she may activate the environmental protection goal. It follows that respondents may be unable to recall the applicable active goals while answering the questions, therefore the questionnaire should try to mitigate these limitations by recreating the usual waste-separation environment in the preamble of the question (for example, the questionnaire may ask the respondent to pretend to be in his/her kitchen while preparing the food for cooking). This limitation represents a crucial aspect for habitual behaviors considering the activation of goals is not under full volitional control as it may happen for other more volitional behavior such as studying or practicing physical activity.

### **6.2.2. Contributions to Practice**

As explained in Chapter 2, the SLR highlights the limited interplay between GenCB and PECB and suggests some corrective measures aiming at creating a favorable environment and a supportive institutional-legal framework. The former can be improved by implementing a reward scheme, sustaining local pro-environmental organizations, promoting imitation driven processes, and organizing “recycling days” in the neighborhood for the collection of specific types of waste (such as batteries, exhausted oils, oversize waste). The latter can be fostered by imposing the utilization of reusable containers for food packaging, defining an effective sanctioning mechanism for people not recycling correctly (e.g., installation of video cameras in the vicinity of road waste bins), and creating ad hoc informational campaigns.

Chapter 5 not only explains the importance of defining the structure of goals to correctly understand an individual’s behavior, but it also provides suggestions on how to influence goals and motivation. In fact, as previously explained, in order to obtain a specific behavior, it is essential to activate one or more specific goals and to motivate people to achieve these goals. Furthermore, considering the key role of motivation and goals, waste service providers and decision makers should understand the goal systems of the targeted population in order to implement tailored interventions. In fact, if people live in a context with a high sensitivity for environmental matters (because, for example, of the consolidated presence of proactive pro-environmental organizations or in view of a high level of pollution), it is beneficial to activate and promote high level altruistic goals such as environmental protection. In this case, waste service providers and municipalities should foster environmental goals in spite of hedonistic goals through persuasive communication; in fact, they should exploit the dynamic nature of goals because “when a goal is activated, competing goals are inhibited” (Kruglanski & Szumowska, 2020, p. 1266). Vice versa, if people live in a degraded socio-cultural context where they do not perceive the importance of protecting the environment (for example, because the recycling program in that area is inefficient and all types of waste are indistinctly sent to



landfill), goals and motivation should also be reinforced through a reward system, especially if the economic and financial conditions are poor.

In addition, Chapter 5 suggests promoting the weakest active goals (namely AAGs), even though this research shows a limited influence of AAGs on motivation. The range of possible interventions to promote AAGs is quite varied depending on the socio-demographic dimension of the target population and the context; in any case, the enhancement of AAGs should be pursued in conjunction with the promotion of subjective norms which are typically based on social recognition. Therefore, interventionists should also consider encouraging the approval of “important others”, both at the family level and at the workplace or school (Hamilton et al., 2022). It is clear that this type of intervention requires a huge effort at different societal levels and the beneficial effects will probably be visible in the long term. For example, schoolteachers should promote environmental goals from the early stages and represent a firm point of reference for pupils; contextually, parents should also be involved in the environmental education of their children and in the diffusion of pro-environmental goals among youngsters.

Similarly, if the final user is not significantly influenced by norms (because law enforcement is weak) and he/she is not guided by strong AAGs, a sanctioning system is not going to be very effective. For these reasons decision makers and waste service providers have to be very familiar with the final users’ goal systems, perceptions and beliefs before implementing any recycling program.

Chapter 5 also addresses the problem of changing incorrect habits, which is often the case of waste separation behavior. The application of TRGP to habitual behavior is based on the consideration that routine behavior is goal-driven behavior as well; it follows “the possibility of changing habits and uprooting ones that are undesirable and harmful” (Kruglanski & Szumowska, 2020, p. 1266) through ad hoc intervention on goals. Therefore, policy makers and waste management companies, after identifying the goal serving the correct behavior, have to define an alternative behavior and couple it with the goal serving the correct behavior. This coupling generates the expectancy that the alternative behavior satisfies the goal more effectively (Kruglanski et al., 2002; Kruglanski & Szumowska, 2020).

Furthermore, Chapters 4 and 5 emphasize the need to tailor waste recycling programs to the socio-demographic characteristics of the final users. For example, different ages and incomes require different measures in order to make waste separation more effective. In fact, the analysis of academic papers on reward methods shows that the efficacy of rewarding schemes (or sanctioning system in case of inappropriate waste separation) is highly dependent on the context and the final user. If the final user has a good remuneration and is not sensitive to environmental issues, a reward scheme is not going to produce significant improvements in his/her recycling quantity and quality. This type of user is likewise not influenced by any campaign promoting household composting regardless of the fact that the compost bins are for free. Also, elders require a different informational and motivational campaign from youngsters in consideration of their different goal systems, different sensitivity to environmental problems, and different reactions to the introduction of new recycling programs. Numerous techniques are available to promote behavioral changes (Hamilton et al., 2022) such as demonstration of virtuous behavior, encouragement, reward programs, intention formation, and prompting specific goal setting. For example, pupils (from elementary school and, possibly, kindergarten) should be taught ad hoc environmental programs including visits to recycling plants, composting exercises at school, participation in pro-environmental events or games (involving the utilization of recycled materials and including motivational awards or recognitions), presence of all types of recycling bins in the school (e.g., battery recycling, WEEE recycling, clothing, besides the most diffused waste bins such as plastic, metal, food, glass, paper and cardboard). Obviously, school programs need to be tailored to the age of the students and to the type of studies as well. In fact, teenagers should be taught topics such as re-utilization of resources, respect of biodiversity, environmental protection and climate change; contextually, these topics should be presented in the form of high-level goals to guide their entire life. For example, considering the great diffusion of mobile phones in advanced economies, teenagers should be taught about the valuable materials a



phone is made of, and about the need to recover these materials because of the limited resources available on the earth. In parallel, industry and retailers should implement WEEE recycling campaigns in order to promote the correct disposal of old mobile phones among teenagers (including a refund scheme). In addition, teenagers should clearly be made aware of the consequences deriving from not following basic and sound pro-environmental principles (e.g., increased pollution, irremediable depletion of resources, climate change, loss of biodiversity). Not only, it should also be explained that their contribution, although minimal, is essential to achieve pro-environmental goals at a worldwide level.

Chapter 5 points out that changing the goals system of elders is going to be much more challenging and, probably, less productive in relation to effort dedicated to obtaining the expected changes. Additionally, educational programs may fail unless elders have already internally developed some level of environmental motivation. Moreover, in the case of the introduction of a new waste separation procedure by the waste management company, there are some risks of failure considering elders are more reluctant to change than youngsters. Last but not least, elders may have inappropriate recycling habits if they had not been adequately instructed how to separate waste in their youth. Consequently, behavioral changes of elders can be achieved with ad hoc techniques aiming at showing the risks for their health in case of inappropriate waste separation and handling. For example, it would be useful to explain to them that sending waste to an incinerator creates air pollution, which in turn causes permanent damage to our breathing system; similarly, continuously sending waste to landfills increases the quantity of leachate which is going to pollute the water that we use daily in our house for washing, cooking and drinking. Further techniques are described in Chapter 5 including demonstration of appropriate behaviors (e.g., practical explanation of the way to separate waste in senior clubs), motivational interviewing and monetary rewarding, especially in the case of poor economic conditions. It follows that the gradual ageing of the population in the years to come requires an enhanced attention to and support for elders by interventionists through tailored programs and interventions.

## **6.3. Recommendations and Implications**

### **6.3.1. Recommendations for Further Research**

In addition to the practice and policy implication provided in the previous sections, this thesis offers additional suggestions for future research.

The SLR in Chapter 2, the MKD in Chapter 3 and the case studies in Chapters 4 and 5 clearly explain the importance and the need for a comparative analysis. In the academic literature a limited number of scholars investigates the differences among nations (Ferronato et al., 2019), between metropolitan and rural areas (Agovino, Crociata, et al., 2016; Crociata et al., 2016) or between workplace and home (McDonald & Oke, 2018); nevertheless, this approach has the potential to better understand recycling behavior and to offer new insights in the field (Blöse et al., 2019). Agovino, Crociata, et al. (2016) ascertain the existence of spatial factors influencing and differentiating waste management at the regional level in Italy. Therefore, this thesis recommends exploiting the advantages of a comparative approach (at different levels) in academic research to unveil hidden key elements or better understand the nuances of human behavior. For example, the comparative analysis between waste management behavior at the workplace and at home may promote an enhanced comprehension of TPB and TRGP constructs in different environments, considering some goals (and, perhaps, some organizational values) may become active only under specific conditions only. As explained in Chapter 5, a comparative analysis offers the possibility to appreciate differences among citizens in terms of goal systems, familiarity with separation procedures, barriers to separation, and motivation. Discovering differences among respondents promotes a deeper analysis of behavioral aspects which may apparently be of limited significance; in addition, it may help in understanding the different efficacy of similar recycling programs in different towns or neighborhoods. In this case it is essential to also

consider the effects of contextual factors in order to correctly compare and contrast the behaviors of interest.

MKD and text mining in Chapter 3 offer some potential areas of interest such as the relationship between pro-environmental behavior and the utilization of bitcoin, food packaging, consumer's responsibility on reducing its environmental impact, reuse and reutilization, products obsolescence, effects of COVID pandemic on recycling behavior, consumer "responsibilization", and consumer-driven interventions.

From the methodological point of view, this thesis warns scholars to be very careful when introducing new constructs in an existing theoretical framework. The common trend of including all presumed important factors in a theoretical model may lead to a misalignment or inconsistency with the principles founding the theoretical framework. As repeatedly stressed by Ajzen, new constructs should satisfy some basic criteria, starting from parsimony and causality; furthermore, each theoretical framework should undergo the important test of generalization. The academic literature shows that, sometimes, researchers add new constructs depending on the specific context of investigation; for example, Fan et al. (2019) introduce the construct of "perception of scroungers" (waste pickers) in their model based on TPB. Acknowledging that a deep understanding of human behavior requires a thorough knowledge of the context because human behavior is the result of numerous contingent and competing factors, scholars should be cautious in adding constructs which are extremely context dependent. This approach goes in the direction of tailoring a framework to a specific context, limiting its possibility to be generalized. In this regard, it is worth mentioning that the great diffusion of TPB as a solid framework for studying human behavior in very heterogeneous contexts (from physical activity to energy saving, from recycling to transportation habits, etc.) demonstrates that the typical TPB constructs are able to capture a myriad of shades of human behavior in different environments. Therefore, the researcher should aim at finding the right balance between the capability of generalizing results and the need for accounting for all key factors. There are great chances that a tailored theoretical framework is able to fully capture a specific behavior, but it remains very context-dependent and cannot be generalized to other environments.

As previously mentioned, the inappropriate definition of some scales (to measure constructs) has to be prevented by a thorough knowledge of the theoretical framework and a careful scrutiny of constructs in terms of pertinence and causality. Therefore, researchers should refrain from mixing average measures with specific ones (e.g., overall recycling frequency and specific recycling quantities (Strydom, 2018)); furthermore, they should continuously cross check if their constructs are measured in accordance with the basic principles of the adopted theoretical framework. Consequently, the correct definition of the basic constructs is not a mere and sterile academic activity, but it actually represents a thorough analysis of the essence of the concepts measured by the constructs.

In the academic literature the construct of recycling knowledge is measured in very different ways. Actually, the analysis of the literature points out that this specific type of knowledge is not correctly tested (Ahmad et al., 2016), except in very limited cases (Cheung et al., 1999; Fielding et al., 2016). First of all, the parameters defining the level of knowledge should be pertinent to the type of behavior under investigation. In fact, quite often, researchers query their sample on waste separation with generic environmental questions which are not capable of verifying whether the consumer really knows how to separate its waste (Zarei & Maleki, 2018). This approach leads to the wrong conviction of having correctly measured the construct and, consequently, increases the risk of wrong conclusions.

Moreover, being that some constructs are significantly influenced by the surrounding context, it is essential to specify what constructs exactly measure. In fact, Chapter 4 clarifies that past behavior is measured in terms of recycling frequency of organic waste, paper, glass and plastic. As previously mentioned, the frequency of separation of different types of waste may not represent an adequate measure of past behavior if some types of waste are not collected in the geographical area of investigation. For example, the waste management procedures of a specific town may not require

separating plastic from metals, whereas they may differ in another town. In addition, past behavior of an individual may be affected, for example, by the participation in specific recycling programs at work or school, or the involvement with pro-environmental organizations. Therefore, the definition of a scale measuring the level of separation frequency is very product-dependent and context-dependent, so it may include other past actions related to waste separation but different from the typical waste sorting at the household level. Moreover, from a statistical point of view, a reduced number of items (composing the scale) may lead to critical Cronbach's alpha values.

Considering TRGP is a recent framework with an extremely limited number of case studies in the academic literature (to the author's knowledge, one article on physical activity and Chapter 5 in this thesis as of September 2022), it is essential to test TRGP with other case studies and in different contexts. As per TPB, a theory has to pass the test of generalization before being considered a solid theoretical framework; this is the reason why TPB is so diffused in the academic world and scholars often propose models which are an extended form of it. At the same time, TRGP may not be a theoretical end state, therefore practitioners and scholars are warmly invited to test this framework by also making possible modifications such as adding new constructs; contextually, these modifications should be in line with TRGP guidelines and undergo the testing described in Chapter 5.

In relation to the sample selection, this thesis recommends not only the importance of an adequate sample size to prevent methodological and statistical issues, but also the correct representation of respondents.

Concerning the sample size, the researcher has to be very familiar with the limitations and implications deriving from a limited or incomplete set of data. In the case of a small sample the weight of each single data increases, therefore possible outliers may significantly influence the overall analysis of data; at the same time, the researcher should refrain from excluding outliers in order to correctly analyze the entire sample. In the case of an incomplete set of data, the researcher may experience problems with bootstrapping, therefore he/she may have to make the decision whether to apply imputation or exclusion of incomplete data; this decision has to be clearly motivated in the methodology section and inferences have to carefully consider these limitations. In addition, researchers should be very familiar with advantages and disadvantages of statistical analysis and related tools such as SEM. SEM is a very powerful tool which allows us to analyze possible relationships among a great quantity of data, but it also has specific requirements to satisfy preliminarily (e.g., normality of data for maximum likelihood (ML) analysis).

Concerning the correct representation of respondents, the review of literature on recycling behavior shows recurring types of samples such as university students or householders and a lack of elders. In this case, it is worth highlighting that the hierarchy of values and goals in elders is likely different from youngsters for obvious reasons, therefore the application of the TRGP framework to a sample of elders may lead to different outcomes from a sample of youngsters. In this regard, multi-group analysis offers the possibility of better analyzing different groups of respondents.

In relation to goals analysis, future research should focus attention on the dynamic characteristics of goals. As previously explained a goal may change over time or depending on the context, it may become inactive, it may be latent or predominant, consequently it is very important to be able to capture the active and applicable goals when applying TRGP. In this regard, a holistic analysis of goals is necessary to understand the hierarchy of goals, their "multifinality" and "equifinality", and their relationship with means.

Chapters 2 and 5 open the debate about the correct relationship among constructs utilized for describing pro-environmental behavior (e.g., linear versus non-linear, equal weight versus predominance of a factor), therefore researchers are recommended not to automatically assume standard relationships among constructs. As stated by Ajzen and Kruglanski (2019), APG and AAG have a privileged status in the genesis of attitude and subjective norms; this inference is in partial contrast with the compensatory approach of the expectancy-value model in which all terms have the same weight. In general, we may expect numerous and different types of influencing factors at

different levels. In this regards, mediation and moderation analysis may help understanding the complexity of the situation.

Another research area which needs further investigation is the study of the relationship between macro and micro-variables. Considering TPB and TRGP focus on the individual and the individual is immersed in a specific context in which macro-economic, macro-social and macro-cultural variables play a key role, it is important to understand their relationship. It is clear that, according to TPB and TRGP, the effects of macro-variables such as the efficacy of educational programs or waste management services are included in the constructs of attitude, subjective norms, PBC, goals, etc. Nevertheless, the analysis of pro-environmental behavior needs to be contextualized in order to correctly assess and understand the influence of key factors on the typical TPB and TRGP components. This approach does not necessarily aim at introducing new constructs in TPB and TRGP frameworks, but it tries to better understand how external mechanisms influence behavior at the individual level. This approach would also be helpful to better assess the validity and efficacy of the implemented corrective measures; moreover, it would promote an interdisciplinary analysis of the topic of investigation. It is also worth remembering that the analyses of Singaporean citizens' pro-environmental behavior in Chapter 2 has highlighted the importance of investigating the influence of the socio-cultural, legal, institutional and infrastructural context. In fact, although Singapore represents a quite rare example of successful institutional pro-environmental management, it demonstrates how a solid institutional framework, supportive information and educational campaigns, a high level of law enforcement, a sense of discipline, an implementation of cultural initiatives, and a diffusion of communitarian values through environmental campaigns create a supportive environment to improve citizens' recycling behavior. Therefore, the holistic analysis of stakeholders and context should guide researchers, policy makers, institutions, managers and waste service providers. In fact, the focus should not only be on separation behavior and recycling scheme, but also on eco-design of products, production and purchase phase, product life cycle, corporate social responsibility, legal framework, etc.

Considering the peculiarities of waste-related behaviors, future research may address the need for a clear taxonomy of these behaviors. In fact, some scholars utilize the term recycling behavior as a synonym of separation behavior or sorting behavior; others distinguish them. At times, re-use or re-utilization are confused with recycling; for example, Lee and Paik (2011) analyze the Korean household "recycling of reusable materials". Some scholars distinguish composting from recycling (Mosler et al., 2008), while others consider composting as an integral part of recycling (Andersen et al., 2011). Furthermore, others distinguish the private dimension of recycling behavior from the public one (Gkargkavouzi et al., 2019). Considering waste-related behaviors are influenced by the context, the socio-cultural background, the legal-institutional framework, the recycling schemes, etc., the definition of the taxonomy is going to be challenging.

Another important aspect requiring further investigation is the effectiveness of intervention measures adopted by waste service providers, municipalities and governmental organizations.

Some scholars have investigated this topic, but it would be useful to define a standardized methodology to assess it in order to properly appreciate this effectiveness and, consequently, better understand how to interact with final users and prevent possible failures in the service.

Another topic for future research (proposed in chapter 2) is the effect of innovation and technology on waste-related behaviors. This analysis may offer new insights on the possible enhancement of consumer awareness in relation to its impact on the environment, or to the quality of its daily recycling. In turn, it would be useful to understand whether this enhanced awareness influences environmental goals and motivation, and at what level.

Last but not least, the research on recycling behavior should take advantage of big data analysis considering waste management systems are getting interconnected in smart cities. A careful analysis of these data may offer an enhanced understanding of final user behavior in terms of habits, quantity and frequency of waste separation.

### 6.3.2. Recommendations for Practice and Policy Implications

A general recommendation to scholars applying cognitive theories such as TPB and TRGP is to always think about the practical implications of their research in order to avoid that their studies remain at a theoretical level only. In fact, these theories tend to focus on the individual in itself, whereas they do not offer, for example, a framework to analyze barriers to perform the behavior of interest. Contextually, the implementation of correct recycling behavior presupposes the thorough knowledge of local recycling procedures among researchers, practitioners, decision makers and the final users. Therefore, besides understanding human behavior, it is important to analyze the obstacles to the correct waste separation and how they are perceived by the final user in order to reach an efficient waste management. It follows that the roles of all stakeholders are important: governmental institutions have to define a supportive legal framework, industry has to design and produce eco-friendly products, final users have to correctly separate waste and waste service providers have to offer an efficient service and widely explain what type of services are provided. In this regard, waste management companies and policy makers should care about understanding how waste related information is perceived by the final users, therefore it is essential to maintain an open channel of communication with them.

Chapters 4 and 5 conclude that corrective measures aiming at improving waste separation at the individual level have to focus on reinforcing pro-environmental goals and related motivation. Numerous examples on how to promote goals and motivation have been presented in a previous section, therefore readers are kindly invited to refer to that section for further information on this topic.

This thesis highlights that the development of effective separation behavior is highly dependent on creating a supportive environment. The range of measures to apply in order to reach this objective is wide: for example, the promotion of educational campaigns, the sharing of information in clear and widespread manner, the development of a supportive legal framework (including a real and timely sanctioning system in case of deviations), the promotion of positive spillover effects, a reward scheme, the support to pro-environmental organization, the adoption of reusable food and drink containers, the optimal distribution of recycling bins for the different types of waste in the neighborhood, the involvement of all stakeholders (especially final users) in the decision making process, the promotion of the interplay between GenCB and PECB.

Another key point to emphasize is the need to distinguish and tailor the intervention measures according to the socio-demographics characteristics of the population of interest. For example, in relation to the age of the target population, schools have to create adequate educational campaigns for youngsters in order to develop pro-environmental values and basic principles such as the respect for biodiversity and the wise utilization of natural resources. In parallel, policy makers, institutions and service providers should create ad hoc informational campaigns for the elders because their system of values and goals is different from the youngsters; it is likely that introducing or promoting pro-environmental values in elders' mind is going to be more challenging than in youngsters, especially if elders have never been directly exposed to environmental issues. Another group requiring particular attention is the middle age because during their school years they were probably not exposed to any structured form of environmental education as happens nowadays in advanced economies (A. Zhang et al., 2019). Nevertheless, their role in the society is fundamental because they may educate young generations, or they may be part of the decision-making process at governmental institutions, enterprises or service providers. At the same time, their mindset and habits are already consolidated, therefore their behavior is tough to modify; moreover, their goal systems may privilege more pragmatic goals (e.g., buying a house or getting a stable job) than pro-environmental goals. In short, they represent a great challenge in relation to the improvement of waste management because they may lack sensitivity towards environmental issues, and they deeply influence youngsters and elders. Just as an example, in case of improper separation behavior their conduct may undermine the daily effort of educators or may nullify the good intentions of any pro-environmental campaign.

This analysis also leads to another important recommendation: considering in many nations the lifespan is getting longer, the definition of effective informational and motivational campaigns for elders becomes essential for the full success of the recycling scheme.

To design effective behavioral corrective measures, it is also essential to understand the preferred means of communication by the final users and the type of information they are looking for. These issues are quite often underestimated in the studies on waste management behavior, leading to findings with limited impact on the design of effective measures. In fact, in relation to electrical and electronic waste, Wang, Guo, et al. (2018) state that “current information publicity about e-waste recycling is insufficient, or the publicity content thereof does not actually promote the willingness to recycle” (p. 1). For example, it often happens that the final user does not receive any direct and regular feedback on the level of recycling in his/her town; on the contrary, it would be beneficial (for the entire recycling chain as well) to keep people regularly updated on that.

Another recommendation concerns the full exploitation of technological advances for improving the level of recycling starting from a better monitoring of the waste produced by the final user and the related behavior. In this respect, environmental IoT, smart waste management, sensor network system, smart city design, ICT have already proved to have great potential for improving many aspects of the waste management process (Sartipi, 2020).

In relation to household recycling, an electronic scanner or an image processor positioned in the vicinity of the waste bins in the kitchen may improve the quality of separation for elders and, in general, for people not familiar with waste separation. In this case, a scanner (with wi-fi internet connection to the waste management company) could visually and verbally indicate the correct bin, the exact waste pick-up days and the money saved in case of a reward system; the scanner could also enhance the understanding of the recycling instructions printed on the packaging. In fact, sometimes, final users have to carefully read small recycling instructions on the packaging to correctly understand how to separate waste; this reading may not even happen in case of time constraints, consequently it would lead to the possibility of wrong separation. Moreover, the final user may not be familiar with local recycling procedures or with the recycling symbols on packaging, especially for elders who are not familiar with waste sorting.

In relation to waste separation and collection through road bins, the utilization of image or weight sensors to remotely control the level of filling of road waste containers would optimize the use of waste trucks and resources. At the same time, it would indirectly promote a virtuous separation behavior because the final user does not find overfilled bins and, possibly, abandoned waste in the vicinity of the bins. It is clear that waste monitoring requires a very supportive infrastructure starting from an adequate ICT (e.g., enhanced mobile broadband, low-frequency coverage to reach remote areas, embedded SIMs, CCTV cameras) in order to guarantee a high level of connectivity and control (Rao & Prasad, 2018). Moreover, this structure would require an adequate power supply and low-power consumption devices, especially considering that road waste containers may not be connected to the power grid or may be located in remote areas; therefore, it would be useful to equip these containers with self-powered system (e.g., small solar panels).

The full exploitation of these technological advances also presupposes the development of specific competences and new roles in governmental offices, industry and waste management companies. These new roles should know the potential of new technologies, define waste programs exploiting this potential, understand the characteristics of the final users, comprehend key factors and barriers to the implementation of these programs, and introduce corrective measures in case of failures or rejection of new waste separation procedures by the final user. Unfortunately, recent studies show that many organizations are not aware of the potential of smart technologies and lack expertise (A. Zhang et al., 2019). Furthermore, managers, institutions and decision makers need to develop a culture of innovation in their organization, otherwise the potential of smart enabling technologies is not going to be implemented. Considering service providers, industry and decision makers often face financial constraints, it is important to establish a supportive network including technology and financial providers as well.

The role of governmental organizations is especially pivotal in the creation of a supportive legal and institutional framework for implementing smart enabling technologies. In fact, SMEs are often ready to develop and implement technologies, but they lack financial instruments, stakeholders cooperation, adequate waste standards and supportive regulations (A. Zhang et al., 2019). Therefore, governmental organizations should be ready to provide financial instruments to support these technologies, especially considering that the cost of innovative technologies is very high, and the treatment of some types of waste is often not cost beneficial. Furthermore, governmental organizations should define adequate standards in relation to waste management requirements and implement effective law enforcement measures. Governmental organizations should also understand that enterprises work in a very competitive environment, highly driven by market pressure and cost benefit considerations, therefore environmental protection may represent an organizational goal. If a farsighted enterprise decides to apply smart enabling technologies to improve its waste management with probable benefits in the medium to long term, institutions are called to support it because the enterprise may not have any value recovery from waste management in the short term. Moreover, the enterprise may be promoting an innovative waste management measure in an unfavorable environment in which other enterprises may focus on immediately making profit and they may not care about reducing their waste or footprint. In this case, the role of governmental institutions is to control enterprises which apply regular waste management procedures and enforce the law in case of mishandling or deviations with prompt interventions. On the contrary, a lack of regulatory pressure and of timely control would favor enterprises' illegal behavior and demotivate all virtuous enterprises in implementing innovative waste management procedures.

In addition to enterprises, the role of governmental institutions is also fundamental for all stakeholders involved with the life cycle of a good or service. It is clear that the correct appraisal of any kind of waste management involves the entire lifecycle assessment (Morrissey & Browne, 2004). In fact, the entire supply chain (including retailers and repair services) actively contributes to waste management as well, therefore these stakeholders also benefit from a supportive legal-institutional framework. Such a framework would also promote cooperation among stakeholders with a positive impact on the final user, who is going to be more motivated to recycle knowing that he/she can re-utilize or repair their own goods. In turn, an efficient lifecycle (including waste management as well) promotes technology implementation, responsibility sharing and cooperation among all stakeholders, diffusion of pro-environmental values and goals.

Obviously, the supportive legal-institutional framework has to be stable throughout the years, especially in the medium to long term; economic crises and conflicts challenge the capability of governments to guarantee economic stability as well. Therefore, the key role of governmental institutions is also related to the possibility of guaranteeing a stable legal-institutional framework on a long horizon. It is beyond any doubt that timings and investments are critical for enterprises. Consequently, enterprises have to find the right balance between "short-term profitability and long-term sustainability" (A. Zhang et al., 2019, p. 6) because investing in smart enabling technologies for waste management calls for great expenditures and appreciable results may require a long period of time. Therefore, the adoption of smart technologies for waste management is not compatible with profitable short-term objectives, especially considering that SMEs are often required to make decisions which do not exceed the short-term horizon.

In short, the benefits coming from the implementation of technological advances in waste management can only be achieved through stakeholders' cooperation (including final users) in the context of a supportive legal-institutional framework.

## 6.4. Limitations

This section recaps the main limitations described in detail in previous chapters.

First of all, the case studies of this thesis are based on self-reported behavior, not on actual behavior. On the one hand, measuring the real separation behavior, especially at the household level, is very problematic considering the privacy limitations impediments, and the difficulties in defining a



standardized method to measure separation behavior. In fact, measuring separation behavior in terms of weight of the different types of waste (e.g., plastic, cardboard, paper, glass) does not automatically indicate whether an individual correctly separates waste. Similarly, the frequency of separation of the different types of waste does provide objective information on separation behavior; for example, an individual may separate waste on a daily basis because of small waste containers inside his/her house; moreover, a person may separate glass more frequently than paper or plastic because the food or drinks he/she purchases are mainly in glass containers instead of paper boxes or plastic packaging. On the other hand, self-reported behaviors are subject to biases, in particular when investigating people's adherence to waste management procedures; in fact, the overall tendency is to overestimate their compliance with rules. It also happens that people think they know the correct separation procedure, but they actually do not. For example, at times, people do not know in which recycle bin a used napkin should be thrown away; similarly, it happens when food packaging is made of different materials such as plastic, glass or paper. The situation gets worse when packaging is made of materials not separable from each other. It follows that the findings of this thesis may not reflect the actual separation behavior and they stop at the level of separation intention. In addition, all constructs may be subject to biases, consequently outcomes have to be carefully scrutinized and inferences cautiously analyzed.

Second, the measurement of some constructs may not be optimal, or it may be influenced by the context. In fact, in the previous case studies, the constructs of past behavior, motivation and habits may require the addition of further items in the questionnaire in order to measure them in a more appropriate way. For example, in Chapter 4 the construct of motivation is measured by two questions, whereas many scholars advise a minimum of three (Fishbein & Ajzen, 2011). Moreover, some scales could consider further aspects of separation; for example, in Chapter 4 past behavior is measured in terms of separation frequency only. The decision to measure past behavior in this way is clearly specified in the methodological section. Nevertheless, this thesis acknowledges that past behavior may be interpreted in a more holistic way by also considering other aspects such as the participation to clean-up days or the membership in pro-environmental organization.

Third, the size and type of the sample may not be fully representative of the entire population, especially in the case of big cities. For example, city districts may have different garbage collection systems (e.g., curbside or "door-to-door" in some areas of Rome and road bin containers for other areas); moreover, the geographic portion of the town under investigation may be affected by commercial activities or heavy flow of tourists who significantly influence the quality of recycling services and habits of local inhabitants. Similarly, some age groups such as the elders or teenagers may not be adequately represented. Furthermore, the goals may differ among age groups; in fact, we may expect that goals such as work satisfaction or achievement are less predominant in elders than in young adults.

The selection of salient referents in Chapters 4 and 5 is very difficult when considering a heterogeneous sample. In fact, the referents (and goals as well) are likely to be different depending, for instance, on age and culture of the sample. Therefore, salient referents of this thesis may not be fully and correctly represented in the samples of Chapters 4 and 5.

The sample may also be biased by contingent environmental conditions such as the COVID pandemic which may influence individual recycling habits as well. For example, during a pandemic, the frequency and type of recycling may change, so routine waste activity may be temporarily modified. Lastly, a limited size of the sample leads to bigger statistical errors and may favor higher RMSEA and lower fitness indexes for the proposed model; in addition, a reduced size influences the validity of multi-group analysis.

Fourth, although the environmental goals and related motivation appear to be quite stable in the short term, the techniques of investigation and data collection may not be able to capture their fluctuations. This aspect should not be underestimated in consideration that the hierarchy of goals for an individual may change depending on numerous and unexpected factors. For example, during the COVID-19

pandemic, health-related goals may have become more important than other goals and environmental motivation may have become predominant over other types of motivation.

Fifth, although it is clearly stated that the SLR, the bibliometric analysis and MKD in previous Chapters are based on papers written in English only, it is worth recalling that the exclusion of papers written in other languages may lead to incorrect outcomes and it may cause the loss of potentially relevant literature (e.g., papers written in Spanish, Arabic or Chinese only). This thesis compensates for this limitation by combining several consistent databases (Web of Science, Science Direct and EBSCO) which provide a huge and trustworthy data set.

Sixth, this thesis does not address all types of recycling behavior such as those of managers, service providers, retailers, members of pro-environmental organizations; similarly, it does not specifically analyze behaviors at the managerial or organizational level (e.g., corporate social responsibility). Nevertheless, it highlights the interactions of consumers and inhabitants of medium-size and major cities with the surrounding environment, including the societal and economic level. It also acknowledges that a full understanding of the individual recycling behavior requires the analysis of the behaviors of all stakeholders.

Seventh, this thesis applies theoretical frameworks which aim at understanding and predicting human behavior, but these frameworks do not offer corrective measures to improve, in this case, waste separation. In this regard, it is worth clarifying that TPB and TRGP do not define whether a behavior is right or wrong; also, they do not specify any objective to reach (e.g., waste reduction, improvement of waste separation); therefore, they do not provide information about the alignment or misalignment with the objective to reach. In fact, TPB and TRGP offer a cognitive approach and are not corrective tools to find an optimal and rational solution for obtaining an efficient behavior. Nevertheless, they significantly improve the understanding of human behavior by offering a valid framework, therefore they fulfill the essential step of the preliminary comprehension of people's behavior before the definition of adequate corrective measures.

