UNDERSTANDING ORGANIC WASTE SEPARATION IN HIGH-RISE BUILDINGS

Investigating the Theory of Planned Behavior, Household-Level, and Neighborhood-Level Characteristics, and the Intention-Behavior Gap

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Understanding Organic Waste Separation in High-Rise Buildings: Investigating the Theory of Planned Behavior, Household-Level, and Neighborhood-Level Characteristics, and the Intention-Behavior Gap

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Abstract

This MSc thesis investigates organic waste separation behavior in Dutch high-rise buildings, focusing on residents' intentions and actions toward waste management. Data were collected from residents in five cities: Almere, The Hague, Rotterdam, Schiedam, and Utrecht. Utilizing multilevel regression models, the study analyzes various factors influencing waste separation behavior to examine correlations with residents' intentions and behavior. The results reveal that intentions, particularly influenced by attitudes and subjective norms, strongly correlate with actual waste disposal behavior, aligning with Ajzen's Theory of Planned Behavior (1991). Household-level factors such as household size and past behaviors, along with neighborhood characteristics like population density and the share of non-western migrants, significantly correlate with waste separation intentions and behaviors. Notably, a disparity is observed between intentions and behaviors, as well as between self-reported and observed behavior. Objective outcome variables are preferred for accurate assessments. These findings contribute to the existing body of knowledge in waste separation behavior, and the factors correlated to residents' intentions and behaviors.

Table of Contents

1 Introduction

Organic waste management poses a significant environmental challenge in the Netherlands, with the country generating over 11 million tons of organic waste in 2021 (CBS, 2021). This waste, which includes food scraps and garden waste, can contribute to greenhouse gas emissions and pollution if not managed properly (Moussaoui et al., 2022). Proper waste separation, particularly of organic waste, is crucial for effective waste management, as it allows for separate processing and conversion into valuable resources such as compost and biogas (EuRIC, 2020; Gentil et al., 2011). However, despite its importance, organic waste remains the least separated waste stream (VANG, 2015).

High-rise buildings, characterized as dwellings with at least three stories, house approximately 4.7 million people in Dutch cities (VANG, 2015). Implementing effective waste management practices in high-rise neighborhoods poses numerous challenges, including limited space, lack of collection and separation infrastructure, low awareness about the importance and consequences of waste separation, and inconvenience experienced by residents (Berends, 2003; Kinnaman & Fullerton, 1999; Ragaert et al., 2017; VANG, 2015). High-rise neighborhoods with a high share of such buildings tend to have lower household waste separation rates (NVRD, 2019), and separately collected waste streams, including organic waste, often contain high levels of non-organic waste, reducing the effectiveness of mechanical separation processes (VANG, 2020).

Understanding the factors influencing residents' intention and behavior toward organic waste separation in high-rise buildings is crucial for several reasons. With urban populations on the rise, high-rise buildings are becoming more prevalent, making waste separation behavior increasingly relevant (Kuo & Perrings, 2010). Inadequate waste separation can have adverse environmental impacts, including contributing to climate change, pollution, and resource depletion (Beede et al., 1995; Dijkgraaf & Gradus, 2020; Faraca & Astrup, 2019; Hornik et al., 1995). Conversely, proper waste separation can lead to economic benefits, such as reduced waste management costs and increased revenue from recyclable materials (Damgaard et al., 2019; Ragossnig & Schneider, 2017; Ventola et al., 2021). Additionally, effective waste management can improve the health and well-being of high-rise residents by preventing issues associated with organic waste, such as odors and pests (VANG, 2015).

The efficiency of waste management policies and systems depends on the intentions and participation of residents. Especially in urban areas, the organic waste separation behavior of residents is unsatisfactory, and results vary per city (Meng et al., 2018; Tai et al., 2011; Wang et al., 2021). However, there is a limited understanding of the factors influencing residents' intention and behavior toward organic waste separation in this specific context in the Netherlands (ROVA, 2021; VANG, 2020). Since the degree of participation of residents determines the success of a policy, it is important to identify the factors affecting residents' behavioral intentions and actions (Kuo & Perrings, 2010; Schuch et al., 2023; Wang et al., 2021). This study aims to investigate and understand the factors correlated to organic waste separation behavior among residents living in high-rise buildings in the Netherlands. By exploring the determinants influencing waste separation intentions and actions, this research seeks to contribute to the development of effective waste management strategies tailored for high-rise urban living environments.

Despite the growing significance of waste separation behavior in sustainable urban development, a considerable knowledge gap exists concerning waste management practices within high-rise buildings (ROVA, 2021; VANG, 2020). Prior research has mainly focused on municipal-level waste management, overlooking the unique challenges faced by residents in vertical communities. This thesis aims to address this gap by providing insights into the factors influencing waste separation

behavior at both individual and neighborhood levels within the specific context of high-rise buildings. Moreover, while the Theory of Planned Behavior (TPB) has been widely applied to investigate pro-environmental behaviors, few studies have comprehensively utilized this theoretical framework to examine organic waste separation behavior. This research aims to advance the existing body of knowledge by applying the TPB in this novel context and incorporating additional variables at the household and neighborhood levels to better understand the complex interplay of factors influencing waste separation behavior in high-rise buildings.

Furthermore, this study focuses on the intention-behavior gap, the difference between an individual's intentions and actions. This gap has important implications for waste recycling as previous research found that individuals' positive intentions toward environmentally friendly behavior did not consistently translate into corresponding behavior suggesting that good intentions alone may not lead to concrete actions (Park & Lin, 2020). Furthermore, variables that are consciously linked to intention do not always predict actual behavior, nor can they accurately estimate the environmental impact of such behaviors (Nielsen et al., 2022). ElHaffar et al. (2020) conducted a comprehensive review of the intention-behavior gap and emphasized the need for more diverse and rigorous qualitative and quantitative analyses. Besides the gap between intentions and behavior, a gap has been found between self-reported behaviors and objective behaviors, underscoring the complexity of understanding sustainable behaviors (Barker et al., 1994; Chao & Lam, 2011; Huffman et al., 2014; Oliphant et al., 2020). Self-reports are often overstatements of actual waste separation behavior (Chung & Leung, 2007; Corral-Verdugo, 1996; Gamba & Oskamp, 1994), suggesting that the intention-behavior gap may be more substantial than previously thought (Kormos & Gifford, 2014).