## 6.5. Concluding Remarks

Although this thesis focuses on a very specific type of pro-environmental behavior (namely waste separation) and it is constrained by some caveats and limitations (e.g., reduced sample, case studies in advanced economies only), the solid research methodology allows to scientifically investigate an important and topical area of interest in order to provide useful and actionable findings. In fact, this thesis highlights trends and gaps in the academic literature on waste management. It defines the conceptual and intellectual mapping of the research on recycling behavior. Also, it studies and tests existing theoretical frameworks; in particular, it investigates the effectiveness of TRGP for analyzing separation behavior; at the same time, it offers a conceptual model (based on TPB) to enhance the prediction of waste separation behavior.

On the methodological side, this thesis highlights the importance of defining an adequate search query, utilizing several databases and selecting appropriate tools for obtaining an effective SLR, bibliometric analysis and mapping knowledge domain (MKD). It also exploits the capabilities of SEM; in particular, it applies multigroup and mediation analyses to the samples, it highlights the requirements for these types of analysis and shows their potential to enhance the understanding of human behavior. Lastly, it shows the advantages of applying comparative analysis to the sample in order to foster the comprehension of the topic of investigation.

Furthermore, this thesis, in order to avoid remaining a sterile academic research with no implications on real life needs, provides very useful insights for researchers, practitioners and waste service providers. For example, it explains the conditions and factors which favor the interplay between generic consumer behavior and pro-environmental one, and the shift of the first type of behavior towards the second one. Also, it offers suggestions on the investigation of areas related to technological advances which will influence recycling behavior in the near future such as environmental IoT, smart waste management, sensor network system, waste segregation through image processing, big data analysis and social media. Last but not least, it provides indications and

insights to waste service providers, policy makers and institutions on how to improve information campaigns and to develop adequate education programs for youngsters and elders.



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# Appendices



## Appendix A - Supplementary Material 1 (SM1) of Chapter 2

Note on numbering and titles: Supplementary material is progressively numbered (e.g., A.1., A.2., A.3., etc.). In addition, the title indicates which section or subsection of the main paper it refers to.

### A.1. SM of Chapter 2: General Results

The overall continental analysis shows a clear predominance of Europe, followed by North America and Asia (Figure 26 and SM tab 6 online). It is evident that several factors significantly influence this analysis, like the different economic development level and the fact that selected papers are in English only. Consequently, peer-reviewed manuscripts in non-English languages are not taken into consideration in this SLR, so it is not possible to accurately analyze the situation of Asia and Central and South America, where there is a significant academic production in other languages like Russian, Chinese, Spanish and Arabic. For example, China may have a consistent production of papers in its own national language, namely Mandarin, and a limited presence in journals written in English; this situation may lead to the wrong conclusion that China is not as active (on waste management papers) as the United Kingdom.

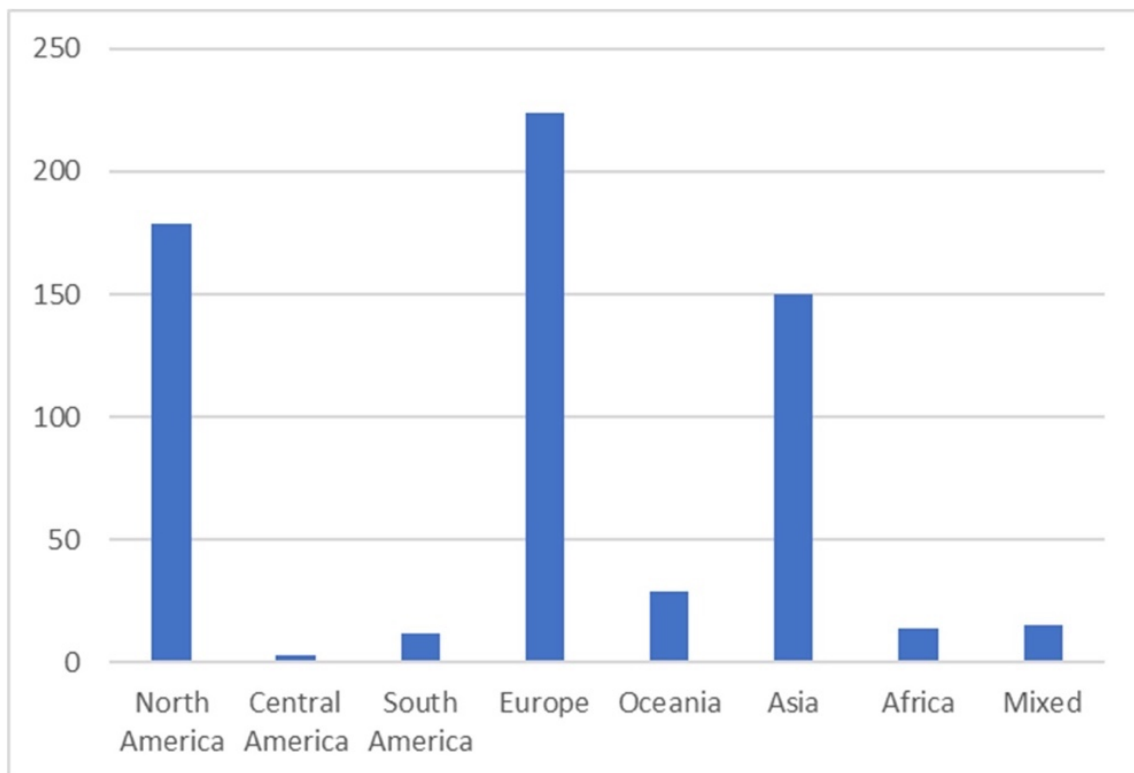
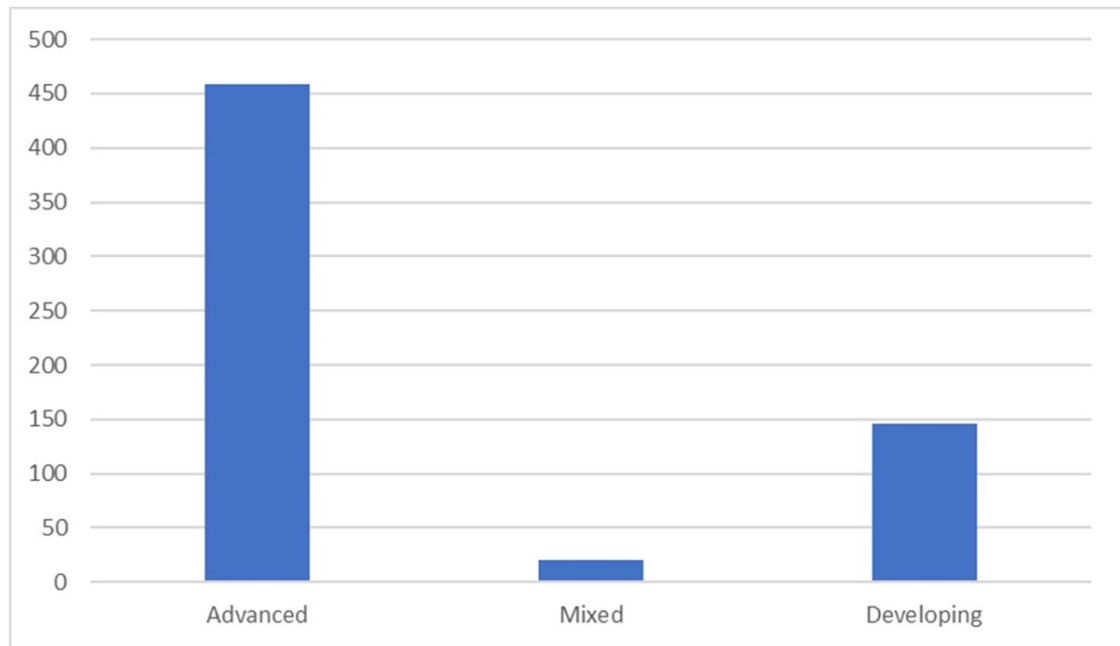


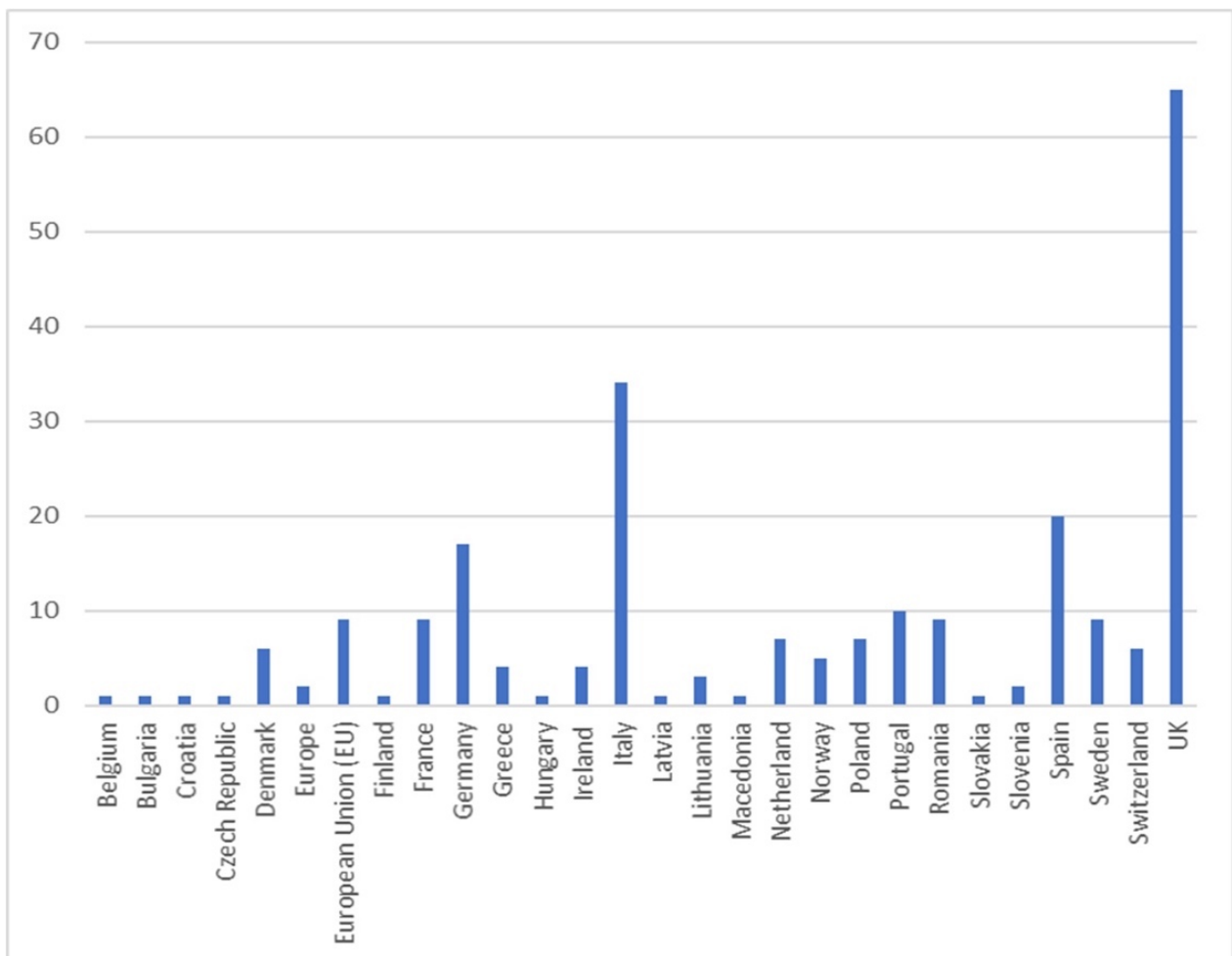
Figure 26. Total number of papers per continent.

The above-mentioned predominance is more exasperated when the analysis is based on advanced and developing economies (as per classification according to International Monetary Fund in October 2019, SM tab 12 online); most of which are European nations as well as the USA, Canada, Israel, Japan, South Korea, Hong Kong, Singapore, Taiwan, Australia and New Zealand (Figure 27 and SM tab 13).

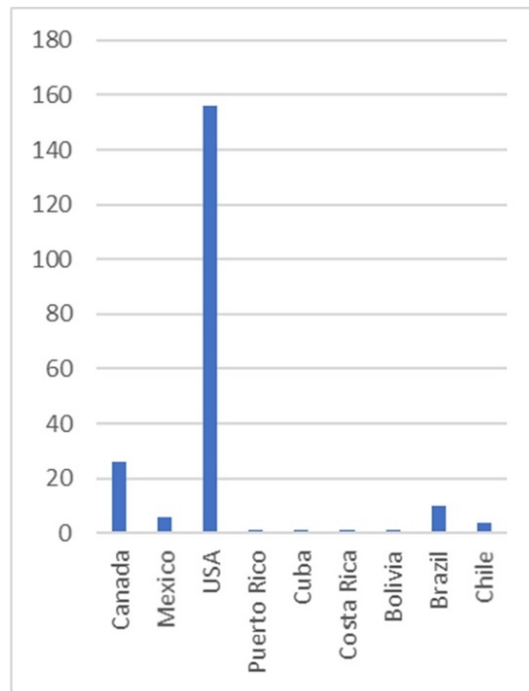


**Figure 27.** Total number of papers for advanced and developing economies.

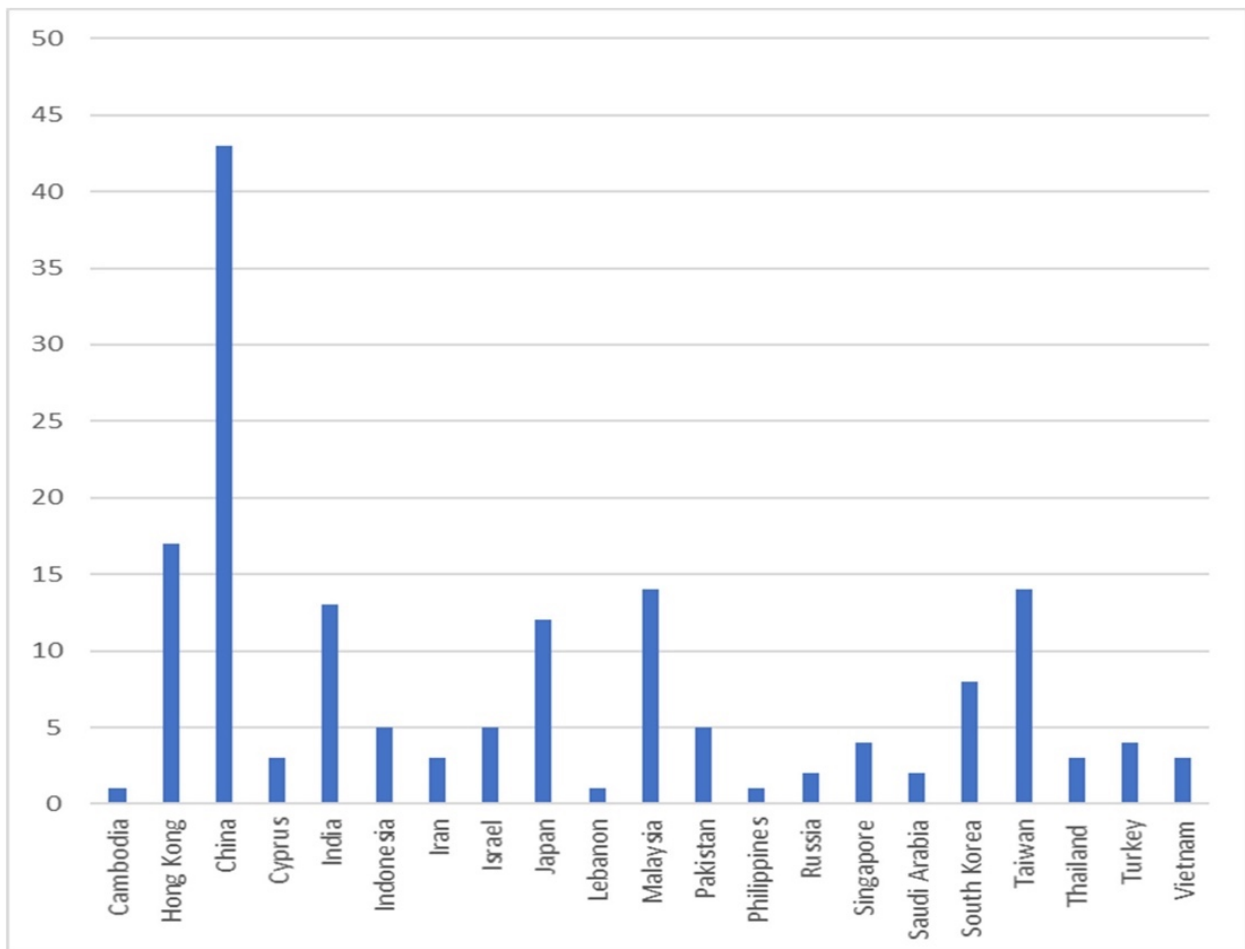
The geographical analysis of the selected articles gives clear information about the interest on this SLR's topic at the national and continental level (Figure 26, Figure 28, Figure 29, Figure 30 and SM tab 6 online).



**Figure 28.** Number of papers per European nation.

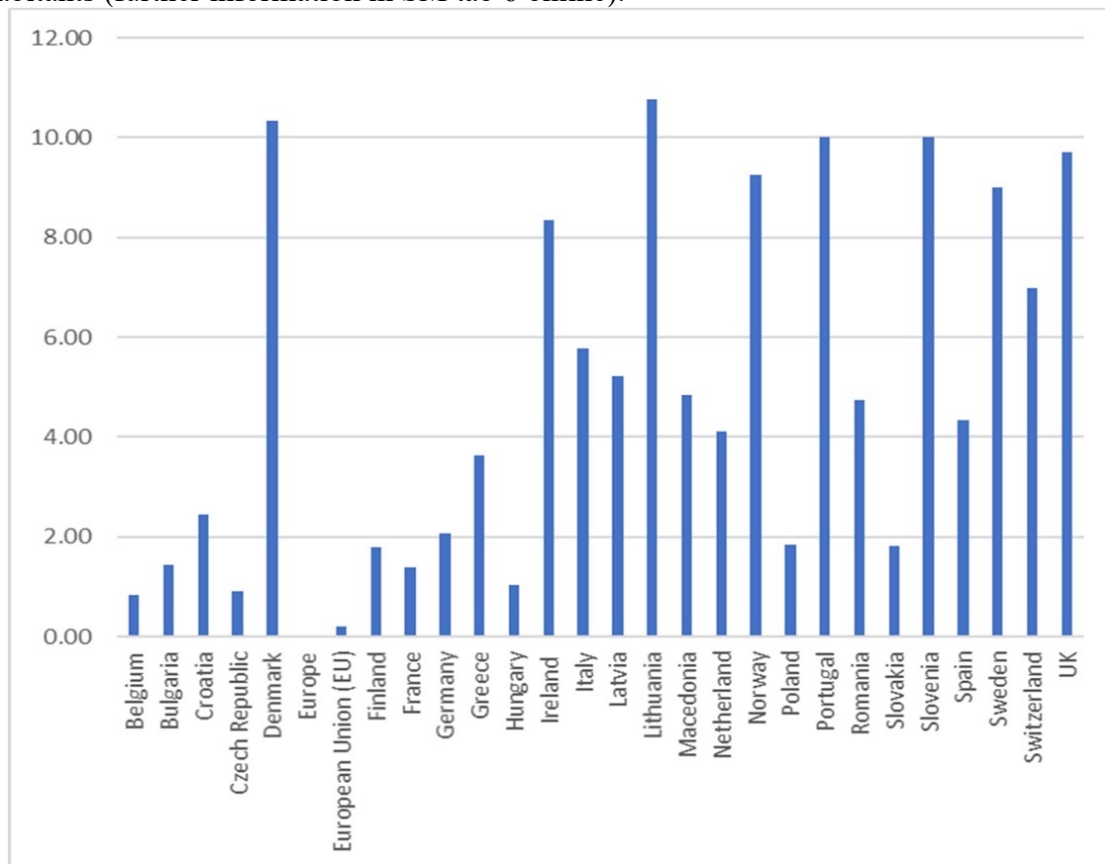


**Figure 29.** Number of papers per American nation.



**Figure 30.** Number of papers per Asian nation.

In addition to the evidence of a strong predominance in Europe and North America in the selected papers (Figure 26), with the exception of China (Figure 30) and Australia (28 papers, SM tab 6 online), the analysis provides further insights when weighting the number of articles with the number of inhabitants (further information in SM tab 6 online).



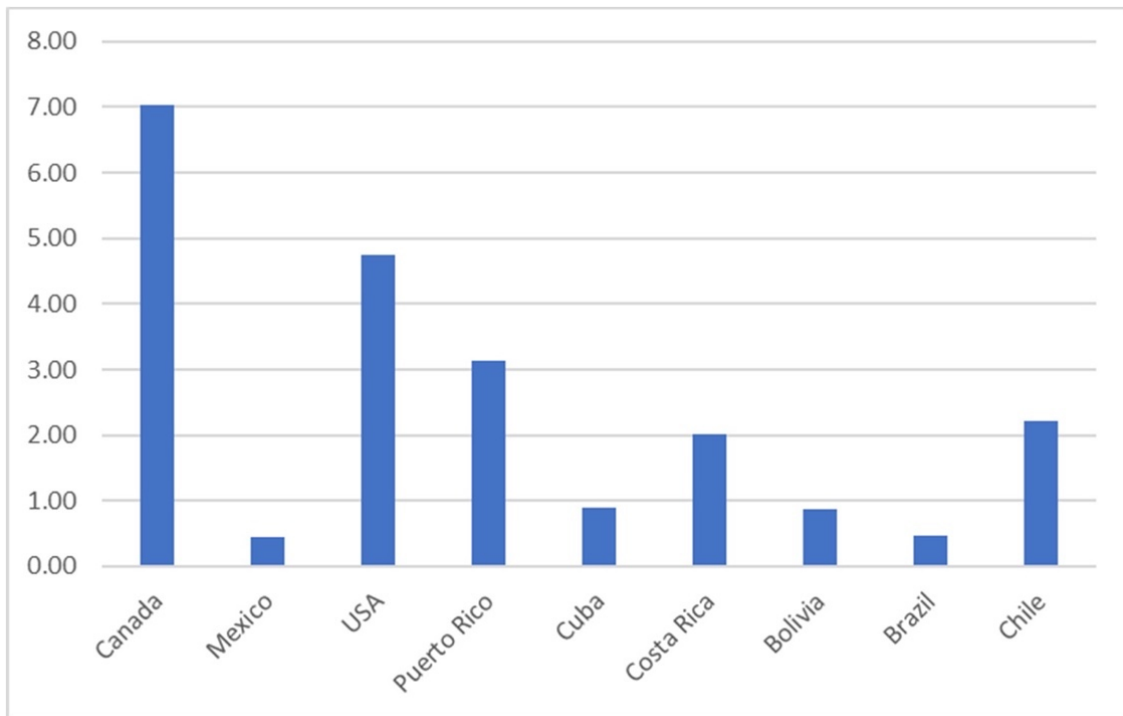
**Figure 31.** Number of papers per 10 million inhabitants per European nation.

By weighting the number of papers with the national population (Figure 31), the predominant production by the United Kingdom among the European nations (a total of 65 articles by the United Kingdom, especially when compared to the second ranking nation, Italy, with 34 articles) changes quite significantly; in fact, the leading role passes from the United Kingdom to Lithuania (10.75 articles/10 million inhabitants), closely followed by Denmark (10.34), Portugal and Slovenia (10.0). For the sake of a correct interpretation of these values, it should be noted that this graph provides reliable indications for nations that have a significant number of articles, so it clearly loses significance for nations like Belgium, Bulgaria, Croatia, Czech Republic, Finland, Hungary and Slovakia that produced only one article each (SM tab 6 online).

Conversely, for nations with an adequate number of articles, like the United Kingdom, Italy, Spain and Germany, this ratio provides more accurate information; for example, the fact that Portugal, Sweden and Romania have a consistent number of articles in relation to their inhabitants may indicate that the Portuguese, Swedish and Romanian populations are particularly sensitive to waste management issues. Focusing on the most populated European nations, this SLR highlights that the United Kingdom shows a high level of production of paper (and possibly interest) in this SLR's topic; Italy and Spain an intermediate level, whereas Germany and France have a reduced production in relation to their number of inhabitants.

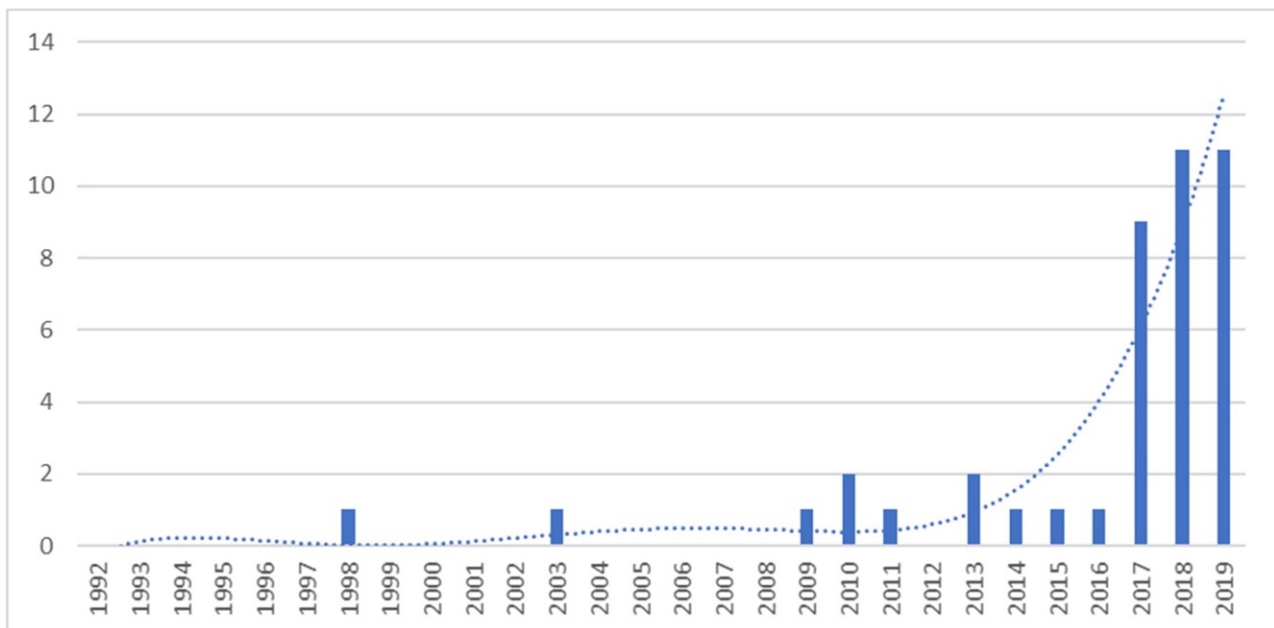
Applying the same approach to North America, the consistent production of papers by the USA compared to Canada is reversed when considering the number of inhabitants; in fact, Canada reaches 7.03 articles/10 million inhabitants, whereas the USA is at 4.74 articles/10 million inhabitants (Figure 32). The values for other American nations are not reliable considering their limited production of papers.





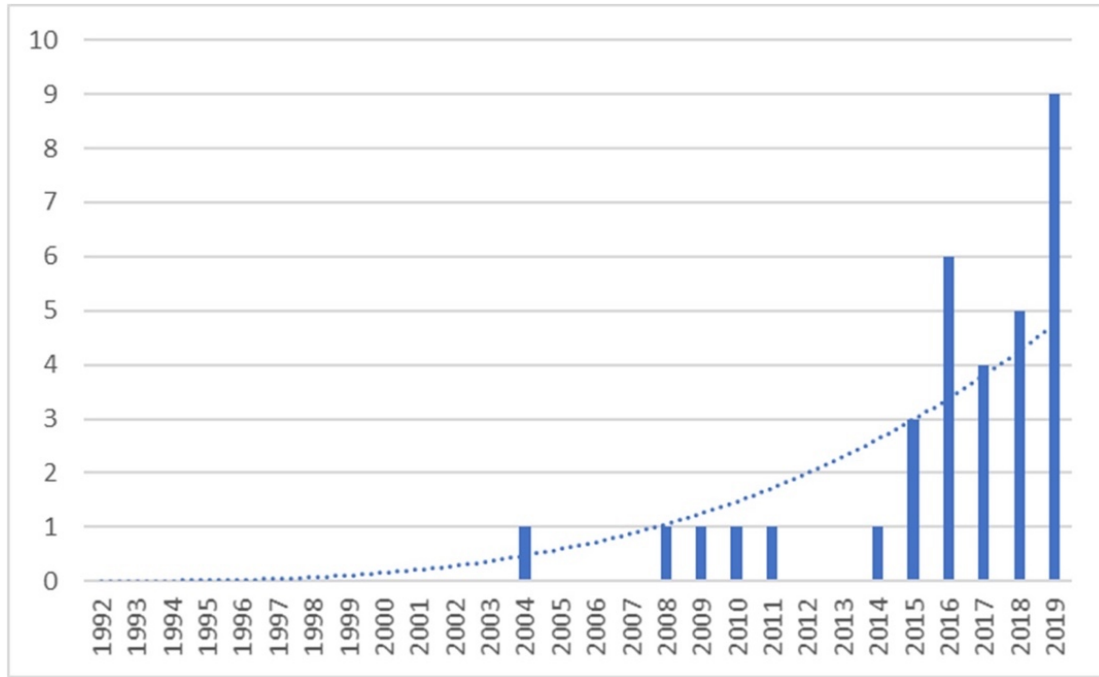
**Figure 32.** Number of papers per 10 million inhabitants per American nation.

Other interesting observations come from the temporal analysis of the yearly production of the papers; for example, China (Figure 33) and Italy (Figure 34) show that most of their articles are not older than three to five years. Furthermore, they display a significant growth (SM tab 7).



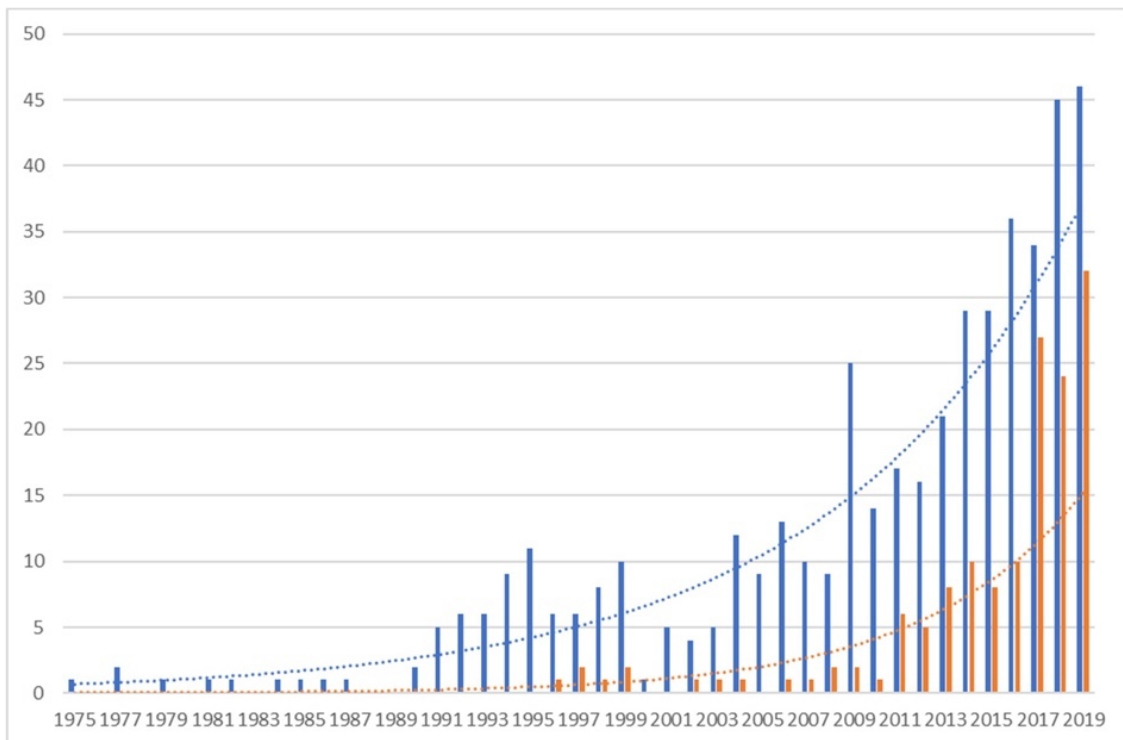
**Figure 33.** Number of papers per year in China with polynomial dotted trend line.

In the case of Italy, the motivation probably resides in the increasing concern for the waste management at all levels (governmental, regional and local) in order to comply with strict European regulations. In addition, the graph certainly reflects the diffused difficulties faced by Italy in dealing with waste management in the latter years; consequently, public institutions (like academia and governmental bodies) or private organizations (like think tanks and non-governmental organizations (NGOs)) have increased their investigations in this field to better understand the critical factors, and define appropriate corrective measures.



**Figure 34.** Number of papers per year in Italy with polynomial dotted trend line.

It is also important to note that just because a nation shows a very limited number of articles in this review on waste management, does not necessarily imply that this specific nation is not sensitive to waste related matters and PECB, as is the case of Singapore. In fact, although Singapore was quite a pioneer in the field of sustainable development, it has only four articles in this review; nonetheless, this value does not imply that Singapore is not a leading nation in this field. Actually, it could be an indication that the waste management system in Singapore has reached an adequate level of efficiency, and the governmental programs for developing sustainable behaviors have achieved their set goals.



**Figure 35.** Yearly number of papers for advanced and developing economies (blue and red colors, respectively).

Through the analysis of yearly numbers of papers per advanced and developing economies it is evident that the exponential growth (highlighted by the dotted trend lines) takes place in both types of economies, but with a different intensity (Figure 35 and SM tab 14 online) In the former the production of papers starts in earlier years, and it is more consistent in terms of quantity (in average, it almost doubles up); in the latter the papers become more significant (again in terms of quantity) after 2010. In relation to the high production peak during 2017 in developing nations, the years to come will perhaps allow better understanding as to whether it is the case of a momentary spike, or there are hidden reasons. In any case, it is important to note that in 2017 the production of papers in developing nations was quite close to that of advanced nations. This indication is confirmed by the 2019 values, and partially motivated by the fact that developing economies are also experiencing the same problems of resources and waste management like advanced nations, but with a few years delay.

## A.2. SM of Section 2.3: Other Theories and Models

Numerous theories and models have been recalled by the authors of the selected papers. In addition to the mentioned “neutralization” theory of Sykes and Matza (1957), it is worth mentioning the tripartite conceptualization proposed by Stern and Dietz (1994), the bipartite conceptualization (ecocentric versus anthropocentric) by Gagnon Thompson and Barton (1994), Perugini and Bagozzi (2001) model of goal-directed behavior, Taylor and Todd (1995a) integrated waste management model, Barr et al. (2001) conceptualization of environmental behavior (Barr & Gilg, 2007), the collective efficacy theory (Bonniface & Henley, 2008), Lindenberg (2006)’s goal framing theory (Scafuto et al., 2018), Celsi and Olson (1988)’s involvement theory (Golden et al., 1996; Wong et al., 2015), the dual-process theories (Best & Kneip, 2011), Dobson (2006)’s ecological citizenship theory (Anantharaman, 2014), Buttel (2000)’s ecological modernization (Flagg & Bates, 2016), the Attitude Behavior Condition (ABC) model (Guagnano et al., 1995), Triandis (1979)’s theory of interpersonal behavior (TIB) (Janmaimool & Denpaiboon, 2016), Grilli and Notaro (2019)’s protection motivation theory (Janmaimool, 2017), Deci and Ryan (2008) self-determination theory (Huffman et al., 2014; Lavergne et al., 2010), Fishburn (1981)’s subjective expected utility (SEU) theory (Best & Kneip, 2011), the social practice theory by Bourdieu (1977) and Giddens and Giddens (1979), the theory of social representations (Abric, 1993; Rateau et al., 2012), and the basic cognitive schemes (BCS) model (Piermatteo et al., 2016). It also has to be noted that in many cases there is some confusion between theory and model, which would require a sort of epistemological discussion that is beyond the overall purpose of this SLR.

The full list of theories and models is available in SM tab 10 online.

## A.3. SM of Section 2.3: Classification of Factors and Conditions Influencing Pro-Environmental Consumer Behavior (PECB)

Table 17 displays the classification of factors and conditions including some examples (the full list is available in SM tab 11 online).

**Table 17.** Classification of factors and conditions (SM of Chapter 2).

Type of Factors	Factors and Conditions	Examples
Individual	Acceptance/rejection of responsibility	Ascription of responsibility, acceptability, reluctance
	Attitude	Recycling/pro-environmental attitudes, political attitude, attitude towards bio-based product
	Awareness/ concern	Awareness of consequences, ecological concerns, considerations of future consequences, environmental awareness/concern
	Beliefs	Conservation/materialistic/austerity belief, normative/introjected belief, beliefs about recycling

	Convenience/ self-interest/ satisfaction	Convenience of recycling, self-interest, egoism-hedonism, selfishness, individual environmental satisfaction
	Education/ knowledge	Subjective/objective knowledge, environmental/ procedural knowledge, competencies, education
	Emotions	Affective and emotional reactions
	Expectations	Individual expectations
	Guilt/shame	Shame, guilt, eco-shame, eco-guilt
	Intentions	Intentions (to recycle), conservation intentions, prosocial intentions, intention to purchase recycled products
	Locus of control	Locus of control (LOC), environmental locus of control (ELOC), internal/external LOC
	Moral norms	Moral responsibility, morality, moral judgment
	Motivations	Recycling motivation/goals, motivations to comply with environmental regulations
	Perceived behav. control (PBC)	Self-efficacy, skills, ability to overcome inconveniences, ability to recycle
	Perceptions	Perceived lack of recycling facilities, perceived policy effectiveness, perceived consumer effectiveness, perceived personal costs, perceived effectiveness of the sanction, perceived environmental responsibility
	Personal/ subjective norms	Personal norms/values, subjective norms/values
	Present and past behaviors	Past behavior, habitual behavior, private/public sphere behaviors, recycling behavior
	Relationships/ gaps	Attitude-behavior gap, attitude-intention relationship, past behavior- intention relationship
	Self-efficacy/ self- esteem/ self- determination	Self-efficacy, environmental self-affirmation, pro-environmental self-identity, centrality of self, self-determination of environmental motivation, self-esteem
	Stress	Psychological/urban stress
	Values	Intrinsic/extrinsic values
	Willingness	Willingness to be environmentally friendly (WEF), willingness to support policy, willingness to pay (WTP), willingness to engage in PEB
Collective (socio- demo_ graphical)	Common values/trust	Worldview, national values, generalized institutional trust, social trust
	Cultural factors	Cultural capital/values, cultural consumption, collectivist culture
	Demographics	Gender, age, income, education, family size, employment, marital status, house ownership/type, race/ethnicity
	General behavior	Household habits, shopping behavior, neighborhood behavior, eating behavior
	Lifestyle	Environmental/sustainable lifestyle, consumerist-type lifestyle
	Presence of social agents	Parents, family, neighbors, friends, activists, block leaders, environmental organization, racial/ethnic groups
	Public awareness	Public awareness of green consumption
	Public perception	Public perception of environmental measures
	Social behavior	Public sphere behaviors
	Social interactions	Personal/family relationship, civil involvement, neighbor influence, social pressure/influence/exclusion, affiliation, spillover, stakeholders influence
	Social norms	Social norms, social acceptance of environmental policy
	Religion	Religion, spirituality
	Institu_ tional-legal	Control, sanctions
Institutional interventions and stakeholders' involvement		Active role of governmental institutions, encouraging bio-diversity and sorting behavior, environmental advocacy, citizens/stakeholders' involvement, citizens engagement in the co-production of public services, diffusion of environmental values/knowledge

	Institutional quality	Efficient legislation, recycling policies, judicial system, ecological Justice, institutional framework at various level (from municipal to national)
	Legal Norms	Legal/environmental norms on moral perceptions and civic enforcement
Informa_tional	Informational intervention	Informational/Media influence/intervention, green nudging, informational pressure/seeking
	Informational quality	Information-vacuum/contamination, source credibility, information publicity, presence of eco-label, media support
Political-ideologi_cal	Consensus/trust	Pro-environmental consensus, trust in politics
	Diffusion/presence of ideologies	Political ideology, party orientation, green skepticism, environmentalism, ideological values
	Political pressure/engagement	Political pressure/polarization, authoritarianism, social Dominance Orientation, partisanship
	Presence of political agents	Political leaders/parties, environmental/green leaders/parties, block leaders
Economic	Consumer economical characteristics	Consumer's identity/ethics, green product purchasing behavior, public awareness toward circular economy, acceptance of remanufactured products, green self-identity, attitude towards bio-based product
	Consumer interaction with economy	Social Responsible Consumption, upcycling, CE-related behavior, market skepticism, consumer authority
	Diffusion and penetration of Circular Economy (CE)	Circular economy, green consumerism, sustainable production/consumption, reverse green supply chain management
	Production and distribution processes/ business management	Eco-design, eco-production, sustainable production, social marketing perspective, appropriate life-cycle and cost-benefit analysis, waste management systems' thinking, environmental impact assessment
Infras_tructural-techno_logical	Incentives/ penalties	Incentives (material bonus, discount), penalties, facilitators
	Service quality/efficiency	User friendliness of the recycling system, optimal utilization of available technologies, recycling frequency
Contex_tual	Local services/ conditions/ factors	Local environmental condition, cleanliness, presence of green buildings/infrastructures, crowdedness of the location, social context, proximity effects, spatial spillovers, local identity, past exposure to pollution





## Appendix B - Supplementary Material 2 (SM2) of Chapter 2 (Spreadsheets)

### B.1. SM of Section 2.2: Concepts, Keywords, Search Terms

#### Concepts, Keywords and Search Terms

Table 18. Concepts, keywords and search terms (SM of Chapter 2).

Macro-area	Concepts	Keywords	Search Terms
waste management	generic concepts	waste management	waste management
		waste valorization	waste valorisation, waste valorization
		waste collection	waste collection
	prevention	waste prevention	waste prevention
	reduction	waste minimization	waste minimisation, waste minimization
		waste reduction	waste reduction
	re-use	waste re-use	waste re-use
		waste re-utilization	waste re-utilisation, waste re-utilization
	recycling	waste recycling	waste recycling
	separation	waste separation	waste separation
	energy recovery	waste incineration	waste incineration
disposal	waste disposal	waste disposal	
	waste destruction	waste destruction	
pro-environmental behavior	generic concepts	pro-environmental behavior	pro-environmental behaviour, pro-environmental behavior
		green behavior	green behaviour, green behavior
		ecological behavior	ecological behaviour, ecological behavior, ecologic behaviour, ecologic behavior
	innovation	eco-innovative behavior	eco-innovative behaviour, eco-innovative behavior, eco-innovation behaviour, eco-innovation behavior
	consciousness/ awareness/ empathy	eco-conscious behavior	eco-conscious behaviour, eco-conscious behavior
		ecologically conscious behavior	ecologically conscious behaviour, ecologically conscious behavior, ecological conscious behaviour, ecological conscious behavior, ecologic conscious behaviour, ecologic conscious behavior
		eco-friendly behavior	eco-friendly behaviour, eco-friendly behavior, ecofriendly behaviour, ecofriendly behavior
		environmental friendly behavior	environmental friendly behaviour, environmental friendly behavior, environment friendly behaviour, environment friendly behavior, environmentally friendly behaviour, environmentally friendly behavior

## B.2. SM of Section 2.2: Inclusion/Exclusion Criteria and List of Included/Excluded Journals and Topics

### Inclusion criteria

**Table 19.** Inclusion criteria (SM of Chapter 2).

Time	All eligible papers available on Web of Science (WoS), Science Direct and EBSCO Host, published until 31 December 2019
Type of papers	All peer-reviewed papers, published and on-line (both empirical and theoretical)
Topics	Pro-environmental (adult) consumer behavior in relation to waste management (as defined by search query)
Language	English-written papers

### Exclusion criteria

**Table 20.** Exclusion criteria (SM of Chapter 2).

Journals	Journals not investigating consumer behavior (like chemistry, metallurgy, hydrology, geology, geomorphology, geophysics, physics, mechanical engineering, mathematics, biology, biogeography, zoology, surgery, virology, epidemiology, genetics, biomedical, neurophysiology, neurology, healthcare management) or investigating very specific aspects of human behavior (like criminology). Refer to below full list
Topics	Main excluded topics: -Professional environment (like workers, farmers, retailers, managers, company-related issues, with the exception of papers studying consumer behavior too) -Education of minors (primary and secondary school) and teaching methods. Refer to below full list.
Specific type of waste	Nuclear, hazardous, hospital, healthcare, space, travelling, tourism waste; building/construction waste
Specific locations	Protected areas, territories under specific environmental laws, national/ state/ regional parks, disaster areas

### List of Included Journals/Conference Proceedings in terms of topics

**Table 21.** List of included journals/conference proceedings in terms of topics (SM of Chapter 2).

Topics of Journals
Anthropology
Applied Science and Technology
Business
Design and Ergonomics
Ecology
Economics (including accounting and econometrics)
Education
Energy
Engineering (except chemical and biomolecular engineering)
Environment
Ethics
Geography
Health (including medical research)
Horticulture
Humanities (including anthology)
Information and Communications (including Info. and Comm. Technology (ICT))
Institutions (e.g. (public) policy, government)
Laws
Management (including system thinking, conflict management)
Manufacturing and Quality Assurance
Marketing
Materials (including textiles)
Natural Sciences (e.g biology)

Nutrition
Philosophy
Politics
Psychology (including social psychology)
Resources (e.g. water)
Sociology
Sustainable Development
Urban and rural sciences (e.g. urbanization, cities)

### List of Excluded Journals/Conference Proceedings

Table 22. List of excluded journals/conference proceedings (SM of Chapter 2).

Journals	Conference Proceedings	Field
Accounts of Chemical Research		Chemistry
Aci Materials Journal		Materials
Acs Applied Materials & Interfaces		Materials
Acs Omega		Chemistry
Acta Physica Polonica A		Physics
Acta Physiologiae Plantarum		Fisiology
Acta Tropica		Health, Biomedics (on infectious diseases)
Adsorption Science & Technology		Chemistry
Advanced Composite Materials, Pts 1-3		Materials
Advanced Electronic Materials		Materials
Advanced Materials		Materials
Advanced Science		Materials, Physics, Chemistry
Advances in Applied Ceramics		Materials
Advances in Materials Science and Engineering		Materials
Advances in Natural Fibre Composites: Raw Materials, Processing and Analysis		Materials
Advances in Polymer Technology		Materials
Airfield and Highway Pavements 2017: Pavement Innovation and Sustainability		Materials
American Mineralogist		Mineralogy
Analytical and Bioanalytical Chemistry Research		Chemistry, Biology
Analytical Chemistry		Chemistry
Animal Behaviour		Zoology
	Annual Review of Chemical and Biomolecular Engineering, Vol 10	Chemical and Biomolecular Engineering
Annual Review of Entomology		Entomology
Applied Clay Science		Materials
Applied Geochemistry		Geochemistry
Aquatic Toxicology		Toxicology
Arabian Journal of Chemistry		Chemistry
Archives of Mining Sciences		Mining
Asian Pacific Journal of Tropical Disease		Disease
Atomic Energy		Atomic Energy
Bmc Veterinary Research		Veterinary
Bulgarian Chemical Communications		Chemistry

Bulletin of Environmental Contamination & Toxicology		Toxicology
Bulletin of the Chemical Society of Japan		Chemistry
Carbohydrate Polymers		Materials
Cellulose		Chemistry
Cellulose Chemistry and Technology		Chemistry
Cement and Concrete Composites		Materials
Cement and Concrete Research		Materials
Ceramics International		Materials
Chemical Science		Chemistry
Chemistry Education Research and Practice		Chemistry
Chemosphere		Chemistry
Clinical Linguistics & Phonetics		Linguistic
Cluster Computing-the Journal of Networks Software Tools and Applications		Computers
Colloids and Surfaces B: Biointerfaces		Materials
	Composite Construction in Steel and Concrete	Materials
Composite Interfaces		Materials
	Composite Science and Technology, Pts 1 and 2	Materials
Composite Structures		Materials
Construction and Building Materials		Materials
Construction Materials and Structures		Materials
Contaminated Sediments: Restoration of Aquatic Environment, Vol 5		Chemistry, Biology, Materials
Corrosion		Chemistry
Corrosion Science		Chemistry
Critical Reviews in Microbiology		Microbiology
Croatica Chemica Acta		Chemistry
Current Green Chemistry		Chemistry
Current Nanoscience		Nanoscience
Current Organic Chemistry		Chemistry
Dalton Transactions		Chemistry
Desalination		Chemistry
Desalination and Water Treatment		Chemistry
Detritus		Chemistry
Early Child Development and Care		Child education, nursery
Ecotoxicology		Toxicology
Emerging Materials Research		Materials
Eurasian Journal of Analytical Chemistry		Chemistry
European Journal of Wood and Wood Products		Materials
Fibers and Polymers		Materials
Filtration + Separation		Chemistry
Frattura Ed Integrita Strutturale		Materials, Chemistry
Frontiers in Chemistry		Chemistry
Fuel		Chemistry
Gene Therapy		Gentics

Glass Technology-European Journal of Glass Science and Technology Part A		Materials
Green Chemistry		Chemistry
Hydrobiologia		Biology
Hydrometallurgy		Metallurgy
	International Conference on Concrete Sustainability - Iccs16	Chemistry
Indian Journal of Chemistry Section a-Inorganic Bio-Inorganic Physical Theoretical & Analytical Chemistry		Chemistry
International Journal of Adhesion and Adhesives		Chemistry
International Journal of Applied Ceramic Technology		Chemistry
International Journal of Applied Glass Science		Chemistry
International Journal of Artificial Organs		Medicine
International Journal of Biological Macromolecule		Biology
International Journal of Drug Policy		Drug
International Journal of Electrochemical Science		Chemistry
International Journal of Mineral Processing		Mineralogy
International Journal of Molecular Sciences		Chemistry
International Journal of Nanoscience		Nanoscience
International Journal of Pharmacy Practice		Pharmacy
International Journal of Polymer Science		Chemistry
International Journal of Rock Mechanics and Mining Sciences		Mineralogy
International Journal of Sediment Research		Chemistry
International Journal of Surgery		Surgery
Inzynieria Mineralna-Journal of the Polish Mineral Engineering Society		Mineralogy
Iranian Polymer Journal		Materials
Ironmaking & Steelmaking		Metallurgy
Journal of Alloys and Compounds		Materials
Journal of Analytical and Applied Pyrolysis		Chemistry
Journal of Applied Biomaterials & Functional Materials		Materials
Journal of Applied Microbiology		Biology
Journal of Archaeological Science		Archeology
Journal of Catalysis		Chemistry
Journal of Chemical Education		Chemistry
Journal of Chemical Technology and Biotechnology		Chemistry/Biology
Journal of Chemistry		Chemistry
Journal of Chromatography A		Chromatology
Journal of Coatings Technology and Research		Chemistry
Journal of Colloid and Interface Science		Materials
Journal of Composite Materials		Materials
Journal of Elastomers and Plastics		Material
Journal of Electroanalytical Chemistry		Chemistry
Journal of Environmental Radioactivity		Radioactivity
Journal of Hazardous Materials		Hazardous Materials
Journal of Hazardous Toxic and Radioactive Waste		Radioactivity

Journal of Insect Science		Entomology
Journal of Materials Chemistry A		Chemistry
Journal of Materials Science		Materials
Journal of Materials Science & Technology		Materials
Journal of Materials Science-Materials in Electronics		Materials
Journal of Medical Entomology		Entomology
Journal of Membrane Science		Materials, Biology
Journal of Molecular Catalysis A: Chemical		Chemistry
Journal of Molecular Catalysis B: Enzymatic		Chemistry
Journal of Molecular Liquids		Chemistry
Journal of Molecular Structure		Chemistry
Journal of Nuclear Materials		Materials
Journal of Petroleum Exploration and Production Technology		Geology
Journal of Photochemistry and Photobiology B: Biology		Chemistry
Journal of Physics and Chemistry of Solids		Chemistry
Journal of Psychopharmacology		Pharmacology
Journal of Radioanalytical and Nuclear Chemistry		Radiology
Journal of Renewable Materials		Materials
Journal of Soil Contamination		Contamination
Journal of Soils and Sediments		Geology
The Journal of Supercritical Fluids		Fluid Dynamics
Journal of Supercritical Fluids		Fluid Dynamics
Journal of Sustainable Metallurgy		Metallurgy
Journal of the Brazilian Chemical Society		Chemistry
Journal of the European Ceramic Society		Chemistry
Journal of the Indian Chemical Society		Chemistry
Journal of the Iranian Chemical Society		Chemistry
Journal of Thermal Analysis and Calorimetry		Calorimetry
Journal of Thermal Spray Technology		Chemistry
	Lignocellulosic Fibre and Biomass-Based Composite Materials	Chemistry
Macromolecules		Chemistry
Materiales De Construccion		Materials
Materiali in Tehnologije		Materials
Materials		Materials
Materials and Structures		Materials
Materials Characterization		Materials
Materials Performance and Characterization		Materials
Materials Research Express		Materials
Materials Science & Engineering C-Materials for Biological Applications		Materials
Materials Science and Engineering a-Structural Materials Properties Microstructure and Processing		Materials
Materials Science and Engineering: C		Materials
Materials Testing		Materials
Materials Today Chemistry		Materials

Materials Today: Proceedings		Materials
Materials Transactions		Materials
Materia-Rio De Janeiro		Materials
Membrane Water Treatment		Materials
	Metal Separation Technologies Beyond 2000: Integrating Novel Chemistry with Processing	Chemistry
Metallurgist		Metallurgy
Metals		Metallurgy
Metalurgia International		Metallurgy
Micro & Nano Letters		Materials
Microporous and Mesoporous Materials		Materials
Mineral Processing and Extractive Metallurgy Review		Metallurgy
Minerals		Mineralogy
	Mineral Resources in a Sustainable World, Vols 1-5	Mineralogy
Monatshefte Fur Chemie		Chemistry
	Multi-Functional Materials and Structures Iv	Materials
Nano Research		Nanotechnology
Nanomaterials		Materials
New Journal of Chemistry		Chemistry
Nuclear Energy and Technology		Nuclear Energy
Nuclear Engineering and Technology		Nuclear Technology
Nuclear Instruments & Methods in Physics Research Section a-Accelerators Spectrometers Detectors and Associated Equipment		Nuclear Technology
Nuclear Technology		Nuclear Technology
Nukleonika		Chemistry
Physiological and Biochemical Zoology		Zoology
Pigment & Resin Technology		Materials
Plastics Rubber and Composites		Materials
Polimery		Materials
Polymer		Materials
Polymer Composites		Materials
Polymer Degradation and Stability		Materials
Polymer Testing		Materials
Polymers		Materials
Powder Technology		Chemistry
	Proceedings of the 4th International Science Conference Woodworking Techniques	Materials
	Proceedings of the Asme Conference on Smart Materials, Adaptive Structures and Intelligent Systems	Materials



	Proceedings of the Royal Society B-Biological Sciences	Biology
Process Biochemistry		Bio-Chemistry
Progress in Organic Coatings		Materials
Radiochimica Acta		Radio-Chemistry
Revista De Chimie		Chemistry
Revue De Medecine Veterinaire		Veterinary
Russian Journal of Physical Chemistry A		Chemistry
Science China-Chemistry		Chemistry
Science of Advanced Materials		Materials
Separation and Purification Technology		Chemistry
Separation Science and Technology		Chemistry
Soils and Foundations		Geology
Steel Research International		Materials
Strain-Hardening Cement-Based Composites		Materials
Structural Concrete		Materials
Surface and Coatings Technology		Materials
Surfaces and Interfaces		Materials
Thin-Walled Structures		Materials
Toxicology and Industrial Health		Toxicology
Toxicology of Organophosphate & Carbamate Compounds		Toxicology
TrAC Trends in Analytical Chemistry		Chemistry
Transactions of the Institutions of Mining and Metallurgy Section C-Mineral Processing and Extractive Metallurgy		Mining, Metallurgy
Ultrasonics Sonochemistry		Chemistry

## List of Excluded Topics

**Table 23.** List of excluded topics (SM of Chapter 2).

Topic's Area	Specific Topic
Business, management	Firm/corporate/organizational behavior
	Business/(sustainable) enterprises/companies/firms
	State/governmental/private agencies/organizations (e.g., Sustainability Victoria, Environmental Protection Agency)
	Micro, Small and Medium Enterprises (MSMEs)
	Recycling trade associations
	Niche players
	Brands
	Entrepreneurship
	Corporate greening
	Sustainable manufacturing
	Corporate Social Responsibility (CSR), corporate behavior
	Extended Producer Responsibility (EPR)
	Pro-environmental operational strategy
	Resource reduction strategy

	Managerial engagement in environmental responsibilities/actions
	Waste project managers
	Management of waste reduction/recycling programs
	Waste disposal acts
	Debates on waste policy
	Waste trade
	Environmental decision tools for managers/agencies/firms
	Promotion of National recycling practices
	National recycling advocacy
	Environmental consultancy
	Real estate
	Commercial buildings
	Retailing and specific commercial services (e.g., commercial lawn care services)
	Private Finance Initiative (PFI)
	Information campaign focused on managerial aspects of environmental protection
Industry and production processes	Industrial waste/residuals
	Production processes
	Industrial/Logistic system
	Producers, supply chain
	Pro-environmental design
	Product development
	Infrastructure developers
	(Eco) designers
	Supply chain
	Manufacturing
	Landfill/dump management (e.g., waste transportation to landfill, activities and procedures inside recycling centers/landfills)
	Waste management solutions after collection (e.g., incineration, regulations of waste facilities)
	Building/construction industry:
	Construction & Demolition (C&D) waste*: -Drilling waste* -Construction projects/system/company -Drilling waste*
Workplaces	Offices
	Factories
	Recycling centers/landfills/dumps*
	Waste management/treatment plants/systems (for sewage, wastewater, etc.)
	Warehouses
	Production plants
Workers and tourists	Managers/entrepreneurs
	Employees
	Workers
	Armed Forces/Police members*
	Medics*
	Economists

	Providers of environmental services (e.g., recycling companies, solid waste industries, waste handling corporations, waste management professionals)
	Urban planners
	Non-academic staff
	Recycling coordinators/managers
	Members of recycling companies
	Tourists
	Leisure boat owners
Agriculture (including mowing services)	Farmers
	Farming practices/methods
	Use of fertilizers/pesticides
	Wineries and wine producers
Fishery	Fisherman
	Blue growth/economy
	Ecosystem-based fishery management
	Fishery community
	Fishing villages/communities*
	Fishing waste*
Forestry	Forestal economy
	Forestal community
	Forestal waste*
Special waste*	Forestal waste
	Fishing/agricultural waste*
	Carcass (dead pig) waste
	Construction & Demolition (C&D) waste
	Drilling waste*
	Nuclear/Radiological/Hazardous (incl. batteries)/Toxic waste
	Contaminated sediments management
	Fluorescent lamps
	Vehicle recycling
	Sewage
	Biomass waste
	Mining waste
	Laboratory waste
	Leisure (boat) waste
	Pharmaceutical waste*
Healthcare, sanitation, toxicology:	Hospital
	Clinics
	Nursing
	Healthcare
	Illness (e.g., depressive sickness, exposure to pollutants/contaminants)
	Pharmaceuticals*
	Pharmaceutical pollution
	Water contamination

	No-mix toilet technology
	Medics*
	Sanitation infrastructure/systems (e.g., sustainability and utilization of sanitation facilities)
Hospitality and tourism:	Hotel/lodging
	Green hotel/tourism
	Tourism
	Eco-Tourism
	Travel
	Eco-Travel
	(wildlife) recreation
	Restaurant customers/managers
	Restaurant industry
	Tour operators
	Vacation, vacationers, leisure boat owners
	Hospitality products
Underage/Professional Education and training:	Children/Adolescent education/behavior
	Primary/secondary/high school education/behavior
	Professional education/training of teachers, engineers, etc.
	Training devices/material
Human-animal relationship	
Virtual games	
Oceanography	
Special locations/occasions:	Recycling centers/landfills/dumps*
	Festival
	Parks, desert, botanical garden, island with environmental protection
	Restricted areas (e.g., areas with salient features/laws)
	Areas under environmental protection
	Coastal wetlands, freshwater marsh, coral reef ecosystems (e.g., Great barrier reef)
Specific communities/associations/categories	Fishing/farming communities*
	Armed Forces/Police members*
	Environmental/non-profit organizations (e.g., Greenpeace, "Group against smog and pollution", Audubon Society, Sierra Club)
	Activist associations
	Recycling cooperatives
	People registered in special recycling programs
	Rural villagers
Special practices	Hoarding
	Begging
	Household carcass waste recycling

**Notes:**

- (1) The \* indicates that some item are repeated in 2 topic areas or more. In some papers, university students are mixed up with non-academic staff.
- (2) Hospitality journals are generally not included except for daily normal activities (e.g., utilization of cafeterias).
- (3) Papers analyzing universities are included when dealing with students as adult consumers (e.g., utilization of dining facilities and university cafeterias), but they are excluded when referring to teaching methods.
- (4) **Disagreement Procedure for Inclusion/Exclusion of Papers:** In case of disagreement between the first and the second review author, the conflict is supposed to be resolved through discussion between the involved review authors; if the dispute is not resolved, the third review author is involved in the discussion. If, at this stage, no agreement is reached, the third author makes the final decision.

### B.3. SM of Section 2.2: Data Extraction Protocol

#### Description of Data Extraction Tables

##### Bibliographic Information

**Table 24.** Bibliographic information (SM of Chapter 2).

Column A	Paper's Title
Column B	Paper's Publication Date (YYYY-MM-DD, if not indicated in pub, the default date is the first day of year/month/season)
Column C	Paper's Source (e.g., Journal of Economics)
Column D	Paper's Authors
Column E	Type of Organization the authors belong to (e.g., University, Research Center, Governmental Institution, etc.)

##### Theoretical Fundament

**Table 25.** Theoretical fundament (SM of Chapter 2).

Column F	Main Reference Theories/Models: TRA=Theory of Reasoned Action TPB=Theory of Planned Behavior NAM=Norm Activation Model VBN=Value Belief Norm Others=anything different from TRA, TPB, NAM, VBN
Column G through J	Specific Reference Theory: TRA, TPB, NAM, VBN
Column K	Other sociological/ ecological/ psychological Theories (different from the theories/models mentioned in columns G through J)
Column L	Other Socio-economic-psychological-environmental Models (excluding mathematical/engineering models)
Column M	Mathematical/engineering models/theories

##### Description of the Study

**Table 26.** Description of the study (SM of Chapter 2).

Column N	Abstract
Column O through X	Author's Keywords (abbreviation: Aut. KW)
Column Y	Other Keywords (if not specified by authors)

##### Paper/Source Type

**Table 27.** Paper/source type (SM of Chapter 2).

Column Z	Paper Type (e.g., article, editorial)
Column AA	Paper's Focus Area (e.g., economy, marketing, engineering, sociology, psychology)
Column AB	Type of Source (e.g., journal, book)
Column AC	Journal's Focus Area (e.g., environment, economy, marketing, engineering, sociology, psychology)

## Geographical Information

**Table 28.** Geographical information (SM of Chapter 2).

Column AD	Geographic Area (e.g., town/ country/ province/ region, if applicable)
Column AE	Nation (or main nation if more than 1 nation)
Column AF	Other Involved Nations (if any) in Alphabetical Order
Column AG	Continent (please note that Cyprus and Russia are considered as Asian nations, whereas Ukraine as a European nation)
Column AH	Advanced/Developing Nation (according to IMF, October 2019)

## Factors

**Table 29.** Factors (SM of Chapter 2).

Tab.14	Factors have been directly collected in tab.14 and subsequently classified
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Disagreement Procedure for Inclusion/Exclusion of Papers: In case of disagreement between the first and the second review author, the conflict is supposed to be resolved through discussion between the involved review authors; if the dispute is not resolved, the third review author is involved in the discussion. If, at this stage, no agreement is reached, the third author makes the final decision.

## Specific Methodologies for RQs

RQ3: The data classification methodology is explained in tab 11 (Factors).

RQ4: The classification of main issues is according the guidelines as follows:

**Table 30.** Specific methodologies for RQs (SM of Chapter 2).

Type of issue	Examples
Methodology	Theoretical framework (e.g., definitions, applications, generalization of models)
	Analysis (e.g., type and level of details of the analysis, selection of key factors)
	Sample (e.g., definition of the right size of the sample)
	Assumptions, generalizations
	Measurements (e.g., measurement of factors, variance)
Context	Context-dependency
Actors	Definition of involved actors, relationship among actors, heterogeneity, behavioral instability (e.g., changing values/goals)
Factors	Definition of involved factors, characteristics of factors, relationship among factors (e.g., linear vs non-linear, overlapping effects)
Conditions	Definition of conditions, characteristics of conditions (e.g., conflicting situations)



## Appendix C - Supplementary Material 1 (SM1) of Chapter 3

Note on numbering and titles: Supplementary material is progressively numbered (e.g., B.1., B.2., B.3., etc.). In addition, the title indicates which section or subsection of the main paper it refers to.

### C.1. SM of Section 3.2: Literature Review

It is also worth mentioning the research of some scholars on recycling behavior through bibliometrics and MKD.

For example, X. Li et al. (2019)'s studies on green behavior contribute to map the knowledge in this field; they individuate key topics like the "theory of planned behavior (TPB), consumers, attitudes, performance, and environment, all of which evolve according to the phase path of germination-growth" (p. 6087). Si et al. (2019) also analyze the application of TPB in environmental sciences through a bibliometric and content analysis; their findings show that, although TPB has been applied to very different types of behavior and groups, the research is still concentrated on consumers and householders. "Therefore, it is necessary to predict and reveal the intention and behavior of business leaders, designers, and government officials" Si et al. (2019, p. 17) in order to develop a holistic understanding of recycling behavior.

Phulwani et al. (2020) apply a SLR and a bibliometric analysis to papers on consumers and households recycling behavior utilizing the Scopus database. They infer the central role of consumers in our society and the predominance of TPB as the theoretical reference framework; nonetheless, they argue that "what is shaping recycling behavior is so complex that a single model cannot encompass all the relevant factors." (p. 16).