This study has a threefold aim: (1) investigate the Theory of Planned Behavior (TPB) in the context of organic waste separation in high-rise buildings, (2) explore the correlations of household-level and neighborhood-level characteristics with residents' waste separation intentions and behavior, and (3) investigate the differences between residents' intentions, observed behavior, and self-reported behavior in the context of waste separation. For these purposes, I pose the following research questions:

1. How do attitude, subjective norms, and perceived behavioral control towards the organic waste separation of residents in high-rise buildings correlate with their intentions to engage in organic waste separation?
2. How does the behavioral intention correlate with the organic waste disposal behavior of residents in high-rise buildings?
3. How are household-level characteristics, such as household size and experience from past behavior, and neighborhood-level characteristics, such as population density and the share of non-western migrants correlated with waste separation intentions?
4. How are household-level characteristics, such as household size and experience from past behavior, and neighborhood-level characteristics, such as population density and the share of non-western migrants correlated with waste separation behavior?
5. Is there a discrepancy between intentions and behavior, and between self-reported behavior and observed behavior in organic waste separation?

To achieve the research aim, data were collected from residents in high-rise buildings in five municipalities: Almere, The Hague, Rotterdam, Schiedam, and Utrecht. A survey assessed waste separation behaviors, intentions, and TPB factors like attitudes, social norms, and perceived behavioral control. Employing a cross-sectional design and multilevel regression analyses to account for clustering at the city level, this study investigates the factors correlated with organic waste separation behavior in high-rise buildings.

The results of this study highlight several key takeaways related to residents' intentions and behaviors toward organic waste separation in high-rise buildings. Firstly, it is evident that intentions play a crucial role, primarily correlated with attitudes and subjective norms. Secondly, strong intentions directly translate into actual organic waste disposal behavior, underscoring the importance of fostering positive intentions. Thirdly, the context in which waste separation occurs is essential, as household-level factors such as the presence of elderly household members and past behaviors, along with neighborhood characteristics like population density, are significantly correlated with intentions and behaviors. Policymakers should consider these factors when formulating waste management policies. Lastly, the study reveals a disparity between intentions and behaviors, as well as between self-reported and observed behavior. Hence, objective outcome variables, such as observed behavioral data, should be preferred to ensure accurate assessments. By acknowledging these key findings, more informed decisions can be made and effective strategies can be created to promote sustainable waste management practices in high-rise buildings.

The subsequent chapters will delve into the conceptual framework (Chapter 2), and the methodology, data description, and analysis (Chapter 3). Chapter 4 will present the results and Chapter 5 will discuss the findings. Finally, Chapter 6 will provide the conclusion.

2 Theoretical framework

This chapter explores the relationship between intentions and behaviors in organic waste separation among high-rise building residents. Drawing on the Theory of Planned Behavior (TPB) (Ajzen, 1991), it examines the correlations of attitudes, subjective norms, and perceived behavioral control with waste separation intentions. Household-level factors, such as household size, past behavior, and dwelling characteristics are considered, along with neighborhood-level factors like population density, non-western migrant share, tenure housing, and highly-educated residents. While intentions play a crucial role in shaping behaviors, the chapter also addresses the intention-behavior gap, where translation into action may not always occur as expected (Sheeran & Webb, 2016). Moreover, the chapter emphasizes the importance of outcome variable selection, comparing self-reported behavior with observed behavior.

2.1 The Theory of Planned Behavior

The TPB (see Figure 1) provides a valuable framework for analyzing individuals' waste separation behavior (Ajzen, 1991). It posits that attitudes (ATT), subjective norms (SN), and perceived behavioral control (PBC) collectively shape an individual's intention, which, in turn, influences their actual behavior.

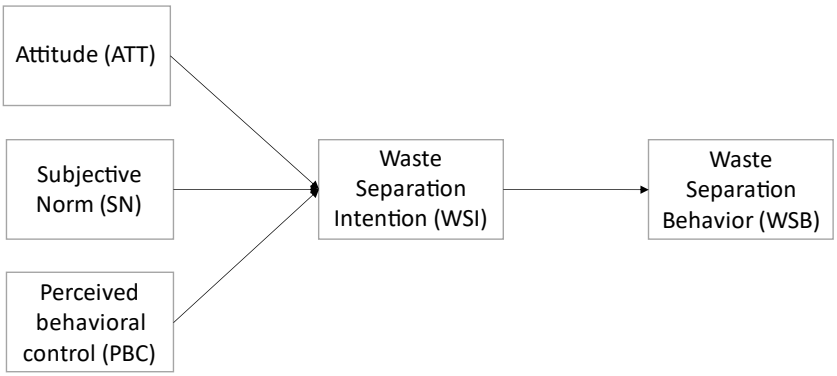

Figure 1 Standard Theory of Planned Behavior Framework

2.1.1 Attitudes

Attitudes play a crucial role in shaping residents' organic waste separation behavior. Positive attitudes toward waste separation indicate that individuals perceive recycling as environmentally beneficial and socially responsible (Nixon et al., 2009). By recognizing the value and importance of separating organic waste, individuals with positive attitudes are more likely to have a stronger intention to engage in waste separation (Geiger et al., 2019; Pearson et al., 2012; Pires et al., 2019). Negative attitudes may arise from perceived inconveniences, lack of awareness about the benefits, or skepticism about the effectiveness of recycling programs (Huffman et al., 2014; Pearson et al., 2012).

2.1.2 Subjective norms

Subjective norms reflect the social influence on individuals' intentions and behaviors. They encompass the expectations and opinions of important referent groups such as family, friends, neighbors, and community leaders (Ajzen, 1980; Schwartz, 1977). Positive subjective norms may arise from the perception that waste separation is valued and encouraged within one's social network. The desire to conform to social norms and perceived social approval can motivate individuals to align their behavior with their positive attitudes (Abbott et al., 2013; Ajzen, 1991; Derksen & Gartrell, 1993; Huffman et al., 2014; Pires et al., 2019). Conversely, negative subjective norms can stem from a lack of support or disapproval from influential individuals or groups (Huffman et al., 2014).

2.1.3 Perceived behavioral control

Perceived behavioral control (PBC) in this study refers to an individual's belief in their ability to perform the desired behavior of waste separation in high-rise buildings (Lange et al., 2014). PBC consists of two components; self-efficacy and controllability. Self-efficacy refers to the ease or difficulty of doing a task, and controllability refers to the amount to which performance is up to the actor (Ajzen, 2002). PBC includes factors such as accessibility to recycling facilities, availability of information and resources, individual capabilities, and logistical constraints (Rosenthal, 2018). Higher levels of PBC make it easier for residents to engage in organic waste separation and strengthen their intentions and subsequent behaviors. Enhancing PBC involves addressing barriers, providing convenient infrastructure such as curbside collection, and offering support mechanisms to facilitate waste separation practices (Canali et al., 2016; Jacobsen et al., 2022; Milios & Reichel, 2013; Reschovsky & Stone, 1994).