### C.2. SM of Section 3.3: Methods and Data

#### C.2.1 Methodology

In general, bibliometric studies investigate significant amount of information in an objective and reproducible way through the utilization of specific tools which help individuating and visualizing trends, network, connections, etc. In fact, bibliometrics, as a quantitative method, reduce the influence of subjective judgments in the analysis of a specific area of study (da Silva et al., 2012) through the utilization of different techniques including, among the others, author, co-author, citation, co-citation, word, co-word analysis (Nova-Reyes et al., 2020).

In relation to SLRs, Petticrew and Roberts (2006) infer that "systematic reviews are literature reviews that adhere closely to a set of scientific methods that explicitly aim to limit systematic error (bias), mainly by attempting to identify, appraise and synthesize all relevant studies (of whatever design) in order to answer a particular question (or set of questions)" (p. 9). Therefore, a SLR is characterized by impartiality, transparency and repeatability (Petticrew & Roberts, 2006), "to improve the reliability and trustworthiness of the study, and enhance the consistency and the legitimacy of the analysis and the related deductions" (Concari et al., 2020).

Methodologies for conducting a SLR may vary among scholars (Candel, 2014; Cooper, 2015; Hart, 2018; Littell et al., 2008; Petticrew & Roberts, 2006; Thi Hong Phuong et al., 2017), but normally agree on some basic steps like the selection of the necessary studies, the execution of an appropriate search through the definition of specific keywords, the screening of the results in accordance to inclusion/exclusion criteria, the appraisal of the selected papers.

Different methodologies are utilized for science mapping. Besides Cobo et al. (2011), Zupic and Čater (2015) organize science mapping with bibliometric methods with a different breakdown of the workflow; they include the early stages of the research design, and group the initial steps of Cobo et al. (2011) in the compilation phase, as follows (Cretu & Morandau, 2020):

- “Research design
- Compilation of bibliometric data
- Analysis
- Visualization
- Interpretation” (p. 2)

In this article the authors apply Cobo et al. (2011)’s approach to better describe the phases leading to the analysis and subsequent visualization and interpretation. As mentioned in the main paper, Cobo et al. (2011) apply the steps as follows: “data retrieval, preprocessing, network extraction, normalization, mapping, analysis, visualization and interpretation” (Hong et al., 2016, p. 3).

It is worth reminding that data retrieval is based on the initial steps of the SLR. The preprocessing phase aims at making the data ready for the subsequent analysis by detecting and removing duplicates (SLR performs this activity too) or correcting errors like a misspelled author’s name or journal’s title. This step is very demanding, especially when dealing with extended data and different databases; in fact, Cobo et al. (2011) consider it as “perhaps one of the most important for improving the quality of the units of analysis (mainly authors and words) and thus to obtain better results in the science mapping analysis” (p. 1384).

The network extraction selects the data depending on the unit of analysis (e.g., author, keyword, journal); this step is performed according to different approaches:

- Citations of documents, sources, authors, institutions, organizations and Nations
- Co-authorship of authors, organizations and Nations
- Co-occurrence of keywords
- Bibliographic coupling of documents, sources, authors, organizations and Nations
- Co-citation analysis of cited references, cited sources and cited authors

The citation analysis of documents studies the citations utilized in the papers (which are screened in the selected database); thus, it provides an information about their perceived relevance (Kraus et al., 2020). For example, the citation analysis of sources monitors the relevance of publications; similarly, the citation analysis of authors highlights the most productive authors.

Nova-Reyes et al. (2020) define co-word analysis as the measure of “the co-occurrence or joint occurrence of keywords extracted from each document, from which matrices of co-occurrences are constructed and similarity measures calculated” (p. 4). When the unit of measure is represented by keywords, the analysis of co-occurrence of keywords captures the frequency of the links between terms that have been selected by the authors to better describe their studies, consequently it may help in highlighting possible research trends (Garfield, 1990). In VOSviewer the frequency of keywords includes the analysis of titles, abstracts and keywords of all selected papers. This software also allows a temporal keyword analysis by selecting specific timeframes; this approach offers the possibility to highlight the most recent topics of interest in the area of investigation (Cobo et al., 2011).

Co-citation analysis studies the frequency an item of the selected unit of analysis is cited with another item of the same unit; for example, if the unit is the authorship, all authors in the reference list of each paper are checked for possible links, namely co-citation links. In this case the objective is to find similarities in the authors’ papers (Kraus et al., 2020) or networks between leading authors in a specific field (Silva et al., 2019). As stated by Hallinger (2019), “co-citation analysis results not only include sources in the author’s dataset but also documents that are neither in the author’s dataset nor in the index from which they were drawn (e.g., Scopus). Thus, co-citation analysis provides a broader measure of influence which complements the more limited scope of coverage provided through traditional citation analysis” (p. 543). Kraus et al. (2020) explain that “journal co-citation analysis identifies research themes based on the frequency journals are cited together in another publication” (p. 3). Document co-citation analysis individuates the most influential papers within a research area by studying the co-citation frequencies for each pair of papers.

In relation to the network extraction, another example of citation analysis is the institutions analysis, which counts the number of citations generated by the institutions in a specific field. The analysis of the cooperation network among institutions investigates possible links between research organisation or universities.

The normalization step takes place after the definition of the network; it is a mathematical process which applies similarity measures (e.g., Salton's Cosine, Jaccard's index, Proximity Index) to the relations (also known as edges) between the nodes (Cobo et al., 2011). The analysis phase applies specific techniques to the previously created map in order to perform a network, temporal or geospatial analysis. The visualization phase applies different techniques to better understand and interpret the output. Lastly, the analyst has to interpret these maps to extract useful and actionable information to support the managerial decision-making process or to guide future research.

After the normalization phase, the normalized data are ready for the application of the mapping algorithm; several techniques are available like dimensionality reduction (to reduce to a bi-dimensional space), graph mining, social network analysis, clustering algorithms.

It worth providing some further details on the analysis phase. This phase often takes advantage of statistical algorithms to measure the number of isolated nodes, their degree, or the graph density (Cobo et al., 2011); the previously mentioned indexes may be applied to perform the analysis of the clusters (the Jaccardi's index can be utilized to detect overlapping clusters). In particular, the temporal analysis studies how the field of investigation changes across the time by identifying different types of trends. It includes the analysis of burst detection which offers the possibility to "find features that have high intensity over finite durations of time periods" (Cobo et al., 2011, p. 1383). For instance, it individuates the seminal papers having a significant effect on steering the research in a specific direction in a defined time frame (Kraus et al., 2020). Differently, the geospatial analysis highlights the location of a specific events and its influence of the neighbouring areas (Batty, 2003; Leydesdorff, 2010).

Lastly, during the visualization phase the previously defined networks are visualized through heliocentric maps, geometrical models, strategic diagrams, cluster strings, alluvial diagrams, thematic maps, etc.

### **C.2.2. Data Collection**

As previously explained, the data collection phase is based on the initial steps of the SLR; thus, after the research questions' definition, the necessary studies have to be defined too.

This study adopts a broad scope of papers categories because it aims at an interdisciplinary understanding of consumer behavior in relation to waste management. Consequently, all disciplines somehow involved with human behavior are investigated; thus, besides psychology, education and sociology, this study also analyses paper from fields like engineering, economics, law, marketing, nutrition. Conversely, disciplines like chemistry, metallurgy, toxicology are excluded (full exclusion list is available in the Excel spreadsheet).

The next phase is the execution of a comprehensive literature search through some steps as suggested by several scholars (Concari et al., 2020; Thi Hong Phuong et al., 2017):

- "Selection of terms and databases
- Inclusion and exclusion criteria
- Data extraction and evaluation of review findings
- Limitations" (Concari et al., 2020, p. 6)

The selection of terms and databases has the purpose of identifying all papers potentially suitable to answer the research questions by utilizing the appropriate search query and databases; in fact, the appropriate analysis of keywords allows the correct selection of applicable papers. This issue has been extensively debated in the academic literature; for example, de Carvalho et al. (2020) analyze specific methods like "Ordinatio" and "Proknow-C". The choice of three databases for this article (Web of Science, Scopus, EBSCO) aims at obtaining an adequate coverage of literature on the

selected topics, especially considering that these databases include different scientific journals and focus on non-identical geographic areas (Biesbroek et al., 2013).

The search query has been defined to cope with the evolution of key terms related to recycling behavior and waste management in the academic literature since the 1970s (Table 31). In fact, it is essential to identify key concepts and search terms to correctly frame the research from the earliest stages, keeping in mind that many terms have changed their meaning or utilization through the years (Concari et al., 2020). For example, words like green consumer behavior have been gradually replaced by pro-environmental behavior or environmental-friendly behavior; in recent time, waste is analyzed not only in terms of recycling but also of minimization and valorization. This aspect is quite underestimated by many authors who define very limited search query which do not represent the actual utilization of keywords throughout the years, especially when considering a period of several decades (X. Li et al., 2019; Phulwani et al., 2020). In this paper, the search query tries to capture all keywords in the academic literature focusing on consumer behavior and waste management since the 1970's, therefore it includes terms like green behavior, pro-environmental behavior, eco-conscious behavior, waste recycling, waste minimization, waste valorization (Table 31)

The inclusion and exclusion criteria have been defined to reduce the consistent initial body of literature and focus on the objectives of this bibliographic research. The inclusion criteria are as follows:

- Topic: adult consumer behavior in relation to waste management
- Time: all eligible papers available on Web of Science, Science Direct and “EBSCO Host” on 08 December 2020 (no start date, end date including papers to be published until 31 December 2020)
- Type of papers: peer-reviewed articles (both empirical and theoretical) and review papers available on scientific journals, “as the academic community acknowledges them as the most advanced and up-to-date knowledge sources” (Nova-Reyes et al., 2020, p. 5)
- Databases: Web of Science, Science Direct and “EBSCO Host” in order to execute a more comprehensive and correct analysis of this topic
- Language: papers written in English

The exclusion criteria are as follows:

- Specific journals, categories and research areas not related to consumer behavior (e.g., zoology, mathematics, chemistry), or journals focusing on very specific topics of human behavior (e.g., mental disorder, criminology pediatrics), requiring specific competencies, methodologies and investigations
- Specific topics related to:
  - managers, suppliers, retailers (considering the focus is not on the production or the managerial process)
  - education of minors and related teaching methods because they would require the analysis of specific socio-psychological mechanisms, didactics and pedagogic approaches
- Specific types of waste requiring special care or treatment (e.g., hazardous waste, nuclear, marine, fishing, sludge) or specific category of waste (e.g., energy waste, water)
- Specific locations: areas with special rules and conditions (e.g., nuclear sites, national parks, productions sites) or contaminated sites (e.g., towns in the vicinity of nuclear depots); these situations would make the findings very context-dependent (Concari et al., 2020)

**Table 31.** Search query (SM of Chapter 3).

Source	Query
Web of Science	<p>TS = ((waste management OR waste minimi*ation OR waste recycling OR waste reuse OR waste re-use OR waste reutili*ation OR waste re-utili*ation OR waste reduction OR waste prevention OR waste destruction OR waste separation OR waste valori*ation OR waste collection OR waste disposal OR waste incineration)  AND  (green behavio* OR pro-environmental behavio* OR proenvironmental behavio* OR eco-friendly behavio* OR ecofriendly behavio* OR ecologica* behavio* OR eco-innovat* behavio* OR ecoinnovat* behavio* OR eco-conscious behavio* OR ecoconscious behavio* OR ecologi* conscious behavio* OR environment* friendly behavio* OR separation behavio* OR disposal behavio* OR reduction behavio* OR separation behavio* OR collection behavio* OR minimi*ation behavio* OR recycling behavio* OR re-utili*ation behavio* OR re-use behavio* OR sorting behavio* OR prevention behavio*))</p> <p>Indexes = Science Citation Index (SCI-EXPANDED), Social Sciences Citation Index (SSCI), Arts &amp; Humanities Citation Index (A&amp;HCI), Conference Proceedings Citation Index-Science (CPCI-S), Conference Proceedings Citation Index- Social Science &amp; Humanities (CPCI-SSH), Emerging Sources Citation Indexes (ESCI).</p> <hr/> <p>Timespan = until 8 December 2020  Language = English  Types of documents = Articles</p>
Science Direct	<p>((waste management OR waste minimi*ation OR waste recycling OR waste reuse OR waste re-use OR waste reutili*ation OR waste re-utili*ation OR waste reduction OR waste prevention OR waste destruction OR waste separation OR waste valori*ation OR waste collection OR waste disposal OR waste incineration)  AND  (green behavio* OR pro-environmental behavio* OR proenvironmental behavio* OR eco-friendly behavio* OR ecofriendly behavio* OR ecologica* behavio* OR eco-innovat* behavio* OR ecoinnovat* behavio* OR eco-conscious behavio* OR ecoconscious behavio* OR ecologi* conscious behavio* OR environment* friendly behavio* OR separation behavio* OR disposal behavio* OR reduction behavio* OR separation behavio* OR collection behavio* OR minimi*ation behavio* OR recycling behavio* OR re-utili*ation behavio* OR re-use behavio* OR sorting behavio* OR prevention behavio*))</p> <hr/> <p>Timespan = All years until 08 December 2019  Language = English</p> <p>(Please note Science Direct does not accept wildcards and more than eight Boolean operators at a time, so the search query has been broken down in multiple queries)</p>
EBSCO	<p>((waste management OR waste minimi*ation OR waste recycling OR waste reuse OR waste re-use OR waste reutili*ation OR waste re-utili*ation OR waste reduction OR waste prevention OR waste destruction OR waste separation OR waste valori*ation OR waste collection OR waste disposal OR waste incineration)  AND  (green behavio* OR pro-environmental behavio* OR proenvironmental behavio* OR eco-friendly behavio* OR ecofriendly behavio* OR ecologica* behavio* OR eco-innovat* behavio* OR ecoinnovat* behavio* OR eco-conscious behavio* OR ecoconscious behavio* OR ecologi* conscious behavio* OR environment* friendly behavio* OR separation behavio* OR disposal behavio* OR reduction behavio* OR separation behavio* OR collection behavio* OR minimi*ation behavio* OR recycling behavio* OR re-utili*ation behavio* OR re-use behavio* OR sorting behavio* OR prevention behavio*))</p> <hr/> <p>Source complete  Document Type = All  Expanders:  - Apply equivalent subjects  - Apply related words  - Limiters:  - Scholarly (Peer Reviewed) Journals  - Published date = All years until December 2020  - Language = English  - Journals: as per attached list</p>

In terms of data extraction, it is noteworthy that this process has been autonomously conducted by an author through the application of the mentioned inclusion and exclusion criteria; subsequently, the other authors have independently verified a sample of papers. In case of disagreement, the selection protocol provides for the application of a procedure for resolving the issues; nevertheless, the reviewing authors have confirmed the initial screening.

The subsequent analysis of screened papers and the network extraction are based on the selection of the appropriate units of analysis, like authors, paper's title, journal, keywords, abstract, Nation, organization (e.g., university), cited references, DOI, year. Moreover, after retrieving the papers, an extensive pre-processing treatment has been performed to avoid, for example, the misspelling of author's names and journals, or remove the statements of copyright from abstracts.

### **C.2.3. Limitations and Implications**

As clearly stated in the main paper and in the previous sub-section, this paper investigates adult recycling behavior in normal situations; therefore, it does not analyze the behavior of minors, specific locations or special waste. In fact, the study of minors involves peculiar factors like personality development, different judgment mechanisms, consequently it requires the application of specific teaching tools and methodologies (Honig & Mennerich, 2013; Krettenauer, 2017; Long et al., 2015). Also, this paper does not analyze peculiar locations like protected areas, national parks, contaminated sites, sanitation infrastructure, hospitals, hotels, farms, fisheries, stadiums; moreover, it does not study specific types of behavior like travel or guest behavior, consumer energy behavior. Specific categories of people or waste are excluded too; the former includes, for example, waste pickers or scavengers, the latter comprises hazardous, nuclear, energy and black water waste. Moreover, considering the managerial practices (e.g., life-cycle assessment, business waste prevention, sustainable supply chain management) and industrial processes (e.g., packaging, waste transportation) do not always focus on recycling behavior, they are excluded from this study, unless they analyze this type of behavior too.

Therefore, this manuscript does not provide significant contributions to economics, marketing or management, whereas it offers helpful insights on the intellectual structure of the literature on the generic recycling behavior throughout the years.

In relation to the selection of papers, the body of literature goes from 1973 to December 2020, and it is made of peer-reviewed articles from three leading databases: Web of Science, Science Direct and "EBSCO Host"; nevertheless, these databases do not automatically guarantee full coverage of the available English literature. Furthermore, it has to be noted that some articles do not have a full set of meta-data, thus some old papers lacking keywords do not contribute, for example, to the keyword co-occurrence analysis. Similarly, some articles do not provide a list of indexed cited references, consequently they do not contribute to some types of analysis like co-citation.

As previously mentioned, the selection of manuscripts is based on the initial screening of an author (according to the specified inclusion/exclusion criteria), followed by sample checks carried out by the other authors. This approach mitigates the risk of biases, although a full double independent screening by different scholars would offer more guarantees (Concari et al., 2020). The risk of biases is also assessed through the application of ROBIS (Higgins & Altman, 2008; Whiting et al., 2016), a well know methodology (in other fields like medicine), which is "designed specifically to assess the risk of bias in systematic reviews" (Whiting et al., 2016, p. 225). In this case, results indicate a low risk of bias (as described in the "Application of ROBIS" file).

Lastly, the quality of the selected papers is not assessed in consideration of the impracticability of defining a homogenous criterion for manuscripts belonging to heterogeneous disciplines (Concari et al., 2020).

### C.3. SM of Section 3.4: Results

#### C.3.1. RQ1 – Evolution of the Research on Recycling Behavior

As mentioned in the main article, the primary sources are mainly from environmental sciences, psychology and economics. The analysis of the other journals (ranking 11-20) provides further information on the contribution of the other fields like health, nutrition, and education (Table 32).

**Table 32.** Primary source journals (Rank 11-20) (SM of Chapter 3).

Rank	Journal	No. of Articles	Percentage
11	International Journal of Environmental Research and Public Health	25	1.21
12	British Food Journal	20	0.97
13	Journal of Environmental Planning and Management	17	0.82
14	International Journal of Sustainability in Public Education	16	0.78
15	Journal of Applied Social Psychology	16	0.78
16	Science of the Total Environment	16	0.78
17	Environmental Science and Pollution Research	15	0.73
18	Environment, Development and Sustainability	13	0.63
19	Journal of Material Cycles and Waste Management	13	0.63
20	Advances in Consumer Research	12	0.58

In relation to the countries, the integration of the network and temporal analysis of the citations by country (Table 33) with other types of analysis offers further insights on the global situation.

**Table 33.** Number of citations and articles per country (ranking 11th to 20th) (SM of Chapter 3).

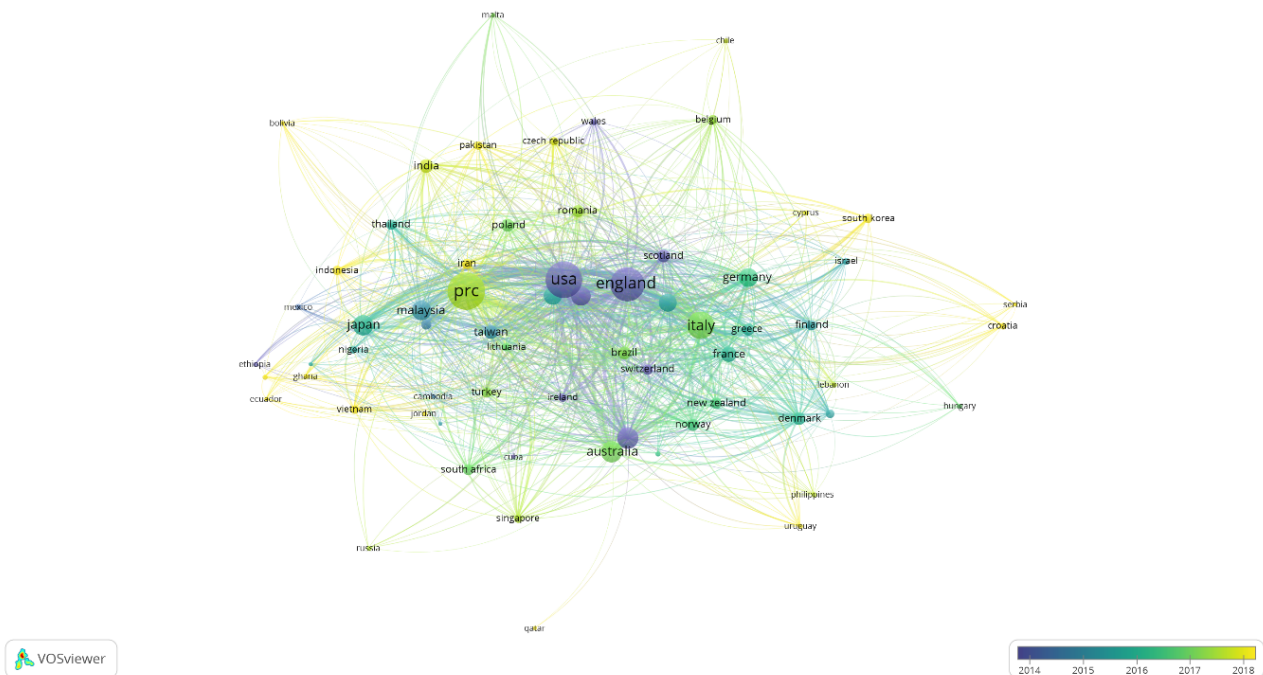
Rank	Nation	No. of Citations	No. of Articles
11	Australia	965	69
12	Denmark	964	25
13	Scotland	812	27
14	Norway	739	22
15	New Zealand	617	19
16	Greece	532	22
17	Brazil	514	25
18	France	491	38
19	Switzerland	481	17
20	Finland	474	18

In Figure 36 (overlay visualization with a colored time scale: blue for 2014 fading in yellow for 2018) the darker blue colors highlight the prominent position of USA, England, Canada and Scotland in the early 2010s, whereas Italy and PRC are enhancing their roles as leading countries in the late 2010s. Moreover, looking at the yellow countries (in a more peripheral position), namely Indonesia, Pakistan, Czech Republic, South Korea, Croatia, Uruguay, Vietnam, Ecuador, Ghana, it follows a wide international spread of the interest in the research about recycling behavior. Overall, the overlay visualization of VOSviewer allows to highlight the dynamic situation of the academic literature on this topic (including the onset of new areas); in this case, it is clear that leading English-speaking countries are gradually balanced by new emerging countries as PRC and Italy.

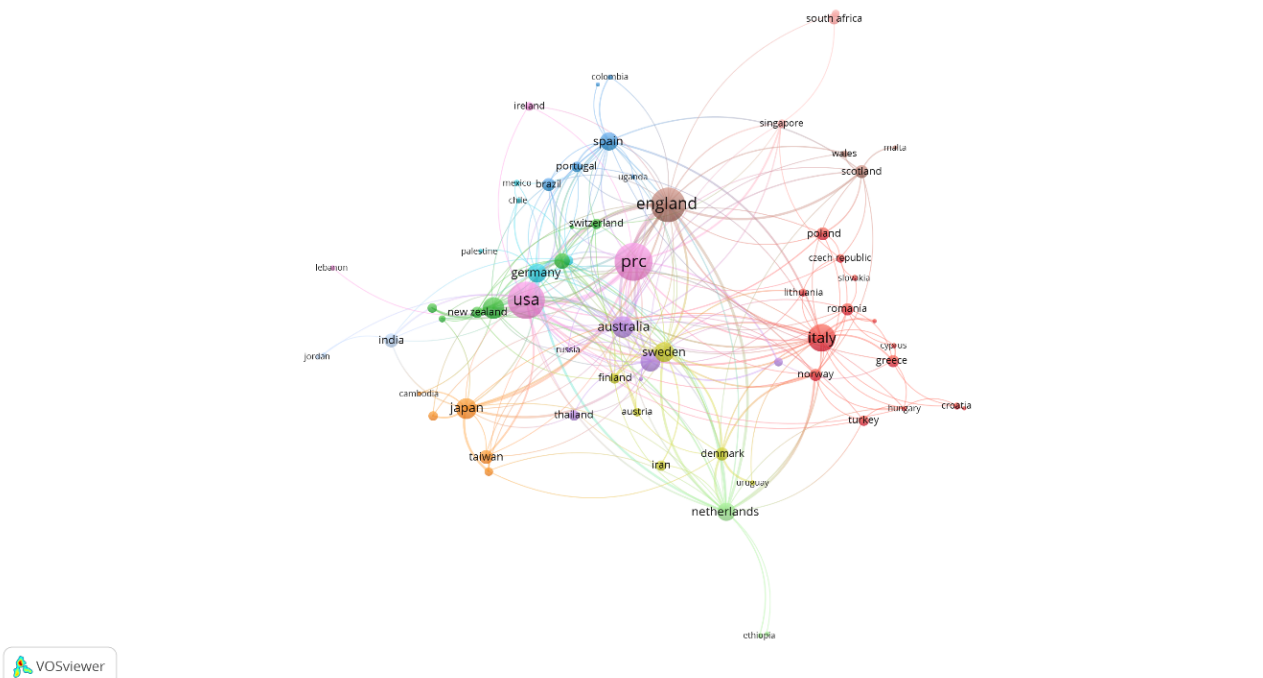
The co-authorship analysis of countries (Figure 37), although highlighting the same main leading nations (namely England, USA, PRC, as per Figure 36), provides a different cluster structure because of the different link strengths. In fact, Italy, The Netherlands, Australia, Sweden, Germany and Japan become the leading country of their own cluster; moreover, USA and PRC belong to the same cluster (same pink color), whereas in the previous figure they belong to different cluster (as indicated by the utilization of different colors). In some cases, the clusters are quite centered in the geographical area



of their respective main nation, as in the case of Italy; in others, the geographical relationship is limited and other factors come into play (e.g., trade, language, culture).



**Figure 36.** Overlay visualization of citations per country (minimum 3 articles per country - VOSviewer).

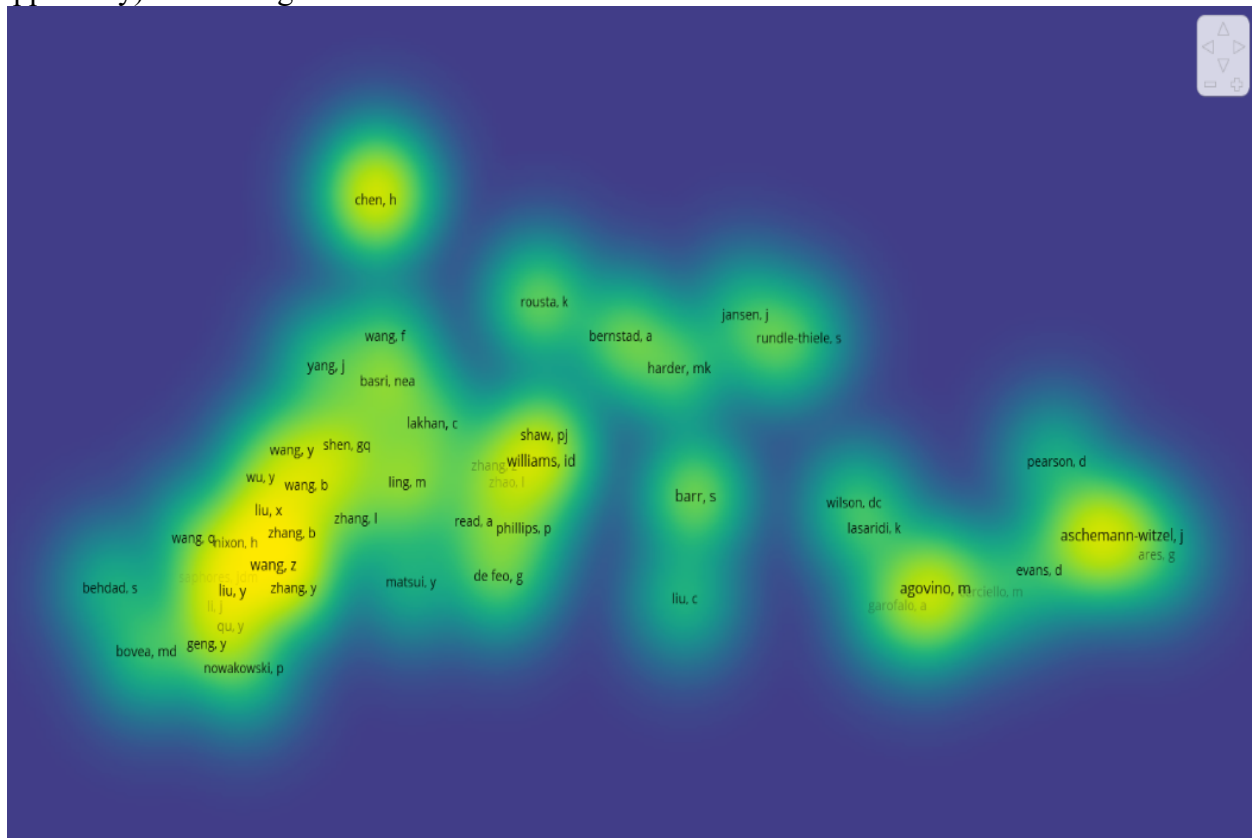


**Figure 37.** Overlay visualization of co-authorship by country (minimum 3 articles - VOSviewer).

These examples highlight the importance of analyzing the topic under different perspectives in order to get more insights and granularity.

The density view of VOSviewer can help in better visualizing, for example, the citation network of the authors (Figure 38); in fact, this view is usually quite straight forward. The yellow areas indicate

a large number of items and a high weight of the neighboring items (vice versa for the blue areas); therefore, Figure 38 displays leading authors like Barr, S. and Williams, I.D. in yellow. However, it may happen that some key authors are not visible or their shades of yellow are not as strong as expected, therefore, it is also worth mentioning some limitations of the density view in VOSviewer. For example, Figure 38 displays Barr, S. with a shade of yellow not as strong as the one for Williams, I.D.; consequently, the lower intensity of the yellow color for Barr S. may lead to the conclusion that Barr, S. is less important (in terms of citations) than Williams, I.D.; actually, Barr, S. has 1161 citations, whereas Williams, I.D. has 522 (as per Table 5 in the main paper). This figure may result (apparently) misleading.



**Figure 38.** Density view of citation of authors (minimum 5 paper per author - VOSviewer).

The correct interpretation of the density view actually requires the knowledge of some VOSviewer mechanisms. As stated in the VOSviewer manual (Eck and Waltman, 2018), the density view combines information about the number of items (in this case the quantity of citations) and the “weight of the neighboring items” (p. 10). Considering Barr, S. and Williams, I.D. have different citation networks, Williams, I.D. has neighboring items with a higher weight than Barr. The same considerations apply to Agovino, M. and Aschemann-Witzel, J. This interpretation is also supported by Agovino, M., Aschemann-Witzel J. and Williams, I.D. having more authors displayed around their names than Barr, S.

Furthermore, it is also worth noting that the names displayed around the main authors are often cited in their papers; for example, Williams, I.D. cites Phillips, P., Read, A., Shaw, and vice versa (in some cases), therefore creating areas with a strong yellow color.

### C.3.2. RQ2 – Leading Scholars and Intellectual Configuration of the Knowledge on Recycling Behavior

The importance of the definition of the intellectual base is also stress by Shafique (2013) who claims that “the intellectual structure of a scientific domain includes its constituent research traditions, their

disciplinary composition, topics addressed by these, and the pattern of their interrelationships” (p. 63).

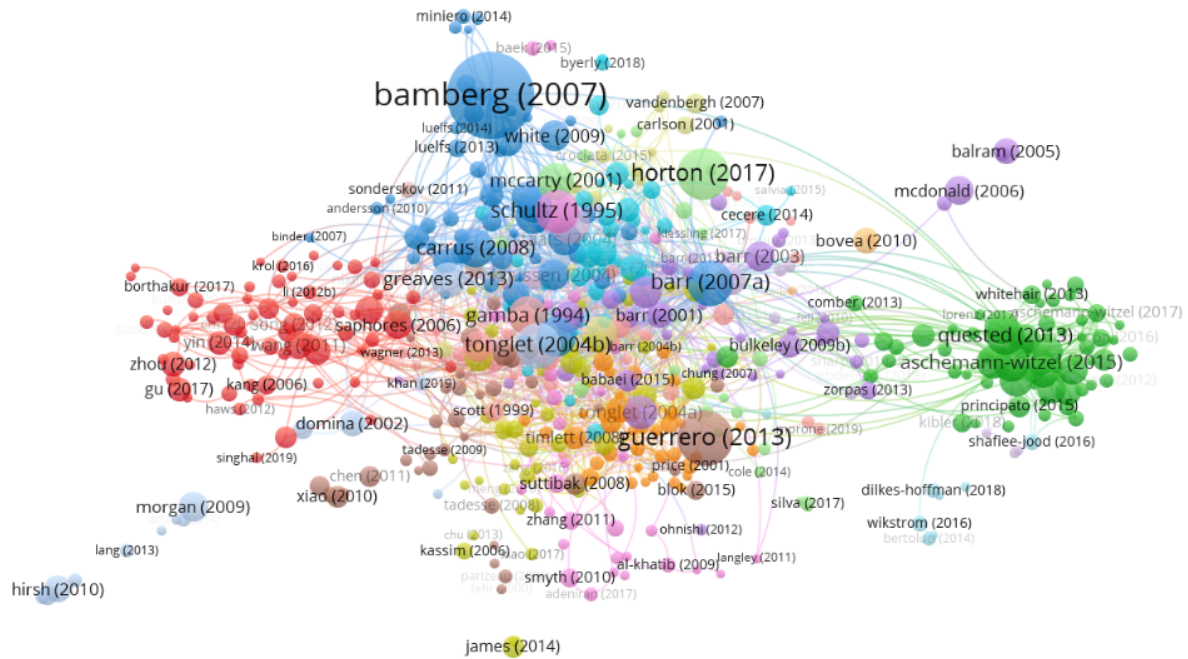
As stated in the main manuscript, the authorship analysis indicates Barr, S., Agovino, M., Williams, I. D., Aschemann-Witzel, J., Chen, H. and Oskamp, S. as the most productive authors in the field of recycling behavior. Table 34 displays the second ten most active scholars.