2.2 Extended Theory of Planned Behavior

While the TPB forms the foundation for the investigation, I extend upon it by incorporating household and neighborhood-level factors to gain a comprehensive understanding of waste separation behavior among high-rise building residents. Ajzen (1991) stated that, in principle, the theory is open to the inclusion of other explanatory variables, as long as they can be proven to have a significant contribution. The household level will include factors such as past behavior, and household size, but also physical factors of the dwelling such as the presence of a balcony. These factors can shed light on individual decision-making processes within households. The neighborhood level will encompass contextual factors, including local circumstances such as the population density, and the share of non-western migrants.

2.2.1 Extended TPB model

Based on a literature review of the household- and neighborhood-level factors, and the TPB, the following factors (see Figure 2) that may have a correlation to waste separation intention and behavior can be identified. For the incorporation of additional factors into the TPB model, I followed the guidelines of Whetten et al. (2009). The conceptual model depicted in Figure 2 aims to answer the main research question of this study: which factors are correlated with residents' intentions and behavior toward organic waste separation in high-rise buildings?

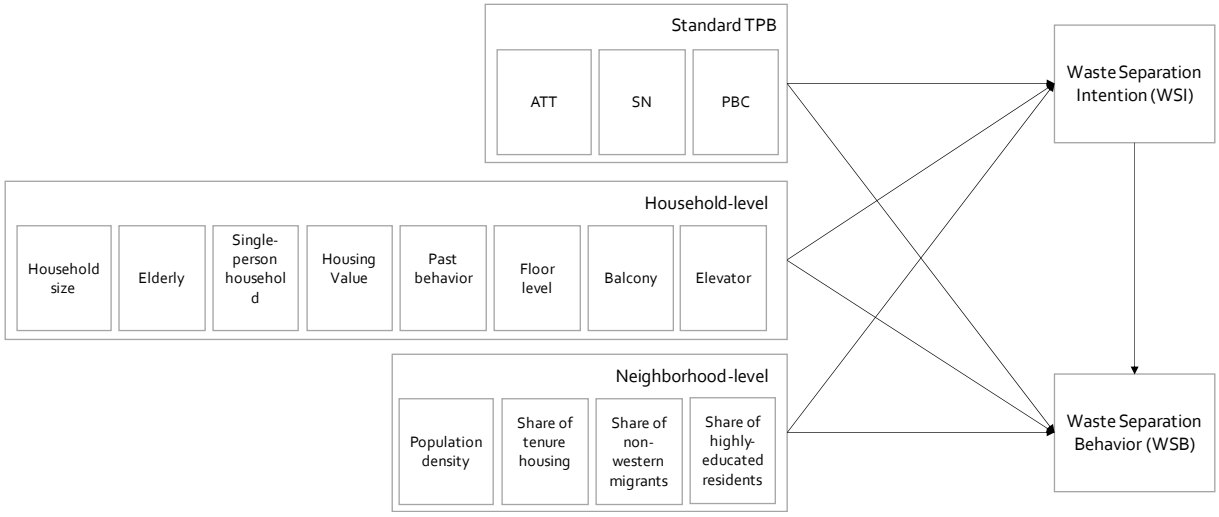

Figure 2 Factors correlated with waste separation intentions and behavior of residents in high-rise buildings (extended TPB)

2.2.2 Justification for extended TPB model

The study focuses on factors influencing waste separation behavior at the household- and neighborhood-level, recognizing their importance in achieving sustainable urban development. Previous studies have examined waste separation factors (Briguglio, 2017; Geiger et al., 2019; Hage et al., 2018; Hornik et al., 1995; Pires et al., 2019; Saphores, 2014), but this thesis uniquely examines the household- and neighborhood-levels within the Theory of Planned Behavior (TPB) framework.

One could argue that the characteristics included in the extended TPB, act through the constructs of the standard TPB, namely attitude, subjective norms, and perceived behavioral control. For example, the presence of a balcony can stimulate waste separation practices since it offers a convenient location for separate waste bins thus increasing the PBC. A similar argument could be made for example for the share of tenure housing. Individuals are more likely to adopt waste separation practices when they perceive their neighbors are engaged thus stimulating the intentions through social norms. However, including housing and neighborhood characteristics separately is justified for several reasons.

Firstly, it allows for a detailed analysis of their individual impacts on waste separation behavior. Variables like floor level, balcony presence, and elevator availability may enhance perceived behavioral control by reducing barriers to recycling. Secondly, treating population density and the share of tenure housing as distinct variables helps identify their specific effects on intention and behavior, beyond their associations with social norms. Thirdly, analyzing these separate variables explores contextual differences within high-rise buildings, accounting for diverse waste management policies, cultural norms, and community characteristics. Lastly, including these variables in the TPB framework provides a comprehensive analysis of the factors shaping waste separation behavior, offering insights into the complex interplay between residents' intentions and actions.

2.2.3 Household-level factors

High-rise buildings often vary in terms of housing characteristics, such as floor level, balcony presence, and elevator availability. Residents on lower floors may have easier access to recycling facilities, promoting higher recycling rates. Additionally, the presence of balconies and storage spaces can facilitate waste separation behaviors by providing convenient locations for recycling bins or composting systems. This section explores the relationships between household-level factors and intentions and behaviors related to organic waste management.

2.2.3.1 Household size

Household size can have both positive and negative impacts on recycling participation. Dijkgraaf and Gradus (2020) reported a negative impact in the Netherlands, whereas Owens et al. (2000) found no significant impact, and other studies found a positive impact of the size of a household on recycling participation (Ekere et al., 2009; Nixon et al., 2009; Volschenk et al., 2021). Larger households, characterized by having more than three members, tend to generate more waste overall, including organic waste, due to higher levels of consumption and food waste production (Dijkgraaf & Gradus, 2020). So, these larger households may generate more waste but also provide opportunities for social support and encouragement in waste separation (Ajzen, 1980). Households with more members could place greater importance on waste management practices, including organic waste separation, due to the larger volume of waste they produce (Ekere et al., 2009; Nixon et al., 2009; Volschenk et al., 2021).

Single-person households typically generate smaller amounts of waste compared to larger households. Consequently, the motivation or perceived need to engage in waste separation may be reduced among individuals in single-person households. Lower personal values, environmental

concerns, and attitudes toward waste management can negatively influence the waste separation behavior of individuals living alone (Gamba & Oskamp, 1994; Geiger et al., 2019; Hornik et al., 1995; Schultz et al., 1995; Volschenk et al., 2021).

2.2.3.2 Elderly

The effect of age on recycling behavior appears to be ambiguous, with studies reporting both positive and negative relationships. Owens et al. (2000) suggest that households consisting of elderly individuals, tend to produce less waste due to smaller food portions and reduced consumption patterns and therefore, they would have a lower disposal frequency. Nevertheless, elderly individuals may exhibit stronger conservation habits and have more spare time, which could positively influence recycling behavior (measured as the number of days per week) (Hage et al., 2018; Volschenk et al., 2021). Overall, the influence of age on recycling behavior remains inconsistent across studies (Geiger et al., 2019; Hornik et al., 1995; Owens et al., 2000).

2.2.3.3 Housing value

Wealth is commonly linked to higher socioeconomic status, and housing value has been used as an indicator or proxy for assessing wealth (Connolly et al., 2010). The influence of wealth on recycling intentions and behaviors has been a topic of interest in the literature, yielding diverse findings. Several studies have reported positive associations between socioeconomic status, wealth, and recycling intentions and behaviors (Kostakis & Tsagarakis, 2021; Oskamp, 1995; Saphores et al., 2006). This suggests that individuals with higher socioeconomic status tend to demonstrate a greater inclination towards recycling and are more likely to engage in recycling practices. Conversely, some studies have not found significant relationships between wealth and recycling behaviors (Abbott et al., 2011; Hage et al., 2008; Hornik et al., 1995; Kipperberg & Larson, 2012). These conflicting results may be attributed to the influence of other intervening variables, such as environmental awareness, access to recycling facilities, or individual attitudes toward sustainability.

2.2.3.4 Past behavior

Knowledge about recycling refers to the extent to which one knows how to recycle waste, whereas knowledge about environmental problems refers to the extent to which one knows about its causes and consequences. A higher level of knowledge about waste separation increases the probability that one engages in recycling (Geiger et al., 2019; Hornik et al., 1995; Volschenk et al., 2021). Knowledge can be obtained from education or past behavior with recycling. Past recycling behavior leads to the habit of recycling, thus converting it into unconscious behavior. The more one has recycled in the past, the more knowledge one has and the likelier this person is to have a recycling habit and thus recycle in the future as well (Geiger et al., 2019; Limayem et al., 2007).

2.2.3.5 Housing characteristics; floor level, elevator, balcony

The floor level of a dwelling, particularly in high-rise buildings, can affect waste separation and recycling as well. Studies have shown that individuals residing on lower floors may have better access to recycling facilities or waste separation infrastructure, leading to higher recycling rates (Langeveld, 2014; Langeveld et al., 2020; VANG, 2015). An elevator may lead to a lower threshold for residents to dispose of their waste separately, thus stimulating waste separation behavior (Geiger et al., 2019). Balconies, storage spaces, and gardens can serve as spaces for residents to place recycling bins or composting systems, thereby facilitating waste separation behaviors. A study by Geiger et al. (2019) found that households with more convenient places for garbage storage were more likely to engage in recycling practices. However, this effect may vary depending on the specific waste management practices and facilities available in different regions (Oskamp, 1995).

2.2.4 Neighborhood-level factors

Besides household-level factors, factors that are determined at the neighborhood-level can influence waste separation behavior amongst residents. For example, it can vary across Dutch municipalities due to socio-demographic characteristics, municipal policies, and infrastructure (Berglund & Matti, 2006; Langeveld, 2014; Rijkswaterstaat, 2017; RIVM, 2019). Factors such as cultural diversity and local recycling regulations have been found to influence waste separation behavior (Abbott et al., 2011 ; Czajkowski et al., 2014; Ekere et al., 2009; Hage et al., 2009; Nyamwange, 1996; Oskamp et al., 1998; Pearson et al., 2012; Reschovsky & Stone, 1994; Saphores et al., 2006; Saphores, 2014; Simmons & Widmar, 1990; Volschenk et al., 2021). In this study, we look at the neighborhood-level characteristics: population density, the share of non-western migrants, the share of tenure housing, and the share of highly-educated residents.

2.2.4.1 Population density

Variables that impact the social cohesion in a neighborhood such as the population density are associated with lower pro-environmental behavior (Fogt Jacobsen et al., 2022; Nyamwange, 1996; Wan & Wan, 2020). A higher population density negatively impacts recycling participation (Derksen & Gartrell, 1993). This could be due to more high-rise buildings, less social cohesion, and less social control, amongst others. Instead of curbside collection, residents have to bring the waste to a central collection point, which has been shown to lower the separation rate (Gamba & Oskamp, 1994; Kurz et al., 2007; Oskamp et al., 1998). In the study from Hage et al. (2018) geographical and demographic variables were not found to be strongly related to waste collection rates. Urbanization rate, population density, and a dummy for big cities were all found to be statistically insignificant. Nevertheless, the study from Derksen and Gartrell (1993) did find that households in smaller neighborhoods recycle more than those in larger neighborhoods. A possible explanation could be increased social pressure in smaller neighborhoods where more people might know their neighbors. This result is confirmed by the study of Geiger et al. (2019).

2.2.4.2 Share of non-western migrants

Cultural norms and language barriers may impact waste separation behavior among migrants (Hage et al., 2018). Literature has revealed that ethnicity has a significant impact on recycling participation. Municipalities with more non-western ethnic groups have been found to recycle significantly less plastic (Abbott et al., 2013; Dijkgraaf & Gradus, 2020). Hage et al. (2008) found the same result only for newly arrived immigrants, which could indicate that the lower participation could be due to a lack of understanding of the waste management system or language barriers. However, no significant relationship between race and waste separation behavior was found by Owens et al. (2000) who studied the waste separation behavior of people of African, American, Caucasian, or other descent. Since the study of Dijkgraaf and Gradus was performed in the Netherlands, it is expected that the share of non-western migrants negatively impacts waste separation targets.

2.2.4.3 Share of tenure housing

Various researchers examined waste management behaviors in different housing tenures and found that homeowners tend to exhibit higher rates of waste separation compared to renters (Geiger et al., 2019; Hornik et al., 1995; Nainggolan et al., 2019). Homeownership is often associated with a sense of responsibility and long-term investment in the property, which can translate into more conscientious waste management practices, including better waste separation behaviors (Owens et al., 2000). Moreover, a study by Schultz (2014) highlighted the role of social norms and community influences in waste management behaviors. Individuals are more likely to adopt waste separation practices when they perceive their neighbors to be engaging in similar behaviors. Thus, the composition of tenure

housing within a neighborhood can influence social norms and collective actions toward waste separation.