**Table 34.** Most productive and cited authors (rank 11-20) (SM of Chapter 3).

Rank	Journal	No. of Articles	No. of Citations
11	Lakhan, C.	7	78
12	Wan, C.	7	1663
13	Nowakowski, P.	6	77
14	Rousta, K.	6	63
15	Wang, Z.	6	462
16	Xu, L.	6	102
17	Pearson, D.	5	47
18	Werner, C. M.	5	92
19	Best, H.	4	110
20	Chen, C. C.	4	55

In relation to the authors’ connection network, it is important to note that changing the threshold of the minimum number of papers to consider per each author influences the number of clusters. For example, by reducing the minimum number of documents of an author from 5 to 2, more authors (namely 643) meet the threshold, thus important authors (as also indicated by the total link strength) like Oskamp become visible. Vice versa, by increasing the minimum number of papers to consider from 5 to 6, only 36 authors are selected, and only 6 clusters are visible; in this case, Agovino, M., Aschemann-Witzel, J. and Barr, S. belong to the same cluster, whereas Lakhan, C. and Wang, Z. to another cluster. In relation to the total link strength, it is important to clarify that an author producing many papers with a relatively low number of citations (e.g., 10 papers by Aschemann-Witzel, J. characterized by 363 citations) can reach the same strength as an author producing less papers but most cited than the other author (e.g., 3 papers by Oskamp, S. with 638 citations).

Figure 39 displays the clusters about the most cited papers, not to be confused with the analysis of most cited authors. As indicated in the main text, the azure blue cluster focuses on household behavior in relation to waste management and the conceptual framework of environmental behavior. The most cited paper is Bamberg and Moser (2007)’s article on responsible environmental behavior; their literature search applies a multivariate meta-analytical approach to papers on pro-environmental behavior, published between 1995 and 2006. Their study is based on two well-known main theoretical frameworks, namely the Schwartz (1977)’s Norm Activation Model (NAM) and Ajzen (1991)’s TPB. Their analysis of the determinants of pro-environmental behavior confirms the mediating role of intention on all other socio-psychological variables; however, also perceived behavioral control and moral norms exert their influence on intention; moreover, problem awareness indirectly impacts on intention. In addition to Barr (2007)’s article on the determinants of waste management behavior, several papers belonging to this cluster (Botetzagias et al., 2015; Carrus et al., 2008; Mannetti et al., 2004; McCarty & Shrum, 1994; Oom Do Valle et al., 2005; Staats et al., 2004; Taylor & Todd, 1995a, 1995b) analyze the behavioral theories and their application to household recycling through integrated models incorporating different factors. As mentioned before, the predominant theory is TPB; therefore, the analysis focuses on attitude, subjective norms, perceived behavioral control and intention (as the antecedents of behavior), often integrated by other factors, like personal values, personal identity (Mannetti et al., 2004), spillover effects (Thøgersen, 1999), habits (Staats et al., 2004), knowledge (Ellen, 1994).



**Figure 39.** Citations of papers (minimum of 15 citations per paper; papers are labelled by their author’s name and year - VOSviewer).

In the brown cluster (focusing on solid waste management through a wider approach), the cities are considered as active actors in the wide waste management strategy: Chen et al. (2011)’s paper focuses on urban China and socio-demographic factors, Esmaeilian et al. (2018)’s on smart and sustainable cities through IoT, B. Zhang et al. (2019); Zhang et al. (2016)’s on accessibility of recycling facilities. This holistic approach is supported by Hadler and Haller (2011)’s paper on global activism and nationally driven recycling; moreover, this article tries to move beyond the typical analysis of households by considering the wider public and private behavior. The analysis of the effectiveness of the policy measures in big cities like Hong Kong characterizes Wan et al. (2014); Wan et al. (2015)’s studies; also, Suttibak and Nitivattananon (2008)’s paper investigates the solid waste recycling program of local government authorities in different Thai urban areas. It is worth noticing that Xiao and Hong (2018)’s and Xiao and McCright (2014)’s papers on gender contribute to the holistic analysis of waste management under different perspectives which characterize this cluster.

The dark green cluster on food waste behavior analyses the drivers of food waste and possible ways of reducing the related behavior. Leading papers are from authors, Whitehair et al. (2013), Principato et al. (2020); Principato et al. (2015), Graham-Rowe et al. (2019), Graham-Rowe et al. (2015), Graham-Rowe et al. (2014), Abdelradi (2018), Hebrok and Boks (2017), Hebrok and Heidenstrøm (2019), Jorissen et al. (2015), Secondi et al. (2015), Schanes et al. (2018), Schanes et al. (2016), Stancu et al. (2016), Thyberg and Tonjes (2016).

As explained in the main text, the light green cluster (on environmental planning, conservation of natural resources and risk awareness) is characterized by Horton et al. (2017)’s paper on microplastics in non-marine environments; this article does not only focus on the socio-psychological analysis of human behavior, but also considers consumer behavior as one of the factors contributing to the problem. In fact, it analyses environmental issues from different points of view by considering, for example, agriculture, nanotechnology, ecology, waste management; moreover, it highlights the lack of knowledge about microplastics in freshwater and terrestrial environment, besides other key gaps. Some leading papers characterizing this cluster are as follows. In addition to the mentioned Oskamp (1995)’s paper applying social psychology to prevent ecological disaster, McCarty and Shrum (2001)’s article expands the analysis by including political planning and economics. Heidbreder et al. (2019)’s article on plastic pollution emphasizes the importance of risk awareness and long-term effects, besides the excessive production and consumption of plastics. Beitzen-Heineke et al. (2017)

analyze the food supply chain and its social and environmental impact; they suggest a “more resource-efficient behaviour” (p. 1528) based on zero packaging, and they propose to develop an enhanced consumer awareness.

It is noteworthy that in the red cluster on e-waste recycling the influence of Saphores et al. (2012) and Saphores et al. (2006)’s papers is stronger than it appears, because this scholar is a co-author of other articles on the same topic with Milovantseva and Saphores (2013), and Nixon et al. (2009), Nixon and Saphores (2007). E-waste-related behavior is also addressed by Wang, Dong, et al. (2018), Wang, Guo, et al. (2018), Wang et al. (2016), Wang et al. (2011), Wang et al. (2017), Gu et al. (2019), Gu et al. (2017). This topic clearly represents a leading sector of investigation in consideration of different factors, like the presence of valuable and reusable materials inside dismissed electronic devices, the complexity of human behavior in getting rid of old personal electronic devices (e.g., mobiles, laptops, tablets), marketing and economic aspects.

In the yellow-to-green cluster on public participation and community activities, Ramayah et al. (2012)’s paper focuses on green movements and social norms, besides more personal factors like attitude and convenience. Pakpour et al. (2014)’s article, starting from the analysis of factors influencing recycling behavior, highlight the importance of creating effective public campaign and specific interventions to improve the recycling rates of the community, especially conducting educational activities to target moral obligation. McDonald and Ball (1998)’s paper analyses public recycling schemes in relation to plastic waste and infers the importance of public contributions. Similarly, Ghani et al. (2013)’s article investigates the public participation to source separation of food waste; they conclude that the implementation of an effective separation requires a supportive communication campaign by the waste management authorities. James and Moseley (2014)’s paper emphasizes the importance of public services and the collective voice of citizens. It is worth noticing that many papers of this cluster (Ghani et al., 2013; Pakpour et al., 2014; Pin-Yu & Ja-Fun, 2003) apply TPB to study the recycling behavior and understand how socio-psychological determinants influence public participation.

The violet cluster features the pro-environmental consumer lifestyle including sustainable consumption and strategies for sustainability. McDonald et al. (2006)’s paper studies the anti-consumer lifestyle of “voluntary simplifier” (VS) and “beginner VS” in relation to sustainable consumption as well as recycling. Barr (2003)’s article on strategies for sustainability highlights the role of policy makers and the importance of these strategies for encouraging pro-environmental behavior (including waste minimization and recycling, energy and water saving).

Among the most important papers of the cluster on household recycling, related policies and tariffs, it is worth recalling Hage et al. (2009)’s article on household recycling (Sweden), Reschovsky and Stone (1994)’s paper on market incentives and government policies to promote household recycling. Sidique et al. (2010)’s article focuses on recycling education, enactment of recycling ordinance, efficacy of different recycling programs, effects of tariffs. Other papers analyze this effect by studying the effectiveness of weight-based billing system for household including willingness to pay (WTP) for an enhanced waste management system (Sterner & Bartelings, 1999; Van Houtven & Morris, 1999). Other articles focus on the role of policymakers, public support, policy instruments, public participation, legal reforms, waste policy and regulations to promote more sustainable behavior (Abbott et al., 2017; Ferrara & Missios, 2005; Ferrara & Missios, 2012; Jones et al., 2010; Ma & Hipel, 2016; Morris & Holthausen Jr, 1994; van den Bergh, 2008).

In the ice blue cluster on personality traits and the convenience of recycling, the choice of a specific theoretical framework clearly influences the selection of determinants of behavior; therefore, the application of TPB implies the analysis of attitude, subjective norms, perceived behavioral control and attitude. Differently, Morgan and Birtwistle (2009) apply the adoption theory to study the disposal habits of young fashion consumers and to consider specific factors like disposition. Domina and Koch (2002)’s paper investigates factors like the convenience and the frequency of recycling, the shopping behavior, the age, the family size and the income. Hirsh (2010)’s paper also considers environmental concern and environmentalism, which lead, in turns, to sustainable development.



Knussen et al. (2004)'s paper integrates the application of TPB to household waste recycling by considering the effect of perceived lack of recycling facilities, the perceived habit of recycling and past recycling. The social context is addressed by Huddart-Kennedy et al. (2009)'s and Yu (2014)'s papers which highlight the difference in environmental attitudes by comparing urban and rural life. The cluster on separate waste collection through the analysis of the local and spatial dimension of recycling behavior is characterized by Martin et al. (2006)'s and Massimiliano Agovino et al. (2019)'s, Agovino et al. (2018)'s, Agovino, Crociata, et al. (2016)'s works. The former analyses the role of local authorities and ethnic minorities, and the effect of public participation; the latter performs a spatial analysis of waste management including proximity effects, location and availability of landfills, spatial dependence, neighborhood influence, cultural consumption (Agovino, Crociata, et al., 2016; Crociata et al., 2016; Crociata et al., 2015). This cluster also analyses aspects like separate collection rates and solid waste reduction through recycling (Agovino, Crociata, et al., 2016; Agovino, Ferrara, et al., 2016; Carlson, 2001; Crociata et al., 2016; Crociata et al., 2015), the influence of social norms on behavior changes and the social capital (Fiorillo, 2013; Hansmann et al., 2006).

In addition to the ten most cited paper, Table 35 displays the second ten most cited manuscripts.

**Table 35.** Most cited papers (11-20) (SM of Chapter 3).

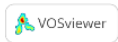
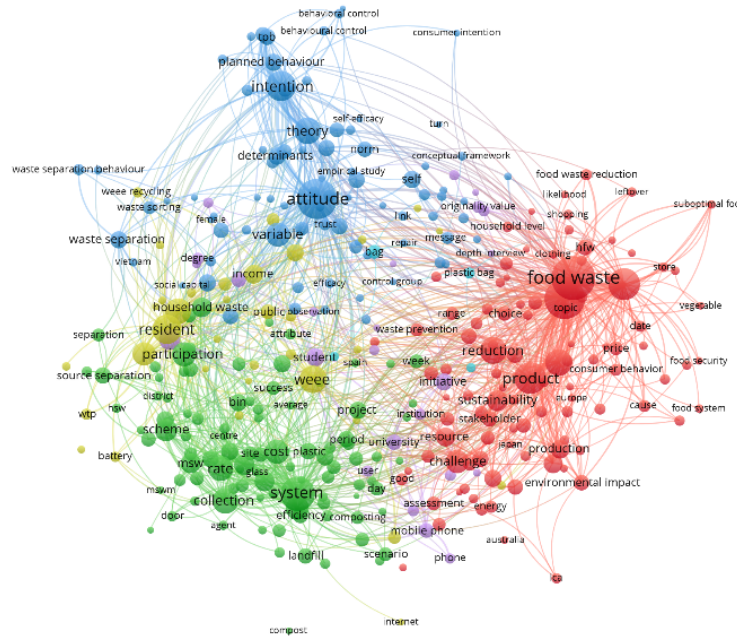
Rank	Articles	Authors	Year	No. of Citations
11	Spaghetti soup: The complex world of food waste behaviors	Quested, T. E., Marsh, E., Stunell, D., Parry, A. D.	2013	257
12	The Influence of Individualism, Collectivism, and Locus of Control on Environmental Beliefs and Behavior	McCarty, J. A., Shrum, L. J.	2001	233
13	Consumer-Related Food Waste: Causes and Potential for Action	Aschemann-Witzel, J., de Hooge, I., Amani, P., Bech-Larsen, T., Oostindjer, M., Taylor, S., Todd, P.	2015	219
14	An integrated model of waste management behavior: A test of household recycling and composting intentions	Mannetti, L., Pierro, A., Livi, S.	2004	208
15	Recycling: Planned and self-expressive behavior	Jones, C. M., Kammen, D. M.	2011	208
16	Quantifying Carbon Footprint Reduction Opportunities for US Households and Communities	Greaves, M., Zibarras, L. D., Stride, C.	2013	205
17	Using the theory of planned behavior to explore environmental behavioral intentions in the workplace	Graham-Rowe, E., Jessop, D C., Sparks, P.	2014	203
18	Identifying motivations and barriers to minimizing household food waste	Tonglet, M., Phillips, P. S., Bates, M. P.	2004	199
19	Determining the drivers for householder pro-environmental behavior: waste minimization compared to recycling	Stancu, V., Haugaard, P., Lahteenmaki, L.	2016	193
20	Determinants of consumer food waste behavior: Two routes to food waste			

### C.3.3. RQ3 – Main Areas of Interests and Possible Gaps

Considering the co-word analysis is highly influenced by the utilization of acronyms and different spelling of the main keywords, it is essential to adequately define and standardize the reference terms, otherwise acronyms are separately counted from the words they refer to (for example, TPB needs to be counted together with “theory of planned behavior” or “theory of the planned behavior”).

### C.3.3.1. Co-word Analysis of Titles and Abstracts in VOSviewer: Comparison of Different Thresholds

By changing the threshold from 50 to 20 citations, the co-word analysis of titles and abstracts reveals more clusters because more terms meet the threshold (please note that VOSviewer automatically selects the 60% of more relevant terms); in fact, the number of clusters increases to 6 (Figure 40).



**Figure 40.** Co-word analysis (minimum 20 citations -VOSviewer).

The most recurring terms changes as follows: food waste, attitude, consumer, system, product, food, intention, resident, WEEE, theory, consumption, reduction (Table 36). In this case, most of the terms do not change, but the word “recycling” is no more a leading term, and WEEE joins the top 12 list.

**Table 36.** Co-word analysis of titles and abstracts (minimum 50/20 co-occurrences) (SM of Chapter 3).

Rank	Terms (min. 50 co-occurrences)	Terms (min. 20 co-occurrences)
1	Food waste	Food waste
2	Recycling	Attitude
3	Attitude	Consumer
4	Consumer	System
5	System	Product
6	Intention	Food
7	Food	Intention
8	Collection	Resident
9	Product	WEEE
10	Consumption	Theory
11	Resident	Consumption
12	City	Reduction

In relation to the most relevant keywords, the changes are significant because two keywords only remain in the list of the top 12 keywords, namely subjective norms and TPB (Table 37).



**Table 37.** Co-word analysis of the keywords (minimum 50/20 co-occurrences) (SM of Chapter 3).

<b>Rank</b>	<b>Term (min. 50 co-occurrences)</b>	<b>Term (min. 20 co-occurrences)</b>
1	Subjective Norms	Suboptimal food
2	TPB	Vegetable
3	Planned behaviour	Fruit
4	Food	Extended theory
5	HFW (Household Food Waste)	Store
6	Food waste reduction	Food loss
7	Packaging	Food security
8	Consumer behaviour	Behavioural control
9	Environmental impact	TPB
10	SEM (Structural Equation Modeling)	Food supply chain
11	Food waste	Subjective norms
12	Intention	Supermarket

Over the years, the new entries are as follows: suboptimal food, vegetable, fruit, extended theory, store, food loss, food security, behavioral control, food supply chain and supermarket; therefore, the focus on food, the related supply chain and food loss significantly increases. This trend is confirmed by the fact that a cluster (the red one in Figure 40) is still centered on food waste, products and consumer; the other associated keywords are very similar to the green cluster of Figure 20 in the main text. For example, recurring words are the production phase (including packaging), purchase and consumption, reduction and prevention of food waste; also, the words on circular economy (CE), sustainable development and climate change, challenges and opportunities, energy and future research do not change.

Similarly, the cluster characterized by the keywords attitude, intentions, determinants does not significantly change; in fact, it still focuses on the antecedents of recycling behavior, like social, personal and subjective norms, beliefs, environmental concern and attitude. It is noteworthy that some papers consider recycling behavior as a component of environmental behavior, made of other practices or aspects, like energy saving, environmental concerns, footprint reduction. Several papers belonging to this cluster are characterized by a robust scientific approach, often based on structural equation modeling (SEM).

Conversely, the cluster about recycling as a waste management system is split into a main cluster centered on the keyword “system” and other minor clusters. The cluster on system maintains a general and managerial approach; in fact, it includes keywords like collection, separation, performance, rate, waste generation, solid waste management (SWM), system, scheme, public participation, citizen, public, service, local authority, municipality, investment. Moreover, it keeps displaying the keywords related to cost, quantity, facilities and types of waste, with the exception of WEEE, which becomes a new distinct cluster. This cluster expands the analysis of WEEE by including some related socio-psychological aspects like WTP, environmental awareness, education level, besides some socio-demographic factors like age, gender and income. In this case many studies on WEEE are characterized by the analysis of the hidden mechanisms which prevent people from improving WEEE recycling; moreover, the papers belonging to this cluster analyze the institutional and legal aspects which influence this type of recycling.

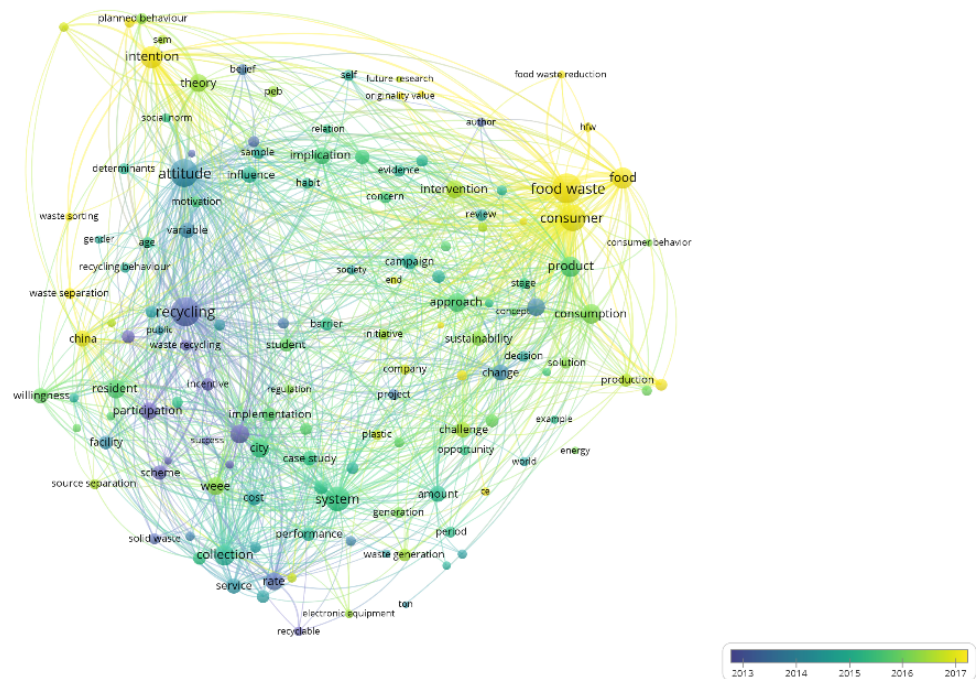
The fifth cluster is characterized by keywords related to the initiative and higher-level education (e.g., university, campus, degree, student, research limitation implications), whereas the last cluster is of made of 4 items only, with a predominance of plastic bag and local government (please note that the dimension of a cluster is not necessarily proportional to its importance, therefore a small cluster might be very relevant).

It is worth noticing that, by lowering the threshold from 50 to 20 citations, new geographical keywords are extracted. For example, whereas for a threshold of 50 citations the only national keywords are China and, to a lower extent, Malaysia (confirming the increasing influence as

explained in section 4.1 on RQ1), for a threshold of 20 citations EU, Europe, India, Japan, Australia, Poland are included in the first cluster, Brazil, Canada, England, Indonesia, Malaysia, Ontario, Spain, Sweden, in the second one, South Africa and Taiwan in the third one, China, Greece and Thailand in the fourth one, Hong Kong, Nigeria and Romania in the fifth one, and USA in the sixth one.

### C.3.3.2. Temporal Analysis of Co-words: Comparison of Different Thresholds

The temporal analysis through the overlay visualization of VOSviewer offers the opportunity of understanding how the above-mentioned themes evolve throughout the years. Noting that the darker the color, the older the paper, Figure 41 shows that some recurring keywords have definitely changed. For example, the most diffused words in the early 2010s like recycling, rates, schemes, participation and attitude, have been replaced by intention, food waste, consumer and China in the late 2010s. On the one hand, this evidence does not mean that the most recent papers no more focus on recycling or attitude; on the other hand, the attention on food waste has definitely increased, and China is actually expanding its literature on recycling behavior with numerous case studies. In this case, the temporal analysis offers the possibility to detect bursts, namely the latest leading topics.



**Figure 41.** Overlay visualization of co-word analysis (minimum 50 keywords - VOSviewer).

The analysis with a threshold of 20 keywords (Figure 42) is pretty much unchanged (in comparison with the threshold of 50 keywords); in fact, the late 2010s still focus on food waste, food, consumer and intention. Moreover, the keyword China is also present in the late 2010s. Please note the slight changes in scale range and related colors between Figure 41 (2013-2017) and Figure 42 (2013-2018); for example, the light green color of Figure 42 refers to year 2016, whereas it corresponds to year 2017 in Figure 42.

The selection of different threshold levels in SciMAT also provides different perspectives on the topic of investigation. In fact, considering the high number of items (e.g., keywords) to analyze, SciMAT offers numerous algorithms both to reduce the complexity of the domain under investigation, and to analyze specific aspects of the research area; for example, it allows to define how to build the network and the minimum number of edges to consider. In this respect, it is worth to mention some key definitions. The minimum frequency threshold indicates the minimum number of times an item (e.g., keyword) has to appear in the selected documents during a specific (sub)period of time (Van Eck & Waltman, 2018). The minimum edge value threshold defines the minimum value of the edges (connecting the items) to be utilized to build the views for each (sub)period. The selection of the

clustering algorithm (e.g., single centers algorithm) defines the principle to apply for the definition of the clusters; moreover, the definition of the maximum and minimum network size directly influence the number and type of clusters.

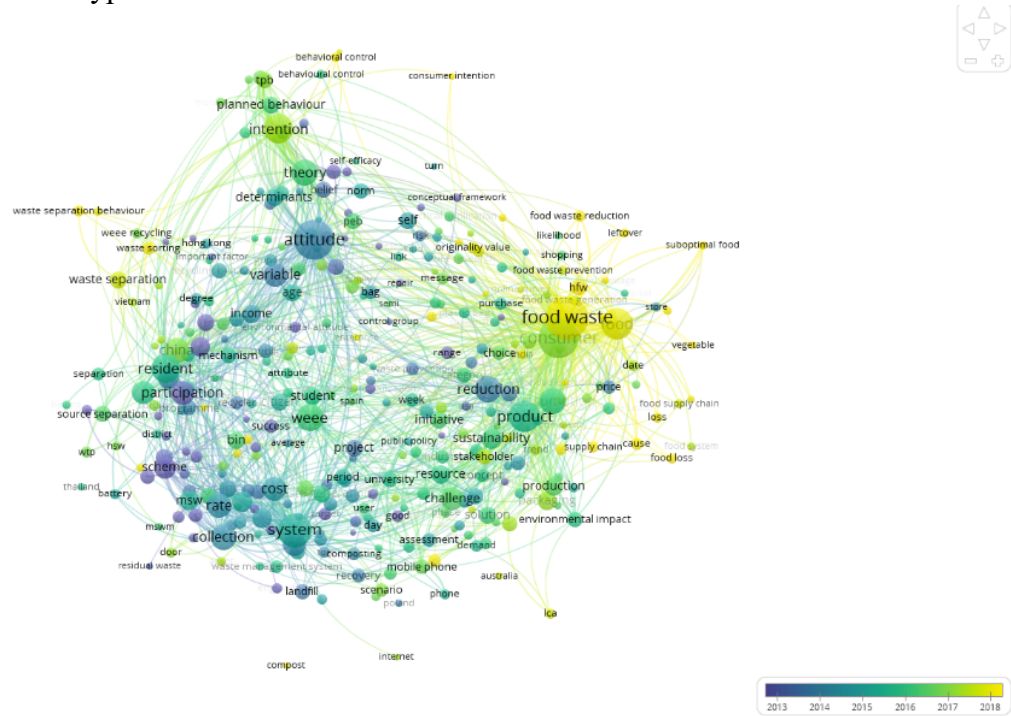


Figure 42. Overlay visualization of co-word analysis (minimum 20 keywords - VOSviewer).

In Figure 43 (based on co-occurrence of keywords, minimum frequency reduction per subperiod=3 items, minimum edge value threshold=3, similarity measure to normalize network=equivalent index, maximum size of the simple center clustering algorithm=12, core document mapper, quality measure=h-index), an apparently simple change of 1 unit in the minimum size of the clustering algorithm causes a significant change in the strategical views.

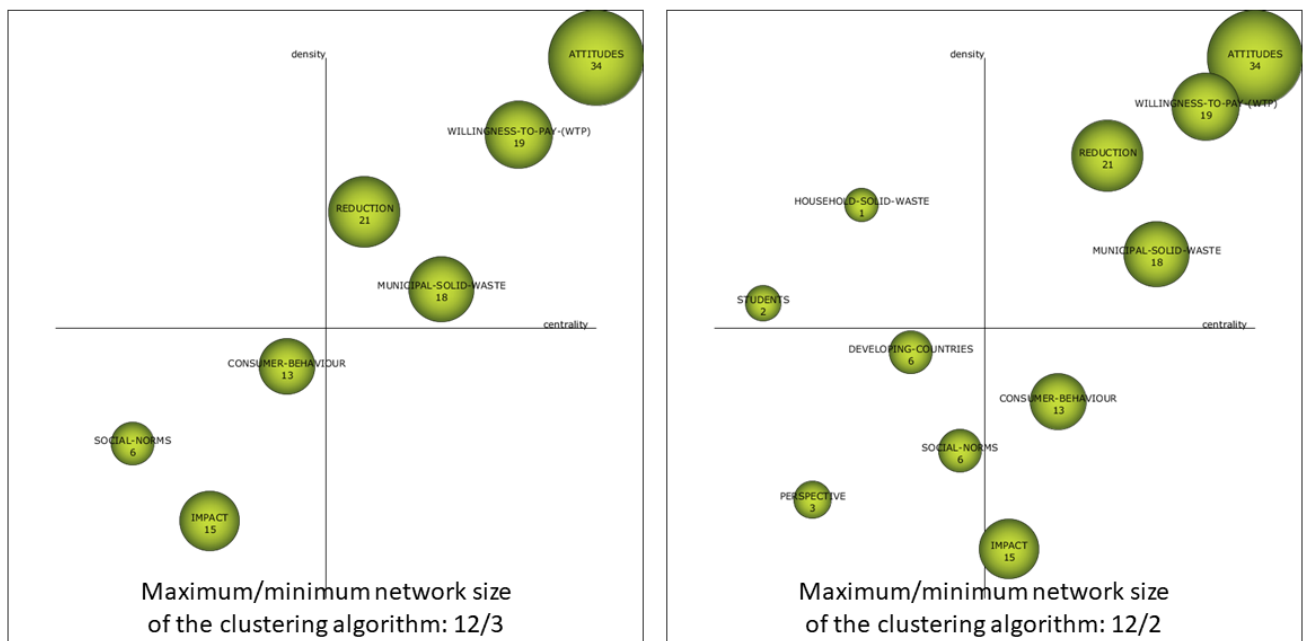


Figure 43. Strategical views: effects of the change of the minimum network size of the clustering algorithm. Subperiod 2015-2020 (SciMAT).

In fact, the reduction of the value of the minimum size of the clustering algorithm causes an increase in the number of clusters (from 7 to 11) and the change of position of some clusters (specifically a shift to the right of the cluster in the lower left quadrant, with a clear increase of centrality).

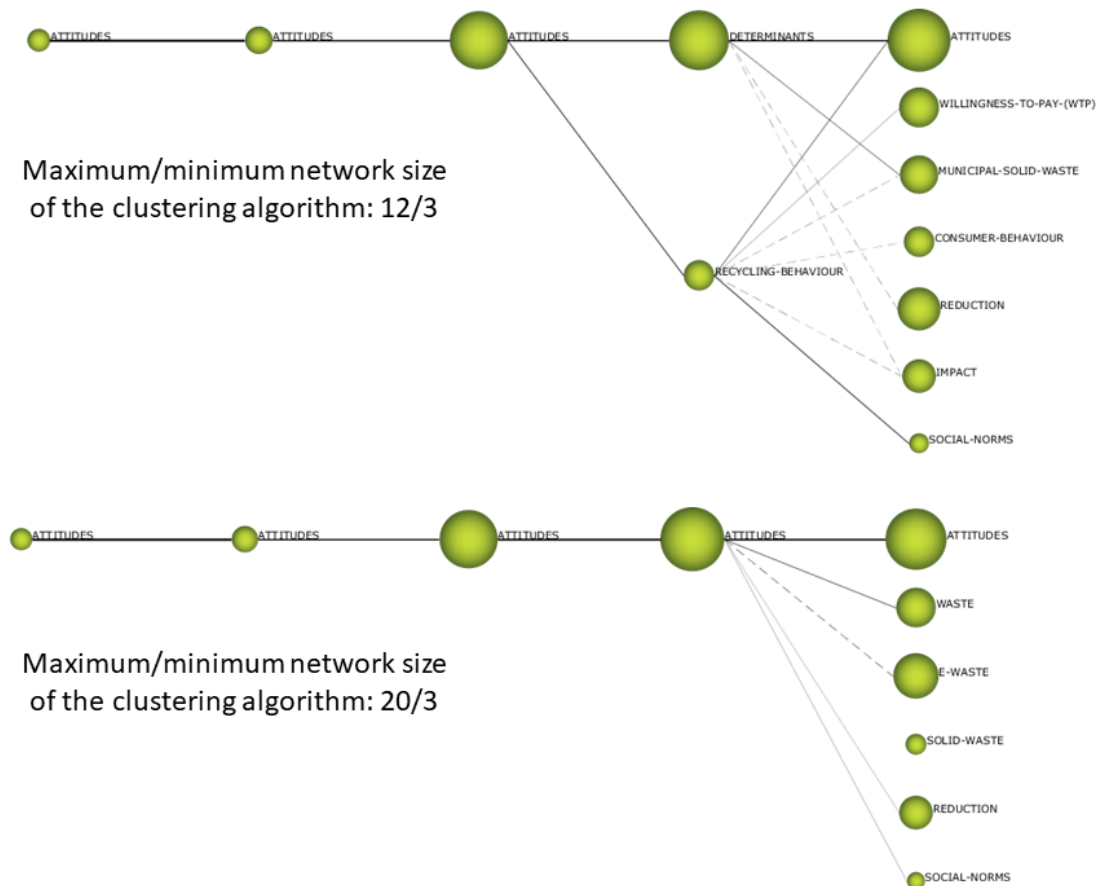
In Figure 44 (based on co-occurrence of keywords, minimum frequency reduction per subperiod=3 items, similarity measure to normalize network=equivalent index, maximum size of the simple center clustering algorithm=12, maximum size of the simple center clustering algorithm=3, core document mapper, quality measure=h-index), an apparently simple change of 1 unit in the minimum edge value threshold (from 3 to 2 units) causes a significant change in the strategical views. In fact, the reduction of the value of the minimum edge threshold (from 3 to 2 units) causes a significant increase in the number of clusters (from 7 to 16), the disappearance of many clusters (willingness-to-pay, reduction, impact and social-norms) and the change of position of some clusters (with the only exception of attitude, which remains positioned in the top right-hand corner).



**Figure 44.** Strategical views: effects of the change of the minimum edge value threshold of the clustering algorithm. Subperiod 2015-2020. (SciMAT).

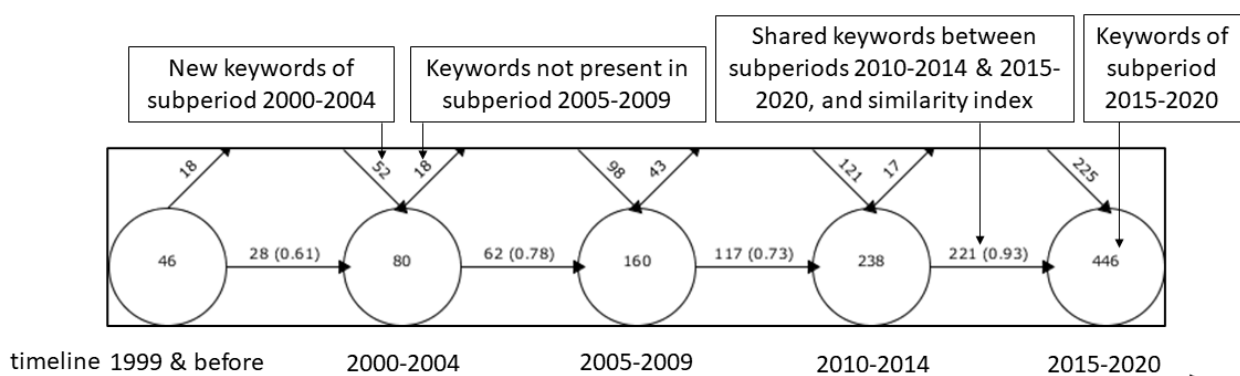
The change of some parameters influences the longitudinal view as well. In Figure 45 (based on co-occurrence of keywords, minimum frequency reduction per subperiod=3 items, similarity measure to normalize network=equivalent index, minimum size of the simple center clustering algorithm=3, the minimum edge value threshold=3, core document mapper, quality measure=h-index), the change of the maximum size of the simple center clustering algorithm (from 12 to 20 units) causes a significant change in the longitudinal views. In fact, the increase of the value of the maximum network size causes the change of clusters of the subperiods 2010-2014 and 2015-2020. In particular, “attitude” becomes the main and only cluster in the subperiod 2010-2014, consequently “attitude” confirms its constant leading position as the main theme throughout all years. Moreover, the cluster “recycling behavior” disappears in the subperiod 2010-2014, and approximately half of the clusters in the subperiod 2015-2020 change.

The longitudinal view of the overlapping map of SciMAT offers the possibility to analyze the evolution of the clusters through the selected timeframes; moreover, it provides indications on the new and discarded items for each period, besides the similarity levels between consecutive subperiods.



**Figure 45.** Strategic views: effects of the change of the maximum network size of the clustering algorithm (SciMAT).

In relation to the selected area of investigation, the numbers inside the circles clearly indicate an increasing number of keywords throughout the subperiods (Figure 46); this trend is mainly explained by the expanding literature on this topic. It is also worth noticing that the evolution of keywords is characterized by a high level of overlapping between subperiods (as indicated by the number of shared keywords between consecutive subperiods and the related similarity index); it follows the existence of strong central and developed themes (as visible in the strategic view).



**Figure 46.** Overlapping map of co-occurrence of keywords (longitudinal view - SciMAT).

By changing the computational algorithm of the evolution map of the longitudinal view, it is possible to gain further insights on the subthemes of the main clusters.



### C.3.3.3. Further Analysis of Keywords and Abstracts in VOSviewer: Packaging and Plastic Bags

Besides topics of diffused interest like WEEE and household waste, the analysis of keywords and abstracts reveals other research lines like packaging and plastic bags. Looking at these keywords in the selected body of literature, packaging appears in 19 papers in different forms: packaging, overpackaging, packaging waste, consumers' willingness for express packaging recycling, packaging recycling, packaging materials, packaging features, container and packaging recycling law, ecologically sustainable packaging, environmental friendly packaging, plastic packages/packaging, product packaging, post-consumers plastic packaging, plastics in packaging, lightweight packaging, bio-based packaging, packaging function/functionality. In this specific case the analysis of the root "pack" brings up one more term (packaged food products). The keyword plastic bag shows up in 5 articles in the form of reusing plastic bags, plastic bag usage, plastic bag recycling, plastic bags and the environment, intention to use plastic bag. The keyword bag is utilized in 12 articles in further forms as follows: bag taking behavior, bringing their own bags, reusing bags, own shopping bags, carrier bags. This limited number of papers utilizing the keywords packaging, plastic bags and bags, requires the analysis of the abstracts too. Table 38 indicates that packaging is known topic with a relatively low relevance, namely 0.89 in binary counting (the terms is counted as long as it appears in the paper, no matter how many times) and 1.76 in full counting (the terms is counted as many times as it appears in the paper); similarly, for plastic bags and bags.

**Table 38.** Occurrence and relevance of terms related to packaging and plastic waste (SM of Chapter 3).

Term	Full Counting		Binary Counting	
	Occurrences	Relevance	Occurrences	Relevance
Bag	81	1.43	35	0.72
Container	72	0.66	44	1.00
Package	32	0.75	//	//
Packaging	134	1.76	53	0.89
Packaging waste	40	0.58	22	0.67
Plastic	111	0.54	61	0.75
Plastic Bag	52	1.77	22	0.50
Plastic Waste	39	0.54	16	0.70

Note: (minimum occurrence of a term=10; filtered by Thesaurus file).

It follows that the challenging part of text mining lies in correctly defining the right keywords and the related words. In this case, the different declinations of "packaging" lead to a reduced use of the term "packaging" alone; actually, the most recent literature makes an extended use of this terms. Therefore, as explained in the main text, it is essential to deepen the keyword analysis of the area of investigation before proceeding with further analysis of word occurrences and relevance.

### C.3.3.4. Further Considerations on Co-occurrence Analysis of Keywords in VOSviewer

It is worth clarifying that the co-occurrence analysis of keywords has to be interpreted with some flexibility, because the clusters are characterized by numerous interdependencies requiring further investigations. In fact, the clusters are not to be interpreted as rigid containers of keywords. For example, the keyword "attitude" is often analyzed by the authors addressing food waste and consumption (Figure 47).

### C.3.3.5. Burst Analysis

As previously mentioned, when mapping knowledge domain, the temporal analysis of words and keywords offers the possibility to individuate possible bursts on specific areas. Looking at "Circular Economy" (CE), it is clear that this term has been utilized in the last years only. In terms of CE utilization as a keyword in the selected articles,

Figure 48 shows a steadily increasing trend to indicate that this topic is taking a leading role and attracts several scholars.

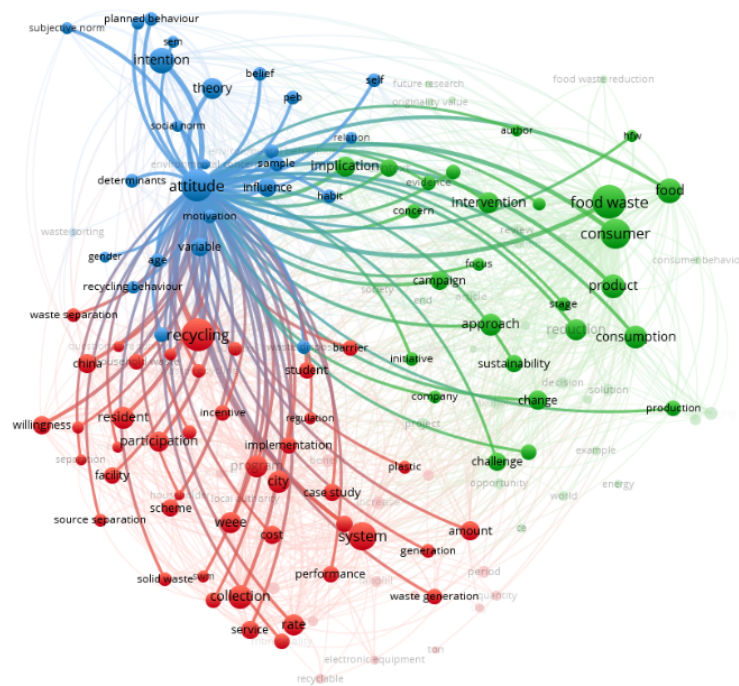


Figure 47. Keyword analysis - "Attitude" network in VOSviewer.

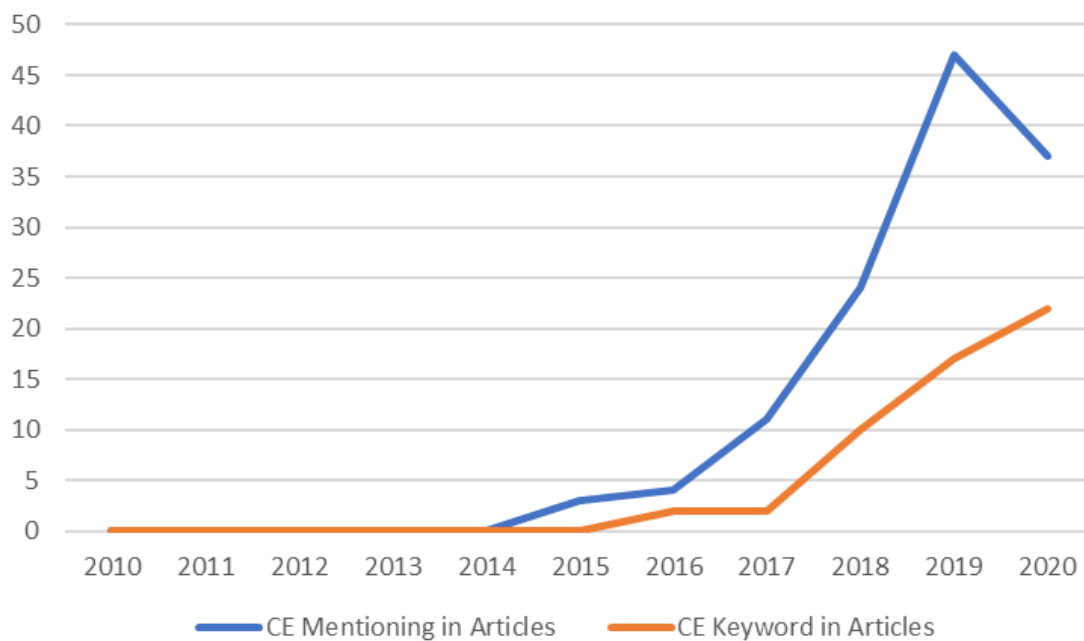


Figure 48. Utilization of "Circular Economy (CE)" in final body of literature.

### C.3.3.6. Occurrence Analysis of Words in the Texts

The occurrence analysis of words including also full counting of words inside the papers (besides titles and abstracts) individuates 1058 terms meeting the minimum threshold of occurrence of 10 times; overall the most relevant terms are different from the most occurring terms. The most relevant words (above 5.0 index) are rice, pasta, tons (per) day, self-identity, e-commerce, toilet paper,



volume-based waste fee, food loss waste, TPB construct, waste separation intention, with a range of occurrence between 10 and 18 times; whereas the most occurring terms (more than 600 times) are study, behavior, waste, food waste, household, recycling, model, consumer, paper, attitude with a relevance well below 1.0 index. Other very recurring terms (more than 300 times) are related to the research activity (e.g., analysis, survey, data, system, respondent), the strategy and policy (e.g., impact), the interventions (e.g., impact, effect, practice), the determinants of behavior (e.g., intention), the product (e.g., food), the socio-demographical dimension (e.g., city, resident, country), the types of waste (e.g., WEEE), the types of management (e.g., waste management), packaging (e.g., sustainable packaging) and plastic bags (e.g., reusing plastic bags).

**Supplementary Material:** The Supplementary Material (text, application of ROBIS and spreadsheet) is available online at <https://doi.org/10.1016/j.jenvman.2021.114160> (at “Appendix A. Supplementary data”, between the “Declaration of competing interests” and the “References”).

## Appendix D - Supplementary Material 2 (SM2) of Chapter 3

### D.1. Application of the ROBIS Tool

The ROBIS tool is made of 3 phases:

- (1) Assess relevance (optional),
- (2) Identify concerns with the review process and
- (3) Judge risk of bias” (Whiting et al., 2016, p. 227) in the review

Phase 1 is not applicable to this article considering it usually focus on “participants, interventions, comparisons, outcomes” (PICO).

Phase 2 aims at detecting possible biases; it assesses “four domains to cover key review processes:

- (1) Study eligibility criteria,
- (2) Identification and selection of studies,
- (3) Data collection and study appraisal; and
- (4) Synthesis and findings.”(Whiting et al., 2016, p. 229)

Phase 3 provides a final assessment of risk of bias in the review.

The next tables (Table 40 to Table 45) answer the “signaling questions” related to phase 2 and 3; these questions aim at assessing any biases which may hinder the review. It is worth noticing that these tables make use of the suggested ROBIS terminology (Whiting et al., 2016).

Specifically, these tables refer to the ROBIS steps as per below description (Table 39). Please note that domains 1-4 (of Phase 2) are as follows:

- (1) Study eligibility criteria: Domain 1
- (2) Identification and selection of studies: Domain 2
- (3) Data collection and study appraisal: Domain 3
- (4) Synthesis and findings: Domain 4

**Table 39.** Description of the tables about the application of the ROBIS tool (SM of Chapter 3).

Table	Phase	Description
40	2	Signaling questions and assessment of domain 1 (study eligibility criteria)
41	2	Signaling questions and assessment of domain 2 (identification and selection of studies)
42	2	Signaling questions and assessment of domain 3 (data collection and study appraisal)
43	2	Signaling questions and assessment of domain 4 (synthesis and findings)
44	2	Summary of concerns identified during Phase 2 assessment
45	3	Risk of Bias (RoB) in the review

**Table 40.** Phase 2: Signaling questions and assessment of domain 1 (study eligibility criteria) (SM of Chapter 3).

DOMAIN 1	STUDY ELIGIBILITY CRITERIA	
Describe the study eligibility criteria, any restrictions on eligibility and whether there was evidence that objectives and eligibility criteria were pre-specified	The study eligibility criteria are clearly described in Section 3 (Methods and Data) and SM spreadsheet tab 1-4, namely: Concept, Keywords, Search Terms Inclusion/Exclusion criteria, respectively: Inclusion: time, type of papers, topics, language Exclusion criteria: journals, topics, specific type of waste, specific locations Excluded journals Excluded categories/areas Please note that search queries are tailored to each data base (Web of Science, Science Direct, “EBSCO Host”). Please refer to SM text.	
<b>Signaling questions</b>	<b>Rationale</b>	<b>Answers</b>
Did the review adhere to pre-defined objectives and eligibility criteria?	The MKD and bibliometric analysis clearly state the objectives in the abstract, Sections 1 (Introduction) and 3 (Methods and Data); moreover, in Section 2 (Background) it specifies the focused research questions which are reflected in the eligibility criteria and, overall, in the study design. Furthermore, a clear protocol is provided in Section 3 and SM tab 1-4.	Yes/Yes
Were the eligibility criteria appropriate for the review question?	The eligibility criteria were appropriate for the review questions. They provided sufficient detail to enable judgement about whether the included studies are appropriate to answer the questions.	Yes/Yes
Were eligibility criteria unambiguous?	The eligibility criteria were unambiguous. For example, the type of studies and population are clearly specified in Section 3 (Methods and Data) and SM tab 1-4; in fact, the review criteria are sufficiently detailed to be easily replicated by other reviewers or “over viewers”.	Yes/Yes
Were all restrictions in eligibility criteria based on study characteristics appropriate?	The limited restrictions were appropriate to the study characteristics, namely: Non-English papers Journals and topics on publications not related to recycling behavior (e.g., chemistry, metallurgy, physics, mathematics, geology, surgery, genetics, zoology) or investigating very specific aspects of it (e.g., criminology or illness) Specific type of waste (e.g., toxic waste) Specific locations (e.g., natural parks) Minors’ behavior Managerial practices These restrictions were appropriated to the study characteristics because the MKD and bibliometric analysis focused on generic adult recycling behavior in normal situations and locations.	Yes/Yes
Were any restrictions in eligibility criteria based on sources of information appropriate?	The restrictions were appropriate. The only restrictions on the sources were related to the selection of the three databases of English peer-reviewed papers.	Yes/Yes
<b>Concerns Assessment</b>		
Concerns regarding specification of study eligibility criteria	Considerable effort has been made to clearly specify the review questions, the objectives, appropriate eligibility criteria (which have been adhered to during the review). Considering all signaling questions have been positively answered, the concern on Domain 1 is assessed as “low”.	<b>Low concern</b>

**Table 41.** Phase 2: Signalling questions and assessment of domain 2 (identification and selection of studies).

DOMAIN 2	IDENTIFICATION AND SELECTION OF STUDIES	
Describe methods of study identification and selection	The methods of study identification and selection follow the typical SLR methodology as described by Petticrew and Roberts (2006). For example, the search query is clearly defined for every database, the paper selection is documented according to the PRISMA methodology, the review is conducted by 3 reviewers to reduce the risk of bias. Further details are provided in Section 3 (Methods and Data), SM text, and tab 1-4 of SM spreadsheet.	
Signaling question	Rating guidance	Answers
Did the search include an appropriate range of databases/ electronic sources for published and unpublished reports?	This SLR utilized a wide range of sources by including Web of Science, Science Direct and “EBSCO Host” (as described in Section 3). The range of database, although not including some existing alternatives, is definitely appropriate.	Yes/Yes
Were methods additional to database searching used to identify relevant reports?	Limited citation searches and no contacting of experts have been performed.	No/No
Were the terms and structure of the search strategy likely to retrieve as many eligible studies as possible?	A full search query per each database is clearly defined and explained to allow both the capture of all applicable papers and the full replication of the SLR. In fact, the search strategy includes an appropriate range of terms for the topic; moreover, the search on EBSCO includes the expander functions “apply equivalent subjects” and “apply related words” to increase the chances of capturing all applicable papers.	Yes/Yes
Were restrictions based on date, publication format, or language appropriate?	English peer-reviewed papers were applied to the search strategy. No restriction on date. Please note that, according to Whiting et al. (2016, p. 15 of supplementary data), “restriction of papers based on language (e.g. restriction to English language articles) or publication format (e.g. restriction to full text published studies) is rarely (if ever) appropriate, and so if any such restrictions were applied then this question should usually be answered as “No”.” (p. 15 of supplementary data). Although this approach has significant implications on the studies in the medical field, it does not fully apply to this MKD and bibliometric analysis, so the answer is “Probably Yes”.	Probably Yes/ Probably Yes
Were efforts made to minimise errors in selection of studies?	As specified in SM text (“Methods and Data” Section), a single author independently screened the papers and extracted the data on the basis of the extraction protocol, whereas the other ones autonomously checked a sample of manuscripts with no disagreement on selected papers	Probably Yes/Yes
<b>Concerns Assessment</b>		
Concerns regarding methods used to identify and/or select studies	Although the restriction to English articles means that some relevant articles may have not been included, and given the review questions and eligibility criteria, a substantial effort has been made to identify as many relevant studies as possible through a variety of search methods, using a sensitive and appropriate search strategy. The review is therefore likely to have included a very high proportion of relevant studies, so the assessment on concerns regarding methods and selected studies is “low”.	Low concern

**Table 42.** Phase 2: Signalling questions and assessment of domain 3 (data collection and study appraisal) (SM of Chapter 3).

DOMAIN 3	DATA COLLECTION AND STUDY APPRAISAL	
Describe methods of data collection, what data were extracted from studies or collected through other means, how risk of bias was assessed (e.g., number of reviewers involved) and the tool used to assess risk of bias	The data collection and its classification are exactly described in Section 2 (Methods and Data) and tabs 1-5 of SM spreadsheet. The utilization of different reviewers allows to reduce the risk of bias. These MKD and bibliometric analysis include a procedure for resolving conflicts in case of disagreement among reviewers during the SLR phase (as described in SM text (“Methods and Data” Section) and tab 2 of SM Spreadsheet). The tool utilized to assess the risk of bias is ROBIS.	
Signaling question	Rating guidance	Answers
Were efforts made to minimize error in data collection?	Data extraction was performed by one reviewer using the protocol described in Section 3, SM text (“Methods and Data” Section) and tab 2 of SM spreadsheet; the other reviewers performed a sample random check. As described in tab. 2 of SM spreadsheet, differences were resolved by agreement; if the dispute is not resolved between the first two reviewers, the third reviewer is involved in the discussion. If, at this stage, no agreement is reached, the third reviewer makes the final decision.	Yes/Yes
Were sufficient study characteristics available for both review authors and readers to be able to interpret the results?	Detailed study characteristics and results tables were provided in the main manuscript and SM. The text of the manuscript reported summarized information, whereas the figures, tables and SM showed detailed information for authors and readers to interpret results.	Yes/Yes
Were all relevant study results collected for use in the synthesis?	Sufficient study results were extracted to permit an appropriate synthesis to be carried out (e.g., main authors, papers, keywords). In addition, graphical summaries and figures highlighted main trends in selected papers. Due to space limitation in the main text, further details were provided in SM.	Yes/Yes
Was risk of bias (or methodological quality) formally assessed using appropriate criteria?	The risk of bias has been formally assessed through ROBIS, a published, peer-reviewed and appropriate tool for SLR. Also, the criteria used in these MKD and bibliographic analysis are considered as appropriate.	Yes/Yes
Were efforts made to minimize error in risk of bias assessment?	Although risk of bias assessment should fully involve at least two reviewers, this review adopted the assessment by one reviewer and checking by the other reviewers. Although not ideal, this is acceptable too.	Probably Yes/Probably Yes
Concerns Assessment		
Concerns regarding methods used to collect data and appraise studies	Given the studies included in the review, the risk of bias was assessed using appropriate criteria. Moreover, data extraction and risk of bias assessment involved all reviewers: one investigator abstracted relevant characteristics (e.g., most cited/co-cited papers, most important keywords and countries); the other investigators reviewed data for accuracy. Discrepancies were resolved through a clearly specified procedure (tab 2 of SM spreadsheet). Although the collection protocol did not include specific details on factors correlation, there were sufficient details to allow reader to interpret the results. All signalling questions were rated as “Yes” or “Probably Yes”, so no potential areas of bias were identified. The review processes of data collection and study appraisal are therefore unlikely to have introduced bias into this review.	Low concern

**Table 43.** Phase 2: Signaling questions and assessment of domain 4 (synthesis and findings) (SM of Chapter 3).

Domain 4	Synthesis and Findings	
Describe synthesis methods	Given these MKD and bibliometric analysis represent a narrative synthesis, authors have sufficiently described the synthesis methods in Section 3 (Methods and Data), SM text (“Methods and Data” Section) and tabs 1-5 of SM spreadsheet. The authors have created ad hoc protocol and methods for the classification and analysis of data.	
Signaling question	Rational	<b>Answer</b>
Did the synthesis include all studies that it should?	Given these MKD and bibliometric analysis investigate the papers available on three robust and recognized databases (Web of Science, Science Direct, EBSCO host), it is assumed that it includes most of significant studies on the investigation topic available online. Considering the consistent numbers of papers (more than 2,000) in the final body of literature, the reviewers have been able to process all available data, and synthesize them by selecting the reference studies relevant to the questions being addressed. A priori, some useful results from individual studies (not available in the mentioned databases) may be missing from the synthesis because these specific studies are unknown to the reviewers (possibly due to publication bias). In any case, the reviewers have collected and processed all the data available in the above-mentioned databases. Moreover, a spreadsheet with the full list of the final body of literature (including main characteristics like authors, year of publication, abstracts) was an integral part of these MKD and bibliometric analysis, so it is possible to verify whether all applicable studies were included in the synthesis. The MKD and bibliometric figures and tables have been utilized to support reviewers’ inferences on included studies.	Probably Yes/Yes
Were all predefined analyses followed or departures explained?	Overall, the authors follow the official PRISMA checklist. No departures were stated or observed. All analyses (anticipated in section 3 (Methods and Data)) are addressed in Section 4 (Results), 5 (Discussion of Results) and 6 (Conclusions). Considering these MKD and bibliometric analysis are a narrative synthesis the reviewers did not suppressed any conflicting data, actually they highlighted debated issues and different inferences by scholars. To execute MKD, the reviewers utilized the mentioned Cobo, Lopez-Herrera, Herrera-Viedma and Herrera’s science mapping methodology(Cobo et al., 2011). Although this methodology does not provide details on RoB assessment, the different analysis outcomes (when changing some parameters) have been explained in the main manuscript and in the SM text. The temporal and geographical analysis of selected paper is clearly defined in Section 3-5 and related SM, consequently it is fully replicable by any assessor. To conclude, although the reviewers did not accomplish a defined RoB assessment (beside this PRISMA checklist) to answer the RQs, Section 3 (Methods and Data) and related SM address the analysis in a sufficiently rigorous manner.	Probably Yes/Probably Yes

Was the synthesis appropriate given the nature and similarity in the research questions, study designs and outcomes across included studies?	Considering the analysis is driven by the SLR, MKD and bibliometric methodologies, the synthesis of the studies and the nature of the questions being asked, are assessed as appropriate. Besides the motivation for this study adducted in Section 1 (Introduction), the manuscript provides clear and sound suggestions for future research. The selection of a quantitative approach is appropriate to answer the RQs in a more systematic way.	Probably Yes/Probably Yes
Was between-studies variation (heterogeneity) minimal or addressed in the synthesis?	Overall, no specific detail was provided on statistical heterogeneity. Whereas the definition of clusters to answer RQ2 and 3 may not favor the analysis of heterogeneity, the gap analysis conducted for RQ3 somehow addresses heterogeneity. In general, it is worth to notice that these MKD and bibliometric analysis represent a narrative synthesis, so the analysis of studies variation may result inappropriate; in fact, in this specific case, Whiting et al. (2016) suggest to consider the possibility of answering “Yes”.	Probably No/Probably Yes
Were the findings robust, e.g., as demonstrated through funnel plot or sensitivity analyses?	Authors did not state whether sensitivity analysis was used to assess the robustness of their findings, however it is worth to notice that these MKD and bibliometric analysis represent a narrative synthesis. Consequently, this question should actually analyze “whether different approaches to summarizing the studies could have led to different conclusions, and whether single studies are driving the conclusions” (Whiting et al., 2016) (p. 27 of supplementary data). In relation to the latter statement, considering all inferences in every RQ are supported by several peer-reviewed papers, it is definitely excluded that single studies have driven the conclusions in a specific direction. In relation to the former statement, the authors cannot exclude that some answers could be somewhat different. However, in the case of quantitative analysis (like the analysis of the most cited papers in the selected body of literature), the results are univocal, whereas, in the case of qualitative analysis (like questions on definitions and conceptualization), there are chances of different inferences.	Probably Yes/Probably Not
Were biases in primary studies minimal or addressed in the synthesis?	Given these MKD and bibliometric analysis represent a narrative synthesis, the biases in primary studies are assumed to be minimal. Moreover, considering RoB is addressed by the reviewers in Section 3 (Methods and Data) and 5 (Discussion of Results) as well as in the related SM, the RoB may be assessed as low (although RoB assessment may deserve a deeper analysis in some cases).	Probably Yes/Probably Not
Concern assessment		
Concerns regarding the synthesis and findings	This synthesis is not expected to produce biased results for RQ1 to 3. Furthermore, considering these MKD and bibliometric analysis represent a narrative synthesis, authors sufficiently addressed heterogeneity in their manuscript. In particular, RoB of studies was analyzed at a general level in Section 3 (Methods and Data). To conclude, these MKD and bibliometric analysis represent a useful synthesis of available literature obtained in a sufficiently rigorous manner.	<b>Low concern</b>



**Table 44.** Summary of concerns identified during Phase 2 assessment (SM of Chapter 3).

Domain	Concern	Rationale for concern
1. Concerns regarding specification of study eligibility criteria	Low	Considerable effort has been made to clearly specify the review questions, the objectives, and appropriate eligibility criteria (which have been adhered to during the review). Considering all signalling questions have been positively answered, the concern on Domain 1 is assessed as “low”.
2. Concerns regarding methods used to identify and/or select studies	Low	Although the restriction to English articles means that some relevant articles may have not been included, and given the review questions and eligibility criteria, a substantial effort has been made to identify as many relevant studies as possible through a variety of search methods, using a sensitive and appropriate search strategy. The review is therefore likely to have included a very high proportion of relevant studies, so the assessment on concerns regarding methods and selected studies is “low”.
3. Concerns regarding used to collect data and appraise studies	Low	Given the studies included in the review, the risk of bias was assessed using appropriate criteria. Moreover, data extraction and risk of bias assessment involved all reviewers: one investigator abstracted relevant characteristics (e.g., most cited/co-cited papers, most important keywords and countries); the other investigators reviewed data for accuracy. Discrepancies were resolved through a clearly specified procedure (tab 2 of SM Spreadsheet). Although the collection protocol did not include specific details on factors correlation, there were sufficient details to allow reader to interpret the results. All signalling questions were rated as “Yes” or “Probably Yes”, so no potential areas of bias were identified. The review processes of data collection and study appraisal are therefore unlikely to have introduced bias into this review.
4. Concerns regarding the synthesis	Low	This synthesis is not expected to produce biased results for RQ1 to 3. Furthermore, considering these MKD and bibliometric analysis represent a narrative synthesis, authors sufficiently addressed heterogeneity in their manuscript. In particular, the RoB of studies was analysed at a general level in Section 3 (Methods and Data) and 5 (Discussion of Results) as well as in the related SM. To conclude, these MKD and bibliometric analysis represent a useful synthesis of available literature obtained in a sufficiently rigorous manner.

**Table 45.** Phase 3: Risk of bias (RoB) in the review (SM of Chapter 3).

Signaling question	Rating	Rationale
Did the interpretation of findings address all of the concerns identified during the Phase 2 assessment?	Yes	Considering all domains of phase 2 have been assessed as “low concern”, the answer is affirmative.
Was the relevance of identified studies to the review's research question appropriately considered?	Yes	The studies included in the review are directly applicable to the MKD and bibliometric research questions. The relevance of studies was appropriately considered as described in previous tables.
Did the reviewers avoid emphasizing results on the basis of their statistical significance?	Yes	The review conclusions reflect both the statistically significant and non-significant review findings. The reviewers presented a balanced account of all analyses.
Risk of bias in the review	Low	Overall, the quality assessment of these MKD and bibliometric analysis revealed “low concerns” regarding the possibility of bias through the papers’ selection and analysis. Also considering that these MKD and bibliometric analysis represent a narrative synthesis and take advantage of a rigorous text mining, the findings of the review are likely to be reliable. Phase 2 did not raise significant concerns about the review process, and concerns were considered in Section 3, 4, 5 and 6 (respectively “Methods and Data”, “Results”, “Discussion of Results” and “Conclusions”) as well as in the SM. The discussion of results and the conclusions were supported by evidence.

**Supplementary Material:** The Supplementary Material (text, application of ROBIS and spreadsheet) is available online at <https://doi.org/10.1016/j.jenvman.2021.114160> (at “Appendix A. Supplementary data”, between the “Declaration of competing interests” and the “References”).

## Appendix E - Supplementary Material 3 (SM3) of Chapter 3 (Spreadsheets)

### E.1. Concepts, Keywords and Search Terms

Table 46. Concepts, keywords and search terms (SM of Chapter 3).

Macro-area	Concepts	Keywords	Search Terms
waste management	generic concepts	waste management	waste management
		waste valorization	waste valorisation, waste valorization
		waste collection	waste collection
	prevention	waste prevention	waste prevention
	reduction	waste minimization	waste minimisation, waste minimization
		waste reduction	waste reduction
	re-use	waste re-use	waste re-use
		waste re-utilization	waste re-utilisation, waste re-utilization
	recycling	waste recycling	waste recycling
		waste separation	waste separation
energy recovery	waste incineration	waste incineration	
disposal	waste disposal	waste disposal	
	waste destruction	waste destruction	
recycling behavior	generic concepts (green, pro-environment, ecology)	pro-environmental behavior	pro-environmental behaviour, pro-environmental behavior
		green behavior	green behaviour, green behavior
		ecological behavior	ecological behaviour, ecological behavior, ecologic behaviour, ecologic behavior
	innovation	eco-innovative behavior	eco-innovative behaviour, eco-innovative behavior, eco-innovation behaviour, eco-innovation behavior
	consciousness, empathy	eco-conscious behavior	eco-conscious behaviour, eco-conscious behavior
		ecologically conscious behavior	ecologically conscious behaviour, ecologically conscious behavior, ecological conscious behavior, ecologic conscious behaviour, ecologic conscious behavior
		eco-friendly behavior	eco-friendly behaviour, eco-friendly behavior, ecofriendly behaviour, ecofriendly behavior
		environmental friendly behaviour	environmental friendly behaviour, environmental friendly behavior, environment friendly behavior, environmentally friendly behaviour, environmentally friendly behavior
	specific recycling actions	separation behavior	separation behaviour, separation behavior
		disposal behavior	disposal behaviour, disposal behavior
		reduction behavior	reduction behaviour, reduction behavior
		separation behavior	separation behaviour, separation behavior
		collection behavior	collection behaviour, collection behavior
		minimization behavior	minimization behaviour, minimization behavior
		recycling behavior	recycling behaviour, recycling behavior
		re-utilization behavior	re-utilization behaviour, re-utilization behavior, re-utilisation behaviour, re-utilisation behavior
re-use behavior		re-use behaviour, re-use behavior, reuse behaviour, reuse behavior, re use behaviour, re use behavior	
sorting behavior		sorting behaviour, sorting behavior	
prevention behavior	prevention behaviour, prevention behavior		

This appendix is based on the Excel made of 12 tabs as follows:

- Concepts, Keywords and Search Terms
- Inclusion/Exclusion Criteria

- Excluded Journals
- Excluded Categories and Areas
- Data Extraction
- Publications per Year
- Top 21 Authors
- Top Authors
- Top 40 Journals
- Top 5 Journals per Year
- Thesaurus Words
- Circular Economy Keywords

For brevity and graphical reasons, a selection of spreadsheet is presented in the following pages.