2.2.4.4 Share of highly-educated residents

The influence of the presence of highly-educated residents has yet to be studied as mixed results have been found for this characteristic and the studies were performed by looking at individual education levels. No significant effect was found between the level of education and the recycling outcomes by Schultz et al. (1995), Meneses and Palacio (2005), and Nixon and Saphores (2009). Other studies found that higher levels of education affect recycling behavior positively (Ekere et al., 2009; Jakus et al., 1996; Saphores et al., 2006).

2.3 Concepts of the Intention and Behavior Relation

Having outlined the factors that may influence waste separation intentions and behavior, this section further elaborates on the concepts of intention and behavior. Recycling behavior can be measured through intention, self-reported behavior, or observed behavior (Geiger et al., 2019; Hornik et al., 1995). Intention reflects individuals' willingness and plans to engage in waste separation. Self-reported behavior captures individuals' subjective accounts of their waste separation practices. Observed behavior provides an objective assessment of residents' actual waste separation behavior. While intention serves as a strong predictor of behavior, the intention-behavior gap highlights the complexities of translating intentions into actual actions.

2.3.1 Waste separation intention

The motivation to engage in organic waste separation behavior arises from an individual's sense of responsibility toward the environment, as waste separation contributes to mitigating the detrimental impacts of climate change (Yu et al., 2019). Intention is defined as the self-imposed instructions that individuals set for themselves to achieve a desired outcome (Sheeran & Webb, 2016). This definition has been derived from the exploration of various variables and models within the field of social psychology, including the well-known TPB proposed by Ajzen (1991). Although the formation of intentions stimulates psychological processes that facilitate their realization, these processes do not guarantee their actual implementation.

2.3.2 Waste separation behavior

Organic waste separation behavior is the desired outcome of an individual's recycling intention. In comparison to intention, behavior also entails self-imposed instructions, but it is geared towards achieving the intended goal through commitment (Levy et al., 2018). Behavioral predictions are based on an individual's thoughts regarding the future consequences of taking action. Empirical studies indicate that intentions serve as a reliable indicator of well-defined behaviors (Barr et al., 2001; Husin & Rahman, 2013; Rosenthal, 2018; Yu et al., 2019). Individuals are motivated by their social responsibility to preserve the environment, which induces them to act upon their recycling intentions and implement pro-environmental behaviors (Guerin et al., 2001).

2.3.3 Intention-behavior gap

The intention-behavior gap refers to the discrepancy between the translation of intentions into action or behavior change (Faries, 2016). Sheeran and Webb (2016) emphasize that numerous correlational studies have shown that intentions predict behavior. However, only about 18 to 23% of the variance in behavior is explained by intentions (Armitage & Conner, 2001). Furthermore, while these studies assert that forming an intention is crucial for initiating new behaviors, this is not always the case when adopting environmentally friendly behaviors such as waste separation (Lanzini & Khan, 2017). Some findings indicate that consumers with positive attitudes and intentions toward pro-environmental behaviors do not necessarily translate those intentions into actual behavior (ElHaffar et al., 2020).

Barriers identified are, amongst others, a lack of knowledge, a lack of opportunities, inconvenience, and perceived difficulty (Fogt Jacobsen et al., 2022; Moussaoui et al., 2022; Simmons & Widmar, 1990).

2.4 The discrepancy between Self-Reported Behavior and Observed Behavior

Besides the gap between intentions and behavior, there also exists a gap between self-reported and observed behavior. Therefore, the choice of outcome variables plays a crucial role in comprehensively understanding waste separation behavior. Interestingly, only a few studies have utilized behavioral observation in recycling research, despite its higher reliability compared to self-reported recycling behavior (Huffman et al., 2014). However, observational research is more difficult due to time constraints, limited financial resources, and measurement difficulties.

Unfortunately, the majority of previous studies on recycling behavior rely on self-reported behavior. This can be problematic as several studies have raised concerns about the accuracy and reliability of self-reported compared to observed behavior (Ajzen, 1991; De Young, 1986; Huffman et al., 2014; Meneses & Palacio, 2005; Pearson et al., 2012; Rosenthal, 2018). When asked, people often exaggerate recycling behavior for example because of a desire to present oneself favorably, also called the social desirability bias (De Young, 1986). Comparisons between self-reported and observational data are infrequent but have revealed notable differences (De Leeuw et al., 2015). However, there is still a significant correlation between the two measures. While measurement errors are present, studies generally find a weak but statistically significant positive correlation between self-reported and observed behavior (Geiger et al., 2019).

Lange and Dewitte (2019) emphasize the need of designing and verifying assessment methods based on the contextual and psychometric aspects of the researched activities in a recent study on measures of pro-environmental behaviors. Francoeur et al. (2021) make similar recommendations after conducting a systematic literature assessment of items used in measuring employee green behavior. Invalidated behavioral measurements may be one of the causes of the so-called intention-behavior gap (Rhodes et al., 2022; Rhodes & de Bruijn, 2013; Sniehotta et al., 2005), which I aim to examine in this study.

3 Methodology

3.1 Procedure and participants

Data was collected by Langeveld et al. (2020) between January 2017 and December 2019 from residents in high-rise buildings in 5 municipalities in the Netherlands; Almere, The Hague, Rotterdam, Schiedam, and Utrecht. Participants were aware of the data collection and gave their consent. High-rise buildings are defined as those with more than 3 floors and without access to a private garden. The participating parties were the municipality of Almere, the municipality of Amsterdam, the municipality of The Hague, the municipality of Rotterdam, the municipality of Schiedam/Irado, the municipality of Utrecht, HVC, the Ministry of Infrastructure and Water Management (IenW), NVRD, Rijkswaterstaat, the Association of Waste Companies, and the Association of Dutch Municipalities (VNG). They form part of the VANG Household Waste program.

The participating households were given access to waste separation facilities through a card which ensured they were only available to the residents of the high-rise buildings. This way, the number of unique days they disposed of their organic waste per week was measured. The amount of weeks for which the behavior was observed, and the number of participating households can be seen in Table 1. The average frequency of organic waste disposal was calculated from this data. The residents were asked to fill in a questionnaire, which will be further explained below.