## E.2. Inclusion Criteria

**Table 47.** Inclusion criteria (SM of Chapter 3).

Time	All eligible papers available on Web of Science (WoS), Science Direct and EBSCO Host, published until December 2020
Type of papers	All peer-reviewed articles, published and on-line (both empirical and theoretical)
Topics	Recycling (adult) behavior in relation to waste management (as defined by search query). Further description in the below list
Language	English-written papers

## E.3. Exclusion Criteria

**Table 48.** Exclusion criteria (SM of Chapter 3).

Journals	Journals not investigating consumer behavior (like chemistry, metallurgy, hydrology, geology, geomorphology, geophysics, physics, mechanical engineering, mathematics, biology, biogeography, zoology, surgery, virology, epidemiology, genetics, biomedical, neurophysiology, neurology, healthcare management) or investigating very specific aspects of human behavior (like criminology). Refer to below full list.
Topics	Main excluded topics: -Professional environment (like workers, farmers, retailers, managers, company-related issues, with the exception of papers studying consumer behavior too) -Education of minors (primary and secondary school) and teaching methods. Refer to below full list.
Specific type of waste	Nuclear, hazardous, hospital, healthcare, space, travelling, tourism waste; building/construction waste; waste from protected or disaster areas.
Specific locations	Protected areas, territories under specific environmental laws, national/ state/ regional parks, disaster areas.

## E.4. Included Topics

**Table 49.** Included topics (SM of Chapter 3).

Topics of Journals about:
Anthropology
Applied Science and Technology
Business
Design and Ergonomics
Ecology
Economics (including accounting and econometrics)
Education
Energy
Engineering (except chemical and biomolecular engineering)

Environment
Ethics
Geography
Health (including medical research)
Horticulture
Humanities (including anthropology)
Information and Communications (including Information and Communication Technology (ICT))
Institutions (e.g. (public) policy, government)
Laws
Management (including system thinking, conflict management)
Manufacturing and Quality Assurance
Marketing
Materials (including textiles)
Natural Sciences (e.g biology)
Nutrition
Philosophy
Politics
Psychology (including social psychology)
Resources (e.g. water)
Sociology
Sustainable Development
Urban and rural sciences (e.g., urbanization, cities)
Note: Hospitality journals are included if the paper investigates daily activity (e.g., utilization of cafeterias). Vacation and tourism are not included (as per below list of excluded topics). In order to guarantee a real interdisciplinary analysis, a wide range of Journals has been considered)

## E.5. Excluded Topics

**Table 50.** List of excluded topics (SM of Chapter 3).

Topics Area	Specific Topic
Business, management	Firm/corporate/organizational behavior
	Business/(sustainable) enterprises/companies/firms
	State/governmental/private agencies/organizations (e.g., Sustainability Victoria, Environmental Protection Agency)
	Micro, Small and Medium Enterprises (MSMEs)
	Recycling trade associations
	Niche players
	Brands
	Entrepreneurship
	Corporate greening
	Sustainable manufacturing
	Corporate Social Responsibility (CSR), corporate behavior
	Extended Producer Responsibility (EPR)
	Pro-environmental operational strategy
Resource reduction strategy	

	Managerial engagement in environmental responsibilities/actions
	Waste project managers
	Management of waste reduction/recycling programs
	Waste disposal acts
	Debates on waste policy
	Waste trade
	Environmental decision tools for managers/agencies/firms
	Promotion of National recycling practices
	National recycling advocacy
	Environmental consultancy
	Real estate
	Commercial buildings
	Retailing and specific commercial services (e.g. commercial lawn care services)
	Private Finance Initiative (PFI)
	Information campaign focused on managerial aspects of environmental protection
Industry and production processes	Industrial waste/residuals,
	Production processes
	Industrial/Logistic system
	Producers, supply chain
	Pro-environmental design
	Product development
	Infrastructure developers
	(Eco) designers
	Supply chain
	Manufacturing
	Landfill/dump management (e.g., waste transportation to landfill, activities and procedures inside recycling centers/landfills)
	Waste management solutions after collection (e.g., incineration, regulations of waste facilities)
	Building/construction industry:
	Construction & Demolition (C&D) waste*: -Drilling waste* -Construction projects/system/company -Drilling waste*
Workplaces	Offices
	Factories
	Recycling centers/landfills/dumps*
	Waste management/treatment plants/systems (for sewage, wastewater, etc.)
	Warehouses
	Production plants
Workers and tourists	Managers/entrepreneurs
	Employees
	Workers
	Armed Forces/Police members*

	Medics*
	Economists
	Providers of environmental services (e.g., recycling companies, solid waste industries, waste handling corporations, waste management professionals)
	Urban planners
	Non-academic staff
	Recycling coordinators/managers
	Members of recycling companies
	Tourists
	Leisure boat owners
Agriculture (including mowing services)	Farmers
	Farming practices/methods
	Use of fertilizers/pesticides
	Wineries and wine producers
Fishery	Fisherman
	Blue growth/economy
	Ecosystem-based fishery management
	Fishery community
	Fishing villages/communities*
	Fishing waste*
Forestry	Forestal economy
	Forestal community
	Forestal waste*
Special waste*	Forestal waste
	Fishing/agricultural waste*
	Carcass (dead pig) waste
	Construction & Demolition (C&D) waste
	Drilling waste*
	Nuclear/Radiological/Hazardous (incl. batteries)/Toxic waste
	Contaminated sediments management
	Fluorescent lamps
	Vehicle recycling
	Sewage
	Biomass waste
	Mining waste
	Laboratory waste
	Leisure (boat) waste
	Pharmaceutical waste*
Healthcare, sanitation, toxicology	Hospital
	Clinics
	Nursing



	Healthcare
	Illness (e.g., depressive sickness, exposure to pollutants/contaminants)
	Pharmaceuticals*
	Pharmaceutical pollution
	Water contamination
	No-mix toilet technology
	Medics*
	Sanitation infrastructure/systems (e.g., sustainability and utilization of sanitation facilities)
Hospitality and tourism	Hotel/lodging
	Green hotel/tourism
	Tourism
	Eco-Tourism
	Travel
	Eco-Travel
	(wildlife) recreation
	Restaurant customers/managers
	Restaurant industry
	Tour operators
	Vacation, vacationers, leisure boat owners
	Hospitality products
Underage/Professional Education and training	Children/Adolescent education/behavior
	Primary/secondary/high school education/behavior
	Professional education/training of teachers, engineers, etc.
	Training devices/material
Human-animal relationship	
Virtual games	
Oceanography	
Special locations/occasions	Recycling centers/landfills/dumps*
	Festival
	Parks, desert, botanical garden, island with environmental protection
	Restricted areas (e.g., areas with salient features/laws)
	Areas under environmental protection
	Coastal wetlands, freshwater marsh, coral reef ecosystems (e.g., Great barrier reef)
Specific communities/associations/categories	Fishing/farming communities*
	Armed Forces/Police members*
	Environmental/non-profit organizations (e.g., Greenpeace, "Group against smog and pollution", Audubon Society, Sierra Club)
	Activist associations
	Recycling cooperatives
	People registered in special recycling programs
	Rural villagers

Special practices	Hoarding
	Begging
	Household carcass waste recycling

Notes:

- (1) The \* indicates that some item are repeated in 2 topic areas or more. In some papers, university students are mixed up with non-academic staff.
- (2) Hospitality journals are generally not included except for daily normal activities (e.g., utilization of cafeterias).
- (3) Papers analyzing universities are included when dealing with students as adult consumers (e.g., utilization of dining facilities and university cafeterias), but they are excluded when referring to teaching methods.
- (4) Disagreement Procedure for Inclusion/Exclusion of Papers: In case of disagreement between the first and the second review author, the conflict is supposed to be resolved through discussion between the involved review authors; if the dispute is not resolved, the third review author is involved in the discussion. If, at this stage, no agreement is reached, the third author makes the final decision.

**Supplementary Material:** The Supplementary Material (text, application of ROBIS and spreadsheet) is available online at <https://doi.org/10.1016/j.jenvman.2021.114160> (at “Appendix A. Supplementary data”, between the “Declaration of competing interests” and the “References”).



## **Appendix F - Supplementary Material (SM) of Chapter 4**

### **F.1. SM of Section 4.2: Literature Review and Theoretical Framework**

#### **F.1.1 Theoretical Framework**

##### **F.1.1.1. Attitude**

In addition to the definition of attitude provided in the main manuscript, it is worth recalling a couple of specific definitions related to the context of reference. Hines et al. (1987, p. 4) offer a general definition of environmental attitude as “individual feelings (that) are pro or con, favorable or unfavorable toward the environment or objects related to the environment”. Momoh and Oladebeye (2010) provide a more specific definition of recycling attitude as “the extent to which people are aware of, care about and view household waste recycling in their areas” (p. 100). Although this study may adopt the latter definition, we stick to the TPB interpretation of attitude.

##### **F.1.1.2. Subjective Norms**

In relation to the impact of norms on individual behavior, Oskamp et al. (1991) show how household participation in recycling programs is highly influenced by neighbors and friends, although this study evidences a different situation in Rome.

In terms of measurement of subjective norms, it is worth mentioning that some scholars deeply investigate this construct and provide new perspectives on it. For example, Fornara et al. (2011) break down norms into four different components: injunctive and descriptive norms, subjective and local norms (e.g., respectively, people important to me, and neighbors). They empirically demonstrate that the influence of descriptive norms is higher than injunctive ones; moreover, the effect of descriptive norms on intention takes indirectly place through PBC as well; lastly, descriptive subjective norms have more influence on PBC than local ones. However, most of the studies on the effects of norms on recycling behavior highlight that the weight of norms is somehow limited; consequently, this study does not break down norms into the above-mentioned components.

##### **F.1.2. SM of Section 4.2.2: Past Behavior and Habits**

Verplanken and Orbell (2003) “argue that habit is a psychological construct, rather than simply past behavioral frequency” (p.1313). For this reason, they developed the “Self-Report Habit Index” (SRHI) to quantify the habit strength by considering “history of repetition, automaticity (lack of control and awareness, efficiency), and expressing identity” (Verplanken & Orbell, 2003, p. 1313) . On the contrary, for some researchers (Eagly & Chaiken, 1993; Ouellette & Wood, 1998), the measure of habits through past behavioral frequency is reasonable considering that the repetition of actions develops and reinforces the behavioral strength. Verplanken and Orbell (2003) deem essential to verify if a specific event causes or activate the behavior to become habitual; moreover, they measure the habit strength to have a comprehensive estimate of habits themselves.

Overall, “in domains in which habits can develop, frequent performance in the past reflects habitual patterns that are likely to be repeated automatically in future responses.” (Ouellette & Wood, 1998, p. 54).

##### **F.1.3. SM of Section 2.3: Motivation and Goals**

Austin and Vancouver (1996) utilize a broad approach by defining “goals as internal representations of desired states, where states are broadly construed as outcomes, events, or processes” (p. 338). Moreover, considering every individual pursue different goal, they state that “single goals cannot be understood when isolated from other goals and from the cognitive, behavioral, and affective responses organized in pursuing goals” (Austin & Vancouver, 1996, p. 338).

Kaiser et al. (2017) make a further distinction between intrinsic and extrinsic motivations in order to distinguish between goals coming from the individual internal orientation and goals driven by external influences. Clearly, an intrinsically motivated behavior does not need to be pushed by “important others” (e.g., the family, a supervisor) or by a reward (e.g., financial gratification, social enticements).

## **F.2. SM of Section 4.3: Methodology**

### **F.2.1 SM of Section 4.3.1: Research Design**

For both recruitment strategies (freely accessible platform for on-line fill in, and trained interviewers), all participants were assured about the anonymity of the survey; in fact, no personal data (like name, email, specific address) were requested to responders. Furthermore, for old people, a direct interview was usually performed to compensate for physical impairments and limited familiarity with on-line platforms. It is worth noticing that the questionnaire was directed to people living or regularly utilizing the Eight Municipality, not to retailers nor to commercial activities.

It is also worth noticing that the objective of this study is not analyzing the correlation among the socio-demographic variables (like age, gender, education, family size, income) with the other variables.

### **F.2.2. SM of Section 4.3.3: Constructs and Measures**

*Intention* (INT) was measured through 3 items asking participants whether they want/will/intend (INT1, INT2, INT3) to separate waste in the next three months on 10-point scale ranging from “no, I don’t” to “yes, I do”.

*Attitude* (ATT) was measured through 3 items asking whether waste is a resource to reutilize (ATT1), inappropriate waste management may damage the environment (ATT2), separate collection of waste is bad or good (ATT3) on a 10-point scale ranging from fully negative to fully positive.

*Perceived Behavioral Control* (PBC) was measured through 2 items asking respondents to rate how difficult or easy it was to perform the separate waste collection in a 10-point scale (PBC1); whether they could manage to separate and collect waste within available time and the available space in their house in a 10-point scale ranging from I am not able to I am able (PBC2).

*Subjective norms* (NOR) were measured through 2 items asking, “People most important to me think I should separate waste in the next 3 months” (NOR1) and “most people like me separate waste in the next 3 months” (NOR2) on 10-point scale ranging from fully disagree to fully agree.

*Past behavior* (PBEH) was measured by asking the frequency of separation of the main types of waste (“organic”, namely food leftovers (PBEH1), plastic (PBEH2), glass (PBEH3) and paper (PBEH4)) on a 7 point-scale going from “never” to “daily” (beside “I do not know” and “I do not produce this type of waste”).

*Habits* (HABIT) were measured through 5 items asking about specific aspects of waste separation at the time it is produced (e.g., while throwing the leftovers in the kitchen bin). The participants were asked if they automatically separate waste in appropriate bins (HAB1), if they feel doing from long time ago (HAB2), if they feel uncomfortable not doing it (HAB3), if separating waste represents a routine activity (HAB4), if they start separating waste before realizing they are doing it (HAB5) in order to understand whether it is a kind of unconscious activation. A 4-point scale was utilized ranging from “no, never” to “Yes, always”.

*Environmental motivation* (EMTV) was measured through 2 items asking about the reasons why we should separate waste: to respect the environment (EMTV1) and to get a better future (EMTV2) on a 4-point scale was utilized ranging from “no, never” to “Yes, always” (beside “I do not know”).

*The functionality of the road drop-off bins* (RBIN) has been investigated through three questions asking whether it was difficult or easy to daily access to the drop-off bins (RBIN1), their adequacy in term of capacity (RBIN2) and their practicality (RBIN3) during the daily use on a 5-point scale ranging from “not at all” to “Yes, completely”.

Please note that each construct has been initially measured through 3 or more indicators in the survey, but some indicators have been removed in the analysis phase to guarantee adequate loadings. Please refer to Table 51 for further information on constructs.

**Table 51.** Constructs (SM of Chapter 4).

Constructs	Indicator Code	Indicators	Source
Intention (INT)	INT1	I want to separately collect waste in the next 3 months	(Ajzen, 2006)
	INT2	I will separately collect waste in the next 3 months	(Ajzen, 2006)
	INT3	I intend to separately collect waste in the next 3 months	(Ajzen, 2006)
Attitude (ATT)	ATT1	Waste as a resource to reutilize	(Zhang et al., 2021)
	ATT2	Inappropriate waste management may damage the environment	(Zhang et al., 2021)
Perceived Behavioral Control (PBC)	ATT3	Separating waste in the next 3 months is bad/good	(Ajzen, 2006)
	PBC1	Separating waste in the next 3 months it is difficult/easy	(Ajzen, 2006)
	PBC2	I can separate waste in the next 3 months within my available time and space	(Ajzen, 2006)
Subjective Norms (NOR)	NOR1	People most important to me think I should separate waste in the next 3 months	(Ajzen, 2006)
	NOR2	Most people like me separate waste in the next 3 months	(Ajzen, 2006)
Past behavior (PBEH)	PBEH1	How often have you separated “organic” waste (food waste) in the past 3 months?	(Ajzen, 2006) (Arli et al., 2019)
	PBEH2	How often have you separated plastic waste in the past 3 months?	(Ajzen, 2006) (Arli et al., 2019)
	PBEH3	How often have you separated glass waste in the past 3 months?	(Ajzen, 2006) (Arli et al., 2019)
	PBEH4	How often have you separated paper waste in the past 3 months?	(Ajzen, 2006) (Arli et al., 2019)
Habits (HABIT)	HAB1	Have you automatically separated waste in the respective bins in your house in the past 3 months?	(Verplanken & Orbell, 2003)
	HAB2	Have you been separating waste in the respective bins in your house since long time ago?	(Verplanken & Orbell, 2003)
	HAB3	Would you feel uncomfortable not separating waste in your house?	(Verplanken & Orbell, 2003)
	HAB4	Separating waste is a consolidated daily/weekly routine of my life	(Verplanken & Orbell, 2003)
	HAB5	Do you separate waste even before you realize you are doing it?	(Verplanken & Orbell, 2003)
Environmental motivation (EMTV)	EMTV1	Does “respecting the environment” motivate you to separate waste?	(Gamba & Oskamp, 1994) (Otto et al., 2018)
	EMTV2	Does “getting a better future” motivate you to separate waste?	(Gamba & Oskamp, 1994) (Otto et al., 2018)
Functionality of road bins (RBIN)	RBIN1	Position of road bins	(Guagnano et al., 1995) (Miller et al., 2016)
	RBIN2	Capacity of road bins	(Sheau-Ting et al., 2016) (Blazquez & Paredes-Belmar, 2020)
	RBIN3	Practicality of road bins	(Leeabai et al., 2019)

### F.3. SM of Section 4.4: Results

#### F.3.1. SM of Section 4.4.1: Descriptive Statistics

The socio-demographic characteristics of the sample are described in the Table 52.

In relation to education the level is quite high, especially considering that 3 responders attended the elementary or middle school only. This situation is probably motivated by the fact that in the geographical area of investigation there are many governmental offices and schools; therefore, the minimum education level corresponds to the high school. In fact, the occupation was mainly represented by clerks 48% (N=27) and retired 29.8% (N=53); the remaining people were freelancers 10.7% (N=19), managers 6.7% (N=12), officials 6.2% (N=11), teachers 5.6% (N=10), etc. Respondents resided in various areas of the municipality with a predominance from Garbatella district 34.8% (N=62). The income was mainly in the range 1.000 to 2.500 euros (38.2%, N=68) and 2.500-5.000 euros (45.5%, N=81); 10.7% (N=19) of respondents stated not to know it, and a very limited portion was above 5.000 euros (2.2%, N=4) or below 1000 euros (3.4%, N=6). The family composition was distributed among single family members (N=27, 15.2%), 2 people per family (N=57, 32%), 3 per family (N=46, 25.8%), 4 per family (N=37, 20.8%); a limited percentage represented families made of 5 members or above (N=11, 6.2%).

Comparing the sample with the data published in the National Registry of the resident population as of 31 December 2019, it is possible to make some considerations about the representativeness of the sample in relation to the real population composition. In terms of gender, the sample overestimate the male population (62.9% males in the sample versus 47.3% in the city of Rome). In relation to age, the sample overestimates the 45-64-year-old range; please note that the sample does not include minors, therefore we cannot directly compare the official figures related to city of Rome and the Eight Municipality (which include minors) with our sample. In any case, the sample is more skewed for the central age. In terms of family composition, the families made of a single person are underrepresented in the sample (15.2% versus 48.7% in the Eight Municipality and 44,6% in the city of Rome). In fact, the mean value of the sample is 2.71 people/family (standard error 0.086 and Standard deviation 1.142), whereas the value for the Eight Municipality is 1.9 and 2.1 for Rome. Lastly, the above-mentioned document from the national Registry does not provide information on income and job, therefore no consideration is presented for these factors.

**Table 52.** Socio-demographics characteristics of the sample and the population in Rome (SM of Chapter 4).

	Sample of Eight Municipality			Registry of Eight Municipality		Registry of Rome (entire city)	
	N	%	Mean	Mean	%	Mean	%
<b>Gender</b>							
M	112	62.9			//		47.3
F	66	37.1			//		52.7
<b>Age</b>							
0-17	//	//			16.8		17.1
18-24	5	2.8			5.6		5.3
25-44	36	20.2			24.2		23.9
45-64	86	48.3			27.4		31.3
65-74	40	22.5			12.1		10.6
75 or above	11	6.2			13.9		11.8
<b>Family Composition</b>							
1 person	27	15.2			48.7		44.6
2 people	57	32.0			24.0		24.0
3 people	46	25.8			14.8		16.3
4 people	37	20.8			9.7		11.4
5 people or above	11	6.2			2.7		3.7
Mean Family Composition			2.71		1.9		2.1
<b>Income</b>							
Below 1.000€	4	2.2					



1.000€-2.500€	68	38.2
2.500€-5.000€	81	45.5
above 5.000€	6	3.4
Do not know	19	10.7
<b>Education</b>		
Elementary School	1	0.6
High School	57	32.0
Middle School	2	1.1
University	118	66.3
<b>Job</b>		
Clerk/Employee	48	27.0
Dealer	1	0.6
Freelancer	19	10.7
Housewife	5	2.8
Manager	12	6.7
Official	11	6.2
Retired	53	29.8
Student	5	2.8
Teacher	10	5.6
Unemployed	2	1.1
Other	12	6.7
<b>District</b>		
Appia antica	4	2.2
Grabatella	62	34.8
Grotta Perfetta	31	17.4
Navigatori	3	1.7
Ostiense	9	5.1
Tor Marancia	21	11.8
Tre Fontane	39	21.9
Valco San Paolo	9	5.1

Table 53 shows a statistical analysis of the main constructs.

**Table 53.** Overall description of constructs.

Constructs	Indicator Code	Range	<i>M</i>
Attitude	ATT	9.173	1.033
Subjective Norms	NOR	9.222	1.310
Perceived Behavioral Control	PBC	8.744	1.395
Intention	INT	9.356	1.099
Functionality of Recycling Bins	RBIN	2.369	0.696
Past Behavior	PBEH	2.827	0.859
Habit	HABIT	3,658	0.490
Environmental Motivation	EMTV	9.645	1.121

## F.3.2. SM of Section 4.4.2: Assessment of Measurement Model

### F.3.2.1. Internal Consistency

In case of a low number of items (composing the scale), the sensitivity of Cronbach's  $\alpha$  values may become critical, therefore Pallant (2020) suggests considering the mean inter-item correlation. A check of this correlation shows acceptable values for our sample.

### F.3.2.2. Reliability and Validity of the Scale

As explained by Thao (2018), the discriminant validity may be tested by applying different criteria like the Fornell-Larcker criterion (Fornell & Larcker, 1981) or the Heterotrait-Monotrait Ratio of correlation (Henseler et al., 2015). The former verifies that the square root of AVE ( $\sqrt{\text{AVE}}$ ) per each construct is above all bivariate correlation coefficients with other constructs; the latter verifies that values are below 0.85. In this paper, the application of the Fornell-Larcker criterion shows that the

measurement model exhibit discriminant validity; therefore, we conclude that the proposed measurement model is adequate (Table 10 of Chapter 4).

In relation to the assessment of the reliability and the validity of the scale, it is worth mentioning that some authors (Hair et al., 2019) suggest indicator loadings higher than 0.700, whereas others accept values above 0.500 (Hulland, 1999). In any case, we infer that our data shows internal consistency.

### **F.3.3 SM of Section 4.4.3: Assessment of Structural Model**

#### **F.3.3.1. Indexes of Fit**

The  $\chi^2$  index (or CMIN) compares the observed variance-covariance matrix to the predicted matrix (Roskam et al., 2016); considering this index is highly related to the degree of freedom (df), the ratio  $\chi^2/df$  (CMIN/df) is considered satisfactory when below 2.5 for samples between 100 N and 200 N. In this model  $\chi^2/df$  is 1.767, therefore it is satisfactory. Different indexes are available depending on the type of software; for example, the Comparative Fit Index (CFI) “measures the relative improvement in fit going from the baseline model to the postulated model” (Shi et al., 2021, p. 4); the index ranges from 0 (poor fit) to 1 (perfect fit). The Tucker and Lewis Index (TLI) “measure a relative reduction in misfit per degree of freedom” (Yammine & Rammal, 2021, p. 10); for both indexes a good fit is above 0.90; in this case CFI is 0.937 and TLI 0.927. The root mean square error of approximation (RMSEA) defines the size of the standardized residual correlations; Shi et al. (2018) define it as a “badness-of-fit” measure (p. 313). It ranges from 0 (perfect fit) to 1 (poor fit). Values at or below 0.05 indicate a very good fit, below 0.08 an acceptable fit, at or above 0.1 poor fit; in this case RMSEA is 0.066. In relation to the standardized root mean square residual (SRMR), Hu and Bentler (1999) consider values in the range 0.00 and 0.08 as acceptable for ML estimation; in this study SRMR is 0.071. It is worth noticing that SRMR is a “badness of fit” index not a goodness of fit index (GOF) (Marsh et al., 2004), as in the case of CFI, TLI, etc.. Therefore, overall, the measurement model shows satisfactory indexes.

#### **F.3.3.2. Confidence Intervals**

Confidence intervals (CI) indicate that the value of a coefficient is within a specified range according to a defined probability (e.g., 95%). In particular, if 0 lies within that range, it means that the value of a coefficient may be 0, therefore there is no relationship between the predictor and the response variable. However, this consideration should not automatically lead a researcher to the conclusion of the absence (or insignificance) of the predictor’s influence on the response variable (also known as treatment effect in the medical field); actually, the researcher should understand that there is uncertainty about this influence (or treatment effect), because it could be positive or negative. Another important consideration concerns the amplitude of the CI: if the CI is wide, the estimate is less precise and, vice versa, if CI is narrow, the estimate is more precise. Obviously, by changing the level of CI (e.g., 90, 95, 99%), a researcher changes the significance of parameter and he/she may end up in including or excluding the 0 value from the CI, although this change should be based on the sample size as well.

Lastly, it is worth mentioning that, if 0 belongs to the CI, we expect  $p$  to be above 0.05.

#### **F.3.3.3. Effect Size**

The effect size ( $f^2$ ) provides an indication of the magnitude of the relationship between two variables; therefore, effect size provides an indication of the strength of a phenomenon. It can be measured in absolute or relative terms; its value is usually quantified in small, medium or large depending also on the area of investigation, context and research method.

There are different ways of calculating the effect size (e.g., Pearson  $r$ , eta-squared, omega-squared, Cohen’s  $f^2$ ); in this paper the effect size of a latent predictor is based on the formula defined by Cohen (1988):  $f^2 = (R^2_{incl} - R^2_{excl}) / (1 - R^2_{incl})$  in which  $R^2_{incl}$  represents the usual square multiple correlation ( $R^2$ ) for a specific latent predictor, whereas  $R^2_{excl}$  represents the  $R^2$  with the exclusion of the relationship between the independent and the dependent variable. Considering small, medium and large effects

usually correspond to 0.02, 0.15 and 0.35 respectively (Wan et al., 2017), this paper shows a medium effect size of attitude on intention ( $f^2=0.214$ ) and a strong effect of habits on PBC ( $f^2=0.884$ ) and environmental motivation on habits ( $f^2=0.635$ ).

## **F.4. SM of Section 4.6: Conclusions**

### **F.4.1 SM of Section 4.6.1: Future Research Directions**

In relation to the macro/micro level of analysis, TPB is generally focused on variables at the micro-level such as intention, attitude, PBC, whereas TPB routes the effects of variables at the macro-level such as government incentives or rewards (Hazen et al., 2017) through the mentioned TPB precursors of behavior. Future studies may better analyze the direct and indirect effects of macro-level variables such as efficacy of educational programs, rewarding of virtuous behavior, efficacy of waste management programs, presence of pro-environmental associations or scavengers in the area of investigation, influence of movements to oppose the installation of waste management plants (Sun et al., 2018). Although the outcomes of this type of research may not support the need for new predictors, this approach is useful both to prove the general validity of TPB and to develop a holistic understanding of the surrounding environment. In fact, the analysis of recycling behavior has always to be fully contextualized to correctly assess the influence of key factors on the typical TPB components.

### **F.4.2. SM of Section 4.6.2: Limitations**

#### **F.4.2.1. Measurement of past behavior**

Considering past behavior is measured in terms of behavioral frequency of specific items (like plastic and paper), an investigation of other past actions (related to waste-separation) may provide a better description and measurement of this specific construct. Moreover, the definition of the optimal level of separation frequency is extremely product-dependent and context-dependent. For example, some people may make more use of food in plastic containers than others, therefore they recycle plastic more frequently than others. In some areas, some waste collection services (e.g., glass) are available on a weekly basis, therefore separation activities at the household level are based on this frequency.

#### **F.4.2.2. Sampling**

Considering sampling is based on a specific municipality of Rome, every type of generalization of the present study to entire city of Rome requires careful consideration of these characteristics and the contextual conditions, such as the presence of tourists, the type of garbage collection system, the presence of commercial or residential areas. Overall, as recommended by Ali and Ahmad (2016), “it is recommended that future research shall utilize broader demographic profile to analyze respondents” (p. 109).

Despite the mentioned limitations we deem our paper offers very useful insights on waste separation behavior to foster future research on this topic.



## **Appendix G - Supplementary Material (SM) of Chapter 5**

### **G.1. SM of Section 5.2: Literature Review and Theoretical Framework**

Several meta-analysis (Miafodzyeva & Brandt, 2013; Xianfang et al., 2017), systematic literature reviews (Concari et al., 2020) and knowledge domain mappings (Concari et al., 2022) have investigated the main socio-psychological frameworks applied to recycling behavior in the last decades. They clearly show a predominance of a cognitive reasoned approach framework, which mainly explains pro-environmental intention and behavior through constructs like individual attitude, influence of norms, perception of being able to control the situation, beliefs, evaluation of consequences, awareness of the situation and ascription of responsibility. In particular, numerous scholars have focused on the discrepancy between behavior and its precursors, namely the “attitude-behavior gap” (Carmi et al., 2015), the “intention-behavior gap” (Carrington et al., 2010, 2014; Zhang & Zhao, 2019), the “intention action gap” (de Koning et al., 2016), or the “attitude-behaviour discrepancy” (Eiser & Eiser, 1986). Other constructs as emotions, desire, motivation and goals have often kept out of the recycling behavior equation (Carrus et al., 2008; Damasio, 1998; Geng et al., 2017; Perugini & Bagozzi, 2001).

#### **G.1.1. Model of Goal-directed Behavior (MGB)**

In MGB the immediate predictor of intention is desire which “mediates the effects of attitude, subjective norms, PBC and anticipated emotions on intention and behavior” (Parkinson et al., 2018, p. 840); at the same time, PBC does not directly influence intention but desire and behaviour. Considering some scholars criticize TPB for not explaining “how intentions become energized” (Perugini & Bagozzi, 2001, p. 83), Perugini and Bagozzi (2001) introduce desire as “the motivational impetus for intention” (p. 83); in turns, attitude, subjective norms and PBC are the catalyst to fire up the dormant desire. Another important additional construct is anticipated emotions which are the referents of personal goals; in fact, Perugini and Bagozzi (2001) state that “anticipated emotions function as independent variables based upon a decision process that takes into account judged consequences of goal achievement and goal failure” (p. 83). Furthermore, Perugini and Bagozzi (2001), consider (frequency of) past behavior as a predictor of desire, intention and behaviour; on the contrary Ajzen infers that the residual effects of past behavior are mediated by PBC. In relation to the application of MGB to recycling behavior Carrus et al. (2008) find out a consistent relationship between negative anticipated emotions and desire to recycle; moreover, this relationship is more statistically significant than the one between attitude and desire, or PBC and desire.

#### **G.1.2. Norm Activation Model (NAM)**

In the Norm Activation Model, in order to perform a pro-social behavior, the individual has to be conscious that an anti-social behavior leads to negative consequences towards others; furthermore, the individual needs to understand its consequent responsibilities towards the society or its group of reference. Overall, NAM focuses on the key role of personal norms, which can be activated in different forms. Some scholars as De Groot and Steg (2009) proved the validity of this framework in predicting pro-social intention and behavior in different environmental contexts.

#### **G.1.3. Other Theoretical Frameworks**

Other theories and model have been applied to recycling behavior, either in combination with the mentioned framework or alone. For example, the Neutralization Theory of Delinquency (Sykes & Matza, 1957) has been applied by Tang et al. (2011) through the construct of justification in combination with TPB. Hansmann et al. (2006) have also created a model including justification, socio-demographic variables, knowledge, attitude, social norms and recycling behavior. In this case Hansmann et al. (2006) combine justification with constructs coming from different models, like TPB and NAM. They interpret justification in terms of ascribed responsibility and awareness of

consequences; they also infer that adding “justification for non-recycling” to the analysis of this type of behavior enhances “the explanatory power of models predicting recycling behavior” (p. 156). Other scholars like Qin and Song (2022); Zhang et al. (2021) combine TPB with the Attitude-Behavior-Context (ABC) model by Guagnano et al. (1995). Gan and Zhang (2020) add the Interpersonal Behavior Theory (Triandis, 1977) to TPB as well.