Table 1 Amount of participating households and weeks behavior was observed per city

City	Amount of households	Amount of weeks measured
Almere	234	63
The Hague	199	38
Rotterdam	214	32
Schiedam	161	60
Utrecht	174	96

3.2 Questionnaire

The questionnaire assessed the organic waste separation behavior, the intention to separate, and the factors included in the TPB. The intention to separate waste was determined by the answer to the question: "Do you plan to separate your organic waste for the coming year?". The outcomes were measured on a 4-point Likert-type scale, ranging from 1 (= very unlikely) to 4 (= very likely). Thus, a low score indicates a low intention, and a high score a high intention to separate organic waste. A similar approach was used for the self-reported organic waste separation behavior, with the question: "Thinking about the past 3 months, how often did you separately storage and dispose of organic waste?". The outcomes ranged from 1 (= never) to 4 (= always). An overview of the variables with their descriptions and scales is given in Appendix A.

The constructs of the TPB that precede intention were measured as follows. The strength of attitude, social norms, and perceived behavioral control was assessed by the (dis)agreement with a list of statements related to the attitudes, social norms, and perceived behavioral control respectively. Attitude (ATT) reflected residents' self-reported attitude towards waste separation. The attitude was assessed on a 4-point scale ranging from 1 (=very undesirable) to 4 (=very desirable). A higher score reflected higher positive attitudes towards organic waste separation. Subjective norm (SN) measured residents' self-reported subjective norms regarding waste separation. It captured individuals' perceptions of social pressure or influence to engage in waste separation. It was assessed on a 4-point scale ranging from 1 (=fully disagree) to 4 = (fully agree). Perceived behavioral control (PBC) assessed residents' self-reported perceived control over their waste separation behavior. It represented individuals' beliefs about the ease or difficulty of separating waste. It was measured on a 4-point scale

ranging from 1 (=very hard to separate) to 4 (=very easy). These variables were constructed as the average of the responses to the questions which can be seen in Appendix B.

For the data at the neighborhood level, I used data from CBS about population density (natural log), the share of non-western migrants, the share of tenure housing, and the share of highly-educated residents (CBS, 2022).

3.3 Data analysis

Analyses were performed in Stata 16.0. To test the constructs ATT, SN, and PBC, a principal component analysis (PCA) with orthogonal rotation was conducted. The PCA aimed to assess the factor structure of the survey items and determine their alignment with the intended constructs. The factorability was studied by investigating the anti-image correlation matrix, where most off-diagonal elements should be small in a good factor model (Bro & Smilde, 2014; Yong & Pearce, 2013). Additionally, the sampling adequacy was tested using the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test of sphericity. A KMO above 0.5 and a significant Bartlett's test at the 5% confidence level were considered indicative of factorability (Mooi et al., 2018). The results indicated that the constructs ATT, SN, and PBC could be created based on the survey responses. Detailed results are included in Appendix B.

To test the internal reliability of the scales, Cronbach's alpha was calculated, with values above 0.7 indicating good internal reliability (Mooi et al., 2018). Additionally, the composite reliability (CR) was assessed, with values well above the 0.6 threshold indicating the good intrinsic quality of the model (see Appendix B). The average variance extracted (AVE) indicated the relatedness between the construct and its separate variables. Although the AVE values were below the critical value of 0.5, the other criteria indicated the validity of the constructs (Yong & Pearce, 2013).

In Appendix C, the correlations between the variables are shown. The null hypothesis for discriminant validity was that the constructs are not distinct from each other and do not demonstrate discriminant validity. For the constructs ATT, SN, and PBC, the correlations are below 0.80 indicating that the constructs have sufficient discriminant validity.

To account for the clustering of data at the city level, multilevel regression was employed with standard errors clustered at the city level. Since residents within the same city may have similar waste separation behaviors due to shared characteristics or local policies, their responses are not independent. This clustering violates the assumption of independence, which is typically required for traditional regression models. To address this, the multilevel regression model accounts for the clustering by estimating the variance at both the individual (household) level and the city level. The standard errors of the regression coefficients are then adjusted, considering the within-city correlations. The multilevel approach was chosen over merely fixing the standard errors of the OLS regression as it better models the data clustering (Cheah, 2009).

Three models were estimated; model 1 estimates the intention based on the TPB constructs, model 2 estimates the observed behavior based on the intention and the TPB constructs, and model 3 estimates the self-reported behavior based on the intention and the TPB constructs. The estimation of models 1, 2, and 3 followed a mixed-effects modeling approach using maximum likelihood estimation. Various specifications were employed which are described below.

3.3.1 Model 1: Theory of Planned Behavior (TPB)

Model 1 aims to understand the correlations of the Theory of Planned Behavior (TPB) constructs, namely, Attitude (ATT), Subjective Norms (SN), and Perceived Behavioral Control (PBC), with residents' intentions to engage in waste separation behavior. Intentions were measured as the

responses to the survey questions on a 4-point scale (see Appendix A). Three specifications of model 1 are estimated: model 1A considers only TPB constructs as predictors; model 1B extends the model by incorporating household-level predictors (household size, elderly, single-person household, housing value, past behavior, floor level, balcony, and elevator); and model 1C further extends the model by including neighborhood-level predictors (population density, share of non-western migrants, share of tenure housing, and share of highly-educated residents).

The estimation equation for model 1A is as follows:

$$Intention_{ij} = \beta_{oj} + \beta_1 * ATT_{ij} + \beta_2 * SN_{ij} + \beta_3 * PBC_{ij} + u_{oj} + \varepsilon_{ij}$$

Where:

$Intention_{ij}$ is the waste separation intention of household *i* in city *j*; *ATTij* is the attitude score of household *i* in city *j*; *SNij* is the subjective norm score of household *i* in city *j*; *PBCij* is the attitude score of household *i* in city *j*; β_{oj} is the intercept for city *j* representing the average waste separation intention when all predictors are zero for households in city *j*; β_1 is the effect of attitude on waste separation intention (fixed effect); β_2 is the effect of social norms on waste separation intention (fixed effect); β_3 is the effect of perceived behavioral control on waste separation intention (fixed effect); u_{oj} is the random effect representing the deviation of city *j* from the overall average intercept (random effect); and ε_{ij} is the household level error term representing the unexplained variability at the individual level.

The equation for model 1B is as follows:

$$\begin{aligned} Intention_{ij} = {} & \beta_{oj} + \beta_1 * ATT_{ij} + \beta_2 * SN_{ij} + \beta_3 * PBC_{ij} + \beta_4 * HouseholdSize_{ij} + \beta_5 \\ & * Elderly_{ij} + \beta_6 * SinglePersonHH_{ij} + \beta_7 * HousingValue_{ij} + \beta_8 \\ & * PastBehavior_{ij} + \beta_9 * FloorLevel_{ij} + \beta_{10} * Balcony_{ij} + \beta_{11} * Elevator_{ij} \\ & + u_{oj} + \varepsilon_{ij} \end{aligned}$$

Where:

$HouseholdSize_{ij}$ is the dummy for household size, $Elderly_{ij}$ is a dummy for the presence of elderly household members, $SinglePersonHH_{ij}$ is the dummy for a single-person household, $HousingValue_{ij}$ is the dummy for a high housing value, $PastBehavior_{ij}$ is the dummy for previous waste separation behavior, $FloorLevel_{ij}$ is the dummy for households at a floor level higher than 3, $Balcony_{ij}$ is the dummy for presence of a balcony, $and\ Elevator_{ij}$ is the dummy for presence of an elevator of household i in city j; β_4 to β_{11} are the additional parameters associated with the household-level variables. All other variables and parameters are the same as in Model 1A.

Model 1C has the following equation:

$$\begin{aligned} Intention_{ij} = {} & \beta_{oj} + \beta_1 * ATT_{ij} + \beta_2 * SN_{ij} + \beta_3 * PBC_{ij} + \beta_4 * HouseholdSize_{ij} + \beta_5 \\ & * Elderly_{ij} + \beta_6 * SinglePersonHH_{ij} + \beta_7 * HousingValue_{ij} + \beta_8 \\ & * PastBehavior_{ij} + \beta_9 * FloorLevel_{ij} + \beta_{10} * Balcony_{ij} + \beta_{11} * Elevator_{ij} \\ & + \beta_{12} * PopulationDensity_j + \beta_{13} * ShareNonWesternMigrants_j + \beta_{14} \\ & * ShareTenureHousing_{\ j} + \beta_{15} * ShareHighlyEducated_j + u_{oj} + \varepsilon_{ij} \end{aligned}$$

Where:

$PopulationDensity_j$ the natural logarithm of population density for city j, $ShareNonWesternMigrants_j$ is the share of non-western migrants in city j, $ShareTenureHousing_{\ j}$ is the share of tenure housing in city j, $ShareHighlyEducated_j$ is the share

of highly-educated residents in city j; β_{12} to β_{15} are the additional parameters associated with the neighborhood-level variables. All other variables and parameters are the same as in Model 1B.

3.3.2 Model 2: Observed Waste Separation Behavior (WSB)

Model 2 explores the determinants of actual waste separation behavior among urban residents. Actual waste separation behavior was measured as the average number of unique days per week a household disposed of their organic waste separately. This could thus range from 0 to 7. As for model 1, I estimated three specifications in which in model 2A only the TPB constructs are included, model 2B includes household-level factors and model 2C includes neighborhood-level factors.

The equations for models 2A, 2B, 2C follow a similar structure as for model 1 including as extra independent variable *intention*, and as dependent variable *observed waste separation behavior*.

3.3.3 Model 3: Self-Reported Behavior

Model 3 investigates self-reported waste separation behavior among respondents. Self-reported waste separation behavior was measured by the survey, in which was asked how often households had disposed of their organic waste in the past three months (see Appendix A.) Again, three specifications of the model were tested in which in model 3A only the TPB constructs are included, model 3B includes household-level factors and model 3C includes neighborhood-level factors. The only difference between model 2 and 3 and their specifications is the outcome variable, which is the observed behavior for model 2 and the self-reported waste separation behavior for model 3.

The equations for models 3A, 3B, 3C follow a similar structure as for model 1 including as extra independent variable *intention*, and as dependent variables *self-reported waste separation behavior*.

3.4 Descriptive statistics

Table 2 describes the main statistics of the relevant variables of this research, such as the mean, and the standard deviation (SD). Skewness and kurtosis were included to check for the normality of the variables which is assumed if the values lie between 2 and 7 (Kim, 2018). Since most of the variables are either categorical or binary, they do not follow a normal distribution.

Table 2 Mean values, standard deviations, skewness, and kurtosis for the model variables

Variable	Mean	SD	Skewness	Kurtosis
Dependent variables				
Waste separation intention (WSI)	3.213 [a]	1.073	-1.048	2.605
Waste separation behavior (WSB) [observed]	0.503	0.730	2.628	12.830
Waste separation behavior (WSB) [self-reported]	2.869 [a]	1.212	-0.512	1.635
TPB variables				
Attitude (ATT)	3.648 [a]	0.476	-1.502	4.941
Subjective norm (SN)	2.913 [a]	0.524	-0.315	2.844
Perceived behavioral control (PBC)	3.257 [a]	0.507	-0.526	2.714
Extended TPB				
Household-level				
Household size	0.181 [b]	0.385	1.661	3.759
Elderly household (presence of member >65 years)	0.386 [b]	0.487	0.467	1.219
Single-person household	0.470 [b]	0.499	0.119	1.014
High housing value	0.567 [b]	0.496	-0.269	1.072
Past behavior	0.400 [b]	0.490	0.410	1.168
Floor level	0.535 [b]	0.499	-0.140	1.020

Balcony	0.600 [b]	0.490	-0.410	1.168
Elevator	0.663 [b]	0.473	-0.688	1.473
Neighborhood-level				
Population density	9.412	0.353	-1.024	3.118
Share of non-western migrants	37.224	19.685	0.143	1.158
Share of tenure housing	50.944	16.913	-0.370	1.380
Share of highly-educated residents	43.380	16.413	0.402	1.950

a Measured on a 4-point scale
b Binary variable (0/1)

The dependent variables in the models are waste separation intention (WSI) and waste separation behavior (WSB). The mean value of WSI is 3.213, indicating an average positive level of intention among the respondents (Pornel & Saldaña, 2013). To interpret the means of the variables measured on the 4-point scales, the interpretation scheme shown in Table 3 was used.

Table 3 Interpretation Scheme of the 4-point Likert Scale, as proposed by Pornel and Saldaña (2013)

Mean Interval	**Interpretation**
3.50–4.00	Very positive
2.50–3.49	Positive
1.50–2.49	Negative
1.00–1.49	Very Negative

The standard deviation (SD) of 1.073 reflects a relatively wide variation in responses. The skewness of -1.048 suggests a slightly left-skewed distribution, indicating a tendency towards higher values. The observed measure of waste separation behavior (WSB) has a mean of 0.503, suggesting respondents engage in waste separation once every two weeks, with considerable variability (SD = 0.730). Most respondents showed low levels of waste separation behavior (skewness = 2.628). In contrast, the self-reported WSB has a higher mean of 2.869, indicating positive engagement in waste separation, with wider variability (SD = 1.212) and a slightly left-skewed distribution (skewness = -0.512).