It is also worth noticing that, besides the above-mentioned cases, TPB and NAM have been combined in the same framework with positive outcomes. For example, Park and Ha (2014) confirmed the influence of personal norms, attitude and PBC on the intention to recycle. Wang, Guo, et al. (2018) analyze the influence of information publicity on intention to e-waste recycling and they conclude that information publicity indirectly influence intention through attitude and personal norms.

#### **G.1.4. Goal Setting Theory**

The Goal Setting Theory concentrates on the individual who sets its own goal to fulfill its needs. These needs are clearly influenced by further factors like attitude towards the goals; similarly, personal goals are affected by social beliefs. Latham et al. (2011) consider goal as “an object or aim that an individual strives to attain”; moreover, “goals are the immediate regulators of behavior”. Considering this theory has been created to analyze the individual motivation at work, it defines four mediators which positively influence the goal: choice, effort, persistence and strategy. Given the specific focus on workplace (Ciocirlan, 2017; Ciocirlan et al., 2020; Kollmuss & Agyeman, 2002; Norton et al., 2015), the academic literature does not show examples of application at the household or consumer level. In any case, “the findings revealed that the corporate environmental strategy significantly explains the psychological green climate, which, in turn, enhances voluntary environmental behavior, like energy-saving behavior, waste reduction behavior, and resource recycling behavior” (Das et al., 2019, p. 12).

#### **G.1.5. Goal Systems Theory (GST)**

As explained in the main paper, Kruglanski et al. (2015) utilize the concepts of “multifinality”, “equifinality” and “counterfinality”. In fact, a goal can be reached by one or more means, and, vice versa, one single mean can satisfy one or more goals; furthermore, a goal can represent a top priority in our life or can compete with other objectives at other times.

Another important aspect of the GST is that goal systems have motivational and cognitive properties (Kruglanski et al., 2002). The former are driven by the “principle of subjective utility, which determines goal-commitment and mean choice” (Kruglanski et al., 2002, p. 342); moreover, the strive for a goal is influenced by persistence of pursuit and affective feedback. The latter are characterized by structural and allocational properties, namely the type of links between goals and means (interconnectedness), and the mental resources availability in a “constant sum” game. Being said that the cognitive properties often take over the motivational ones, goals may range from short terms and narrow objective to long term ambitions (Kruglanski et al., 2002).

## **G.2. SM of Section 5.3: Methodology**

### **G.2.1 Research Design – Sample Definition and Data Collection**

The Slovin’s formula (De Feo et al., 2017; Dhokhikah et al., 2015) has been applied to determine the sample size ( $n$ =sample number,  $N$ =total population,  $e$ =margin of error)

$$n = \frac{N}{Ne^2 + 1}$$

In year 2018 households in Maastricht and Zwolle are respectively 69,180 and 58,546, therefore the corresponding samples are respectively 69.37 and 69.36 respondents (with a margin of error of .12). Please note that the study of the relationship between the socio-demographic variables (e.g., age, gender) and socio-psychological constructs is out of the scope of this paper.



## G.2.2. Socio-psychological Constructs and Related Measures

The socio-psychological constructs are described as follows:

- *Active Procurement Goals* (AGPs) are measured through two indicators asking respondents if a cleaner world is important to them (APG1), and if they can contribute to a cleaner world by separating waste accurately on a daily basis (APG2), on 7-point Likert scale ranging from “True (1)” to “False (7)” (with “Neutral (4)”).
- *Active Approval Goals* (AGPs) are measured through two indicators asking respondents if it is important that people (around them) approve their waste separation (AAG3), and if he/she is supported in separating waste accurately on a daily basis by applicable “important others” (AAG4), on 7-point Likert scale ranging from “True (1)” to “False (7)” (with “Neutral (4)”). Before posing the previous question, and in order to define the important referents, a specific multiple-choice question asks respondents to define their “important others” (“Who’s approval is important to you”). The possible choices are based on the eliciting questionnaire: partner, closest friend(s), family, neighbor (s), government, others to specify.
- *Attitude* (ATT) is measured by three items asking whether the respondent waste separation is bad or good (ATT1), pleasant/unpleasant (ATT2), useful/useless (ATT3), on a 7-point Likert scale ranging from fully positive to fully negative.
- *Subjective norms* (NOR) are measured by two items asking: “The most important person/group of people to me separates waste accurately on a daily basis” (NOR1) and “The most important person/group of people to me think that I should accurately separate waste on a daily basis” (NOR2) on 7-point scale ranging from fully agree to fully disagree.
- *Motivation* (MOT) is measured by two items asking: “I am motivated to separate my waste accurately” (MOT1) and “Do you desire to separate waste accurately?”, on a 7-point Likert scale ranging from “True (1)” to “False (7)” (with “Neutral (4)”).
- *Perceived Behavioral Control* (PBC) is measured by two items asking: “If I wanted to, I am confident that I can accurately separate waste on a daily basis” (PBC1) and “It is my own conscious decision to accurately separate my waste on a daily basis” (PBC2), on a 7-point Likert scale ranging from “True (1)” to “False (7)” (with “Neutral (4)”).
- *Intention* (INT) was measured through three items asking participants whether they expect/will/intend (INT1, INT2, INT3) to separate waste on a daily basis, on a 7-point Likert scale ranging from “True (1)” to “False (7)” (with “Neutral (4)”).

It is worth noticing the questionnaire asked three or four questions (items) per each construct, but some items have been dropped out because of a reduced loading.

Table 54 indicates the source as well (as applicable).

**Table 54.** Constructs and sources (SM of Chapter 5).

Constructs	Indicator Code	Indicators	Source
Active Procurement Goal (APG)	APG1	A clean(er) world is important to me	//
	APG2	I can contribute to a cleaner world by separating waste accurately on a daily basis	//
Active Approval Goal (AAG)	AAG3	To me, it is important if people around me approve of my waste separation	//
	AAG4	I am supported in separating waste accurately on a daily basis by my important referent	//
Attitude (ATT)	ATT1	My waste separation on a daily basis for the next three months is good/bad	(Ajzen, 2006)
	ATT2	My waste separation on a daily basis for the next three months is pleasant/unpleasant	(Ajzen, 2006)



	ATT3	My waste separation on a daily basis for the next three months is useful/useless	(Ajzen, 2006)
Subjective Norms (NOR)	NOR1	The most important person/group of people to me separates waste accurately on a daily basis	(Ajzen, 2006)
	NOR2	The most important person/group of people to me think that I should accurately separate waste on a daily basis	(Ajzen, 2006)
Motivation (MOT)	MOT1	I am motivated to separate my waste accurately	(Gamba & Oskamp, 1994)
	MOT2	Do you desire to separate waste accurately?	(Otto et al., 2018) (Gamba & Oskamp, 1994)
Perceived Behavioral Control (PBC)	PBC1	If I wanted to, I am confident that I can accurately separate waste on a daily basis	(Otto et al., 2018) (Ajzen, 2006)
	PBC2	It is my own conscious decision to accurately separate my waste on a daily basis	(Ajzen, 2006)
Intention (INT)	INT1	I expect to separate my waste accurately on a daily basis	(Ajzen, 2006)
	INT2	I will separate my waste accurately on a daily basis	(Ajzen, 2006)
	INT3	I intend to separate my waste accurately on a daily basis	(Ajzen, 2006)

### G.3. SM of Section 5.4: Results

#### G.3.1 Descriptive Statistics

The below tables integrate the main manuscript as follows:

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- Table 55 provides an overall statistic description of the overall sample
- Table 56 describes the samples per each town
- Table 57 presents *M* and *SD* of constructs
- Table 58 presents the correlation matrix

**Table 55.** Overall description of sample (Zwolle and Maastricht respondents) (SM of Chapter 5).

Variables	Answers (values for <i>M</i> and <i>SD</i> calculation)	<i>M</i>	<i>SD</i>	Frequency n	Percentage %
Respondents		3.2	1.6	208	100%
Age Range	18-24 (1)			32	15.4%
	25-34 (2)			57	27.4%
	35-44 (3)			35	16.8%
	45-54 (4)			32	15.4%
	55-64 (5)			29	13.9%
	65-74 (6)			19	9.1%
	75-84 (7)			4	1.9%
Gender		0.9	0.7		
	Male (0)			59	28.4%
	Female (1)			134	64.4%
	Other (2)			1	0.5%
	Prefer not to answer/specify (3)			14	6.8%
Education		3.3	1.1		
	Different cases/not specified (0)			13	6.3%
	Elementary/primary school (1)			3	1.4%
	High school/secondary school (2)			21	10.1%
	Associate degree (3)			51	24.5%
	University education (4)			120	57.7%

Type of dwelling		1.4	0.8		
	Other (0)			42	20.2%
	Flat (1)			45	21.6%
	House (2)			121	58.2%
Employment status		6.5	2.6		
	Other/Not specified (0)			14	6.8%
	Unemployed (not looking for a job) (1)			5	2.4%
	Unemployed (looking for a job), Student (2)			2	1.0%
	Unemployed (looking for a job) (3)			8	3.8%
	Disabled (4)			6	2.9%
	Student (5)			29	13.9%
	Employed part time, Student (6)			5	2.4%
	Employed part time (7)			56	26.9%
	Retired (8)			20	9.6%
	Employed full time (9)			63	30.3%

**Table 56.** Description of sample by town (SM of Chapter 5).

Variables	Answers	Zwolle Frequency n	Zwolle Percentage %	Maastricht Frequency n	Maastricht Percentage %
Respondents		133	63.9%	75	36.1%
Age Range	18-24	13	6.3%	19	9.1%
	25-34	33	15.9%	24	11.5%
	35-44	30	14.4%	5	2.4%
	45-54	25	12.0%	7	3.4%
	55-64	18	8.7%	11	5.3%
	65-74	13	6.3%	6	2.9%
	75-84	1	0.5%	3	1.4%
Gender	Male	28	37.3%	31	23.3%
	Female	42	56.0%	92	69.2%
	Other	0	0.0%	1	0.8%
	Prefer not to answer/ specify	9	6.7%	5	6.7%
Education	Different cases/not specified	8	6.0%	5	6.6%
	Elementary/primary school	2	1.5%	1	1.3%
	High school/secondary school	10	7.5%	11	14.7%
	Associate degree	39	29.3%	12	16.0%
	University education	74	55.6%	46	61.3%
Type of dwelling	Other	33	24.9%	9	12%
	Flat	26	19.5%	19	25.3%
	House	74	55.6%	47	62.7%
Employment status	Other	8	5.9%	6	7.9%
	Unemployed (not looking for a job)	2	1.5%	3	4.0%
	Unemployed (looking for a job), Student	0	0.0%	2	2.7%
	Unemployed (looking for a job)	3	2.3%	5	6.7%
	Disabled	5	3.8%	1	1.3%
	Student	9	6.8%	20	26.7%
	Employed part time, Student	2	1.5%	3	4.0%

Employed part time	44	33.1%	12	16.0%
Retired	14	10.5%	6	8.0%
Employed full time	46	34.6%	17	22.7%

**Table 57.** Overall description of constructs (SM of Chapter 5).

Constructs	Indicator Code	Range	<i>M</i>	<i>SD</i>
Active Procurement Goal	APG	1-7	2.3	1.3
Active Approval Goal	AAG	1-7	4.1	1.7
Attitude	ATT	1-7	2.4	1.3
Subjective Norms	NOR	1-7	2.8	1.4
Motivation	MOT	1-7	1.9	1.2
Perceived Behavioral Control	PBC	1-7	2.0	1.3
Intention	INT	1-7	2.2	1.3

**Table 58.** Correlation matrix (SM of Chapter 5).

	APG	MOT	INT	PBC	AAG	ATT	SN
APG	<b>.734</b>						
MOT	.654**	<b>.816</b>					
INT	.630**	.809**	<b>.820</b>				
PBC	.578**	.640**	.750**	<b>.788</b>			
AAG	.260*	.331**	.271*	.268*	<b>.727</b>		
ATT	.581**	.674**	.678**	.526**	.280*	<b>.711</b>	
SN	.358**	.426**	.478**	.393**	.482**	.375**	<b>.753</b>

Note: The values (in bold characters) along the diagonal indicates the  $\sqrt{\text{AVE}}$  of the latent variable. \*\*=correlation is significant at the .01 level (2-tailed). \*=correlation is significant at the .05 level (2-tailed).

## G.4. SM of Section 5.5: Discussion

### G.4.1. Goals Fluctuation

The topic of goal fluctuation deserves adequate attention in the analysis of human behavior, especially considering that people are often guided by different goals and, at times, a specific goal takes over other goals for a multitude of reasons. The individual mood, high-level of stress, the influence of “important others” or media, contextual conditions, etc. may explain the selection of a goal in spite of another one. In the specific case of environmental goals, we acknowledge that, although goals are often fluctuating and conflicting, the global critical environmental situation contributes to maintain a continuous high level of attention on topics like energy-saving, resource consumption, pollution, waste and circular economy; these topics are daily addressed on the news, on magazines and on social media as well.

## G.5. SM of Section 5.6: Conclusions

### G.5.1. Implications and Policy Suggestions

As explained in the main paper, governmental interventions need to be adequately tailored on the targeted audience, especially from the socio-demographical point of view. For example, the youngsters need appropriate school programs including environmental education since the early stages, whereas the elders require a different approach considering they may have inappropriate recycling habits, they me reluctant to implement new separation procedures or they may lack of environmental motivation. Numerous behavior change techniques are available depending on the situation (Abraham & Michie, 2008). In the former case the environmental education needs to be supported by prompting specific goal setting, demonstration of appropriate behavior, techniques of

intention formation, encouragement and rewards. In the latter case behavior changes may be pursued by providing information on health risks and conducting motivational interviewing; explaining benefits and costs for proper and improper action may prove beneficial as well.



## **Impact of This Thesis on Research and Society**

Overall, this thesis contributes to the understanding of an important aspect of our society, namely waste management behavior of citizens and consumers. Indeed, it shows that any waste management procedure (defined by decision makers or service providers) requires a preliminary and thorough understanding of the final user's behavior and motivation in order to be really effective.

This thesis applies an extended form of the "Theory of Planned Behavior" (TPB) by Ajzen (1991) and the "Theory of Reasoned Goal Pursuit" (TRGP) by Ajzen and Kruglanski (2019). The utilization of these socio-psychological theoretical frameworks (in combination with the application of a rigorous scientific methodology) enhances the academic knowledge on people's waste separation behavior in middle-to-big size cities in Europe. Specifically, this thesis provides valuable insights on human behavior and useful suggestions to researchers for future studies in this field. Furthermore, this thesis offers some practical recommendations to several waste stakeholders, especially to institutions, waste service providers and educators. For these reasons, this thesis impacts the theoretical and empirical fields with its own contribution as described in the next sections.

## **Contribution and Relevance of This Thesis to the Scientific Field**

On the theoretical side, this thesis addresses waste-related behaviors starting from the analysis of the body of academic literature in this field, mapping the conceptual structure and individuating knowledge gaps. Specifically, Chapter 2 provides a valuable summary of the academic literature on waste-related behaviors, which include not only waste separation but also waste re-utilization, minimization, recycling, etc. Chapter 2 also applies and promotes an interdisciplinary approach in order to better comprehend the interconnection of socio-psychological sciences with economics, law, engineering, ecology, sustainable development, etc. Considering the complexity and relevance of waste-related behaviors, this study proposes a useful classification of the myriad of factors and conditions influencing these behaviors. In fact, it helps scholars and practitioners of different disciplines to extricate themselves in this complex field by offering a useful guide for understanding the main theoretical frameworks, concepts, factors and conditions related to this topic. Furthermore, Chapter 2 points out trends and gaps in the existing research. For example, it highlights leading nations and journals in the research on pro-environmental consumer behavior; also, it points out weak areas in current studies such as the limited research on the effectiveness of the intervention measures adopted by governments and institutions.

Chapter 3 defines the conceptual structure of studies on recycling behavior through specific scientific methodologies such as bibliometric analysis, science mapping and text mining; it identifies current trends, the research network and hot topics by analyzing 2061 articles produced between 1975 and 2020 from three different databases. Chapter 3 highlights leading nations and the intellectual configuration of knowledge on recycling behavior; it identifies key areas such as food waste, "waste electric and electronic equipment" and waste management systems. It also points out that the effects of innovation and technology on waste-related behaviors need to be further analyzed (e.g., "Internet of Things", smart cities). In this regard, recent technological advances offer the possibility to better monitor consumer behavior in relation to purchase of goods and subsequent waste production, therefore they can contribute to a better understanding of the actual recycling behavior.

Chapter 4 also contributes to the body of literature on recycling behavior by showing the benefits of considering the effects of habits and environmental motivation when the TPB framework is applied to waste separation behavior. These additional constructs (habits and motivation) are not in contrast with the TPB principles; actually, they better explain some peculiarities of separation behavior. For example, habits highlight the repetitive nature of recycling, whereas a lack of environmental motivation can explain why a person does not recycle although he/she is able to do it and people around him/her regularly do so. This chapter shows that waste separation behavior is goal-driven as

well (even if it may not seem to be influenced by goals). In fact, this study proves that, although recycling activities are usually mandatory for citizens in advanced economies, motivation is pivotal in promoting separation behavior because it has the capability to spark the intention to separate, whereas the typical predictors of the TPB framework (attitude to separate, one's own norms and the intention to separate) alone may not be enough for doing that.

Chapter 5 represents, to the author's knowledge, the first application of TRGP to waste-related behaviors (as of September 2022). After the first application of TRGP to physical activity in an academic paper in the English language (Hamilton et al., 2022), this chapter represents a seminal study in the field of pro-environmental behavior. TRGP introduces the constructs of "active procurement goals" and "active approval goals": the former are the "desired outcomes and experiences that follow from" (Ajzen & Kruglanski, 2019, p. 779) separating waste, the latter aim at obtaining the approval of people important to us. Chapter 5's findings highlight the importance of active goals and motivation in addition to the typical TPB predictors; in particular, "active procurement goals" have a predominant effect on the precursors of the intention to separate compared to "active approval goals". This situation is due to several reasons such as the fact that nowadays waste separation is a mandatory activity in advanced economies, therefore people have somehow accepted recycling procedures, and recycling has become a routine activity. In addition, people living in these economies have developed an enhanced environmental awareness and they presume that neighbors and friends perform waste separation on a regular basis. This chapter supports the validity of the TRGP model in the study of recycling behavior. In particular, Chapter 5 demonstrates that TRGP shows a strong explanatory capability for behavior not under full volitional control such as routine behaviors. Nevertheless, it is essential to test TRGP with other case studies and in different contexts. In addition, future research should focus attention on the dynamic characteristics of goals because a goal may change over time depending on the situation (e.g., it may become inactive or predominant).

## **Contribution and Relevance of This Thesis to Society and Societal Actors**

Considering this thesis applies predictive theoretical frameworks which aim at understanding human behavior but not at correcting or modifying it, this dissertation overcomes this limitation by providing some empirical recommendations to societal actors involved with waste management. Specifically, this thesis proposes different types of interventions which range from the organizational level (e.g., legal framework) to the individual (e.g., personal goals, changing wrong recycling habits).

First of all, this thesis highlights that the development of an effective separation behavior is highly dependent on creating a supportive institutional-legal framework and a favorable environment for daily recycling activities. This framework is essential to guide and harmonize the efforts of different stakeholders and to support all pro-environmental initiatives from strategic to tactical level. For example, governments should impose the utilization of reusable containers for food packaging at the national level and involve all stakeholders (especially final users) in the decision-making process. Also, municipalities and waste service providers should favor individual recycling through a reward scheme and the optimal distribution of recycling bins in the neighborhood.

Obviously, a supportive legal-institutional framework has to be stable throughout the years, especially in the medium to long term; in fact, economic crises and conflicts challenge the ability of governments to guarantee economic and political stability, hence their key role to support pro-environmental measures and enterprises on a long horizon. In this regard, it is beyond any doubt that timely interventions and investments are fundamental for an effective waste management. For example, enterprises have to find the right balance between profitability and sustainability (A. Zhang et al., 2019) because investing in smart enabling technologies for waste management calls for great expenditures and appreciable results may take a long time.



The full exploitation of these technological advances also presupposes the development of specific competences and new roles in governmental offices, industry and waste management companies. These new roles should be very familiar with the potential of new technologies and define waste programs exploiting this potential. They should understand the characteristics of the final users and comprehend key factors and barriers to the implementation of these programs. In parallel, managers, institutions and decision makers need to develop a culture of innovation in their organization, otherwise the great potential of smart enabling technologies is not going to be exploited.

Governmental organizations should also understand that enterprises work in a very competitive environment, highly driven by market pressure and cost benefit considerations, therefore environmental protection may not represent an organizational goal. If a farsighted enterprise decides to apply smart enabling technologies to improve its waste management with probable benefits in the medium to long term, institutions are called to support it because the enterprise may not have any value recovery from waste management in the short term.

This thesis also explains the importance of a systemic view of waste management starting from the complete analysis of the life cycle of a good or a service. For example, the entire supply chain (including retailers and repair services) actively contributes to waste management as well; in turn, an efficient maintenance service promotes final users' cooperation, who are going to be more motivated to recycle knowing that they can re-utilize or repair their own goods. At the same time, an efficient lifecycle favors the implementation of new technologies, sharing of responsibility among all stakeholders, and the diffusion of pro-environmental values.

In relation to the individual dimension, this thesis also provides suggestions on how to influence goals and motivation. In effect, in order to obtain a specific behavior, it is essential to activate one or more specific goals and motivate people to achieve these goals; therefore, waste service providers and decision makers should understand the goal systems of the targeted population in order to implement effective interventions. In fact, if people live in a context with a high sensitivity for environmental matters, it is beneficial to activate and promote high level altruistic goals such as environmental protection. Vice versa, if people live in a degraded socio-cultural context where they do not perceive the importance of protecting the environment, goals and motivation should also be reinforced through a reward system, especially if the economic conditions are poor.

Even though this research shows a limited influence of "active approval goals" on motivation, Chapter 5 also suggests promoting this type of goals which aim at getting the approval of important people (e.g., parents, teachers). Therefore, interventionists should also encourage this approval, both at the family level and at the workplace or school (Hamilton et al., 2022). For example, schoolteachers should promote environmental goals in the early stages and represent a firm point of reference for pupils; at the same time, parents should be involved in the environmental education of their children and in the diffusion of pro-environmental goals among youngsters.

Chapters 4 and 5 emphasize the need to tailor waste recycling programs to the socio-demographics characteristics of the final users. In effect, different ages and incomes require different measures in order to make waste separation more effective. For example, educational campaigns for youngsters have to develop pro-environmental values and basic principles such as the wise exploitation of natural resources; whereas campaigns for elders require a diverse approach considering their system of values and goals is differently structured. In addition, elders may have inappropriate recycling habits if they have not been correctly explained how to separate waste in their youth. Consequently, behavioral changes of elders can be achieved with ad hoc techniques aiming at showing, for example, the risks to their health in case of inappropriate waste separation and handling. It follows that the gradual ageing of the population in the years to come requires an enhanced attention for elders by interventionists through tailored interventions.

Last but not least, the design of effective behavioral corrective measures requires the understanding of the preferred means of communication by the final users and the type of information these users are looking for. These aspects are quite often underestimated, but they are pivotal for the full success of waste management.



## Summary

Chapter 1 introduces the topic of investigation by providing the background of the study, its purpose, rationale and significance. It analyzes the main available theoretical frameworks, and it introduces the proposed conceptual framework in order to be able to answer the research questions.

Building on the fact that nowadays waste management is a topical issue and individual behavior represents a key aspect of the success of waste management procedures, Chapter 1 highlights that the role of motivation and goals in recycling behavior is often underestimated or omitted in the most diffused socio-psychological theoretical frameworks (e.g., Theory of Reasoned Action (TRA) by Ajzen and Fishbein (1970), Theory of Planned Behavior (TPB) by Ajzen (1991), Norm Activation Model (NAM) by Schwartz (1977), Value Belief Norm (VBN) theory by Stern (2000)). Considering that waste recycling behavior is a kind of habitual act, a correct analysis of this behavior cannot exclude the investigation of habits as well. Acknowledging that several theoretical frameworks have already proved their validity in understanding and predicting recycling behavior (e.g., TRA, TPB), the integration of the original constructs with additional ones creates new conceptual models which may improve the predictive capability of the original theory. In this regard, the recent Theory of Reasoned Goal Pursuit (TRGP) by Ajzen and Kruglanski (2019) combines the construct of goals and motivation with the typical TPB predictors, hence offering a new framework to analyze human behavior.

By answering some specific research questions, this thesis aims at improving the understanding of waste separation behavior through the analysis of the effects of habits, motivation, goals (and other possible constructs) on the intention to separate waste starting from the basis of the TPB, proposing an extended TPB model and applying TRGP to a couple of ad hoc case studies.

In addition, Chapter 1 introduces the overall methodology, and it specifies the assumptions, the delimitations and limitations of the research in order to correctly define the research field and expectations. Lastly, it explains the key terms by defining their meaning, therefore preventing possible misunderstanding and confusion.

Chapter 2 utilizes the systematic literature review methodology to study the concepts and factors related to pro-environmental consumer behavior in relation to waste management through an interdisciplinary approach. In particular it describes how these concepts are addressed in the academic literature on waste management. It investigates the interplay between pro-environmental consumer behavior (PECB) and generic consumer behavior (GenCB); moreover, it analyzes the factors and conditions which favor this interplay. To ensure a robust and rigorous approach, this systematic review utilizes three databases in the timeframe 1975-2019, it applies a solid search query, it follows the “Preferred Reporting Items for Systematic Reviews and Meta-Analyses” (PRISMA) guidelines and it reduces the risk of bias by adopting the “ROBIS” methodology. The findings reveal that, regardless of the numerous types of behavioral models applied to pro-environmental behaviors, these models mainly refer to a limited number of theoretical frameworks, namely TRA, TPB, NAM and VBN. Moreover, the above-mentioned level of interplay is quite limited, however it is significantly influenced by a favorable context or institutional-legal framework. The spectrum of promoting factors and conditions is wide and it involves different sectors such as economics, law, social psychology, government and institutions. Lastly, this chapter highlights the limitations of the research in this field, the importance of a more interdisciplinary approach, the role of intervention measures by key stakeholders and the need for a clear classification of factors and conditions.

Chapter 3 applies bibliometrics and knowledge domain mapping to recycling behavior through the study of the body of literature produced in the timeframe 1975-2020. More than 2,000 articles coming from three scientific databases are analyzed through two bibliometric tools and text mining. The findings reveal that the production of papers on recycling behavior keeps growing at an exponential

rate and 60% of papers have been published between 2015 and 2020, confirming the global interest on this topic. Leading nations are mainly from the European Union, North America and Commonwealth. However, other nations such as China and Malaysia are expanding their academic production. This chapter describes the intellectual configuration of the knowledge on recycling behavior and individuates several conceptual sub-domains focused, for example, on food waste, waste electric and electronic equipment (WEEE), plastic bags, determinants of recycling behavior; other sectors are also getting topical such as Internet of Things (IoT), Life Cycle Analysis (LCA), utilization of bitcoins, circular and smart cities, products obsolescence. Moreover, the findings indicate that waste management and the related human behavior represent a universal challenge and requires an interdisciplinary approach at all levels ranging from the individual to the institutional. In fact, this chapter highlights the importance of a more comprehensive view of the area of investigation starting from the holistic analysis of all stakeholders including their goals and motivation.

Chapter 4 analyzes waste separation behavior at the household level in Rome through the utilization of a model based on TPB; specifically, it studies the influence of environmental motivation, habits, past behavior and functionality of bins (besides the typical TPB predictors, namely attitude, perceived behavioral control (PBC) and subjective norms) on the intention to separate waste. The results of this study are analyzed through structural equation modeling (SEM): they confirm not only the validity of the typical TPB predictors, but also the key role of environmental motivation on attitude and habits, and the influence of habits on attitude, PBC, intention and past behavior. This chapter also applies mediation analysis to these constructs; in fact, it reveals that environmental motivation has an indirect effect on intention through attitude, and habits on intention through PBC and attitude. These outcomes clearly show that, when the TPB framework is applied to waste separation behavior, it benefits the addition of habits and environmental motivation. Furthermore, this chapter demonstrates that habitual behaviors such as waste separation are driven by motivation as well. The final part of this chapter proposes some suggestions for policy makers and researchers; for example, it highlights the importance of activating householders' pro-environmental goals to increase the efficacy of recycling campaigns.

Chapter 5 aims at understanding the effects of goals on waste separation intention and at testing TRGP when applied to separation behavior considering this framework has the potential for improving the understanding of human behavior. It is worth mentioning that, at present, no study has verified the efficacy of TRGP on recycling behavior, therefore this chapter applies it to the study of separation behavior of the households of Maastricht and Zwolle, the Netherlands. The outcomes definitely indicate that active procurement goals (APGs) and motivation influence separation intention; specifically, the effects of APGs on attitude and motivation are statistically significant; moreover, motivation is a very reliable proxy of intention to separate. At the same time, active approval goals (AAGs) do not significantly influence subjective norms and motivation. Therefore, this study confirms that the TPB framework can benefit the addition of further constructs by increasing its explanatory power. Furthermore, TRGP changes the "compensatory nature of the expectancy-value model" in which "each product of the belief strength times outcome evaluation is given equal weight" (Ajzen & Kruglanski, 2019, p. 799); in fact, in TRGP, AAPs and APGs have a privileged status and predominate on non-active goals. Lastly, this chapter proposes some suggestions on how to promote behavioral changes.

Chapter 6 recaps the analysis and outcomes of the previous chapters; in particular, it highlights that separation behavior, although habitual in nature, is goal driven. Not only that, the impact of AAGs and motivation on separation behavior are significant and TRGP definitely improves the understanding of this type of behavior. This chapter, after recalling the main limitations of this thesis (e.g., self-reported measures in spite of observed measures), describes the implications of this research and offers some ways ahead for future research. In particular, it stresses that, in order to

increase the efficacy of recycling campaigns, interventionists have to activate final users' pro-environmental goals and tailor their interventions depending on socio-demographic characteristics of final users. In fact, whereas youngsters can be educated, in their early years, to develop pro-environmental values and basic principles such as the respect for biodiversity and the wise exploitation of natural resources, elders require a diverse approach considering that their system of values and goals is differently structured (in this case, ad hoc campaigns could stress the risks to their health in case of inappropriate waste separation and handling). It follows that the gradual ageing of the population in the years to come requires an enhanced attention and support for elders by interventionists through tailored programs and interventions.

Furthermore, governments have to create a supportive legal-institutional framework to support all stakeholders; in turn, municipalities and waste service providers have to develop a favorable environment for daily recycling activities. This framework is essential to guide and harmonize the efforts of different stakeholders and to adequately support all pro-environmental initiatives from strategic to tactical level. For example, this thesis suggests that governments impose the utilization of reusable containers for all food packaging at the national level, support enterprises which introduce and regularly apply pro-environmental measures; in parallel, municipalities and waste service providers should implement measures such as an optimal distribution of recycling bins (for different types of waste in the neighborhood including exhausted oil and batteries), a reward scheme, and an effective sanctioning system for people not recycling correctly.

Moreover, this thesis recommends that specific competences and new roles are to be developed in governmental offices, industry and waste management companies to fully exploit new technologies. These new roles should be very familiar with the potential of state-of-the-art technologies, define waste programs exploiting this potential, understand the characteristics of the final users, comprehend key factors and barriers to effectively implement these programs.

Last but not least, the design of effective behavioral corrective measures requires the understanding of the preferred means of communication by the final users and the type of information these users are looking for. These issues are quite often underestimated, but they are pivotal for the full success of waste management.



## About the author

Alessandro Concari was born in 1969 in Casalmaggiore (Cr), Italy. He joined the Italian Air Force Academy as a cadet in 1989. After becoming a military pilot, he was assigned to different flying squadrons for his flight operational activity on fighters, training and support aircrafts. He is currently on active duty.

During his spare time he enjoys studying, so, during his assignment in the Netherlands, he started his PhD at Maastricht Sustainability Institute (MSI, former ICIS), Maastricht University, under the supervision of Prof. Pim Martens and Prof. Emeritus Gerjo Kok. His



research mainly focuses on human behavior in relation to waste management through an interdisciplinary approach. He is also interested in applying methodologies such as systematic literature reviews, bibliometrics, knowledge mapping, text mining, big data analysis, to his studies. His research aims at developing an integrated framework for analyzing consumer behavior in relation to waste management under different domains, like social, psychological, economic and cultural. He received a Bachelor of Science in Aeronautics at “Federico II” University of Naples (Italy) and a Master of Science in "Management and Business Communication" at the University of Teramo (Italy) with a specialization in “Green Economy”. He also holds a Bachelor of Science in Business Engineering at the University of “Tor Vergata” in Rome, as well as three Masters in “Communication in Business and International Organizations” at the University of Tuscia (Viterbo, Italy), “International Strategic-Military Studies” at the University of "Rome Tre" in Rome, “Geopolitics, Economics, Globalization and International Institutions” at the University of Teramo (Italy).