Regarding the Theory of Planned Behavior (TPB) variables, attitude (ATT), subjective norm (SN), and perceived behavioral control (PBC) show positive means of 3.648, 2.913, and 3.257, respectively, indicating favorable responses. The household-level variables, represented by binary dummies, have means ranging from 0.181 to 0.663, capturing various characteristics such as household size, elderly household members, single-person households, high housing value, past behavior, floor level, balcony, and elevator. The skewness and kurtosis values are not very relevant as binary variables do not follow a normal distribution.

At the neighborhood level, the variables capture population density, the share of non-western migrants, the share of tenure housing, and the share of highly-educated residents. The natural log of population density has an average value of 9.412, indicating that there is an average of 12,234 persons per km^2. The averages for the share of non-western migrants, the share of tenure housing, and the share of highly-educated residents are 37.2%, 50.9%, and 43.4% respectively.

4 Results

This chapter presents the findings of the study, focusing on the factors correlated with the intention to separate waste and the observed and self-reported waste separation behavior. The analysis considers the Theory of Planned Behavior (TPB) constructs (attitude, subjective norms, and perceived behavioral control) and incorporates household and neighborhood-level variables to enhance the understanding of waste separation behavior.

4.1 Factors correlated with the intention to separate waste

The initial focus wass on the correlation of the three TPB constructs: attitude (ATT), subjective norm (SN), and perceived behavioral control (PBC) with the intention to separate waste. Additionally, the study explored the correlations of various socio-demographic and contextual variables with the intention to separate organic waste.

4.1.1 Model 1A: Examining the Association Between Waste Separation Intention and TPB Constructs

In model 1A, the association between waste separation intention and the TPB variables (ATT, SN, and PBC) was examined. The results, presented in Table 3, revealed that attitudes and subjective norms have significant positive correlations with waste separation intention, with coefficients of 0.921 ($p < 0.01$) and 0.344 ($p < 0.01$), respectively. A one-unit increase in attitudes toward waste separation is thus associated with a 0.921-unit increase in waste separation intention. This means that individuals who hold more positive attitudes towards waste separation are more likely to express a stronger intention to engage in waste separation behavior. Likewise, a one-unit increase in subjective norms is associated with a 0.344-unit increase in waste separation intention. This suggests that individuals who perceive stronger social norms and pressures to participate in waste separation are more likely to have a higher intention to do so. However, perceived behavioral control (PBC) did not show a significant correlation with waste separation intention ($p > 0.10$).

The random intercept variance (σ_2) measured the variability of the outcome variable at the city level, indicating how much the outcome variable varies across cities after accounting for the fixed effects in the model. On the other hand, the intraclass correlation coefficient (ICC) represented the proportion of the total variance in the outcome variable that can be attributed to the differences between cities, providing insights into the clustering or similarity of observations within each city.

In model 1A, the random intercept variance was estimated to be 0.049, suggesting significant variability in individuals' intention to adopt pro-environmental practices across different cities. The ICC of 0.051 indicated that approximately 5.1% of the total variance in intention was attributed to differences between cities, while the remaining variance was explained by variations within each city.

4.1.2 Model 1B: Extending TPB with Household-Level Variables

Model 1B extended the TPB framework by incorporating household-level factors into the analysis. Attitudes (ATT) and subjective norms (SN) remained significant predictors of waste separation intention, with coefficients of 0.824 ($p < 0.05$) and 0.321 ($p < 0.05$), respectively. Perceived behavioral control (PBC) did not show significant correlations with waste separation intention. Among the socio-demographic variables, household size ($\beta = 0.323$, $p < 0.01$) and past behavior ($\beta = 0.524$, $p < 0.01$) were positively related to intention. This means that participants living in larger households are 0.323 units more likely to have the intention to separate waste compared to those in smaller households, and participants with a history of engaging in waste separation are 0.524 units more likely to have the intention to continue waste separation compared to those without a history of waste separation. On the other hand, being a single-person household ($\beta = -0.260$, $p < 0.05$), having a higher housing value

(β = -0.469, p < 0.01), and having an elevator (β = -0.163, p < 0.10) were negatively correlated to the intention of separating waste. Therefore, individuals living in single-person households are 0.260 units less likely to have the intention to separate waste compared to those living in larger households, participants residing in higher-value homes are 0.469 units less likely to have the intention to separate waste compared to those in lower-value homes, and participants living in buildings with elevators are 0.163 units less likely to have the intention to separate waste compared to those in buildings without elevators. The estimated random intercept variance was 0.182, indicating considerable variation in the intentions to separate waste among different cities. The ICC value of 0.182 suggested that approximately 18.2% of the total variance in intentions can be attributed to differences between cities.

4.1.3 Model 1C: Incorporating Neighborhood-Level Variables

Model 1C further extended the analysis by including neighborhood-level factors in addition to household-level factors. After controlling for all variables, attitudes (ATT) and subjective norms (SN) continued to exhibit significant positive associations with waste separation intentions, with coefficients of 0.823 (p < 0.05) and 0.322 (p < 0.05), respectively. However, perceived behavioral control (PBC) remained statistically insignificant (β = 0.277, p > 0.1), suggesting its limited correlation with intentions. Household size (β = 0.324, p < 0.05) and past behavior (β = 0.524, p < 0.01) continued to have a significant positive correlation with intention, indicating their robust relation with the intention of organic waste separation behavior. Likewise, being a single-person household (β = -0.260, p < 0.05), having a higher housing value (β = -0.472, p < 0.01), and having an elevator (β = -0.163, p < 0.10) continued to be negatively correlated to the intention to separate waste.

At the neighborhood level, population density exhibited a negative and statistically significant relationship with intentions (β = -1.167, p < 0.05). Specifically, for each one-unit increase in the natural log of population density, waste separation intention is expected to decrease by 1.167 units. This negative relationship suggests that residents living in more densely populated neighborhoods may be less likely to have the intention to engage in waste separation. Moreover, the share of non-western migrants had a small but statistically significant positive correlation with intention (β = 0.027, p < 0.01). For every one percentage point increase in the share of non-western migrants, waste separation intention is expected to increase by 0.027 units. This indicates that residents in neighborhoods with a higher proportion of non-western migrants might show a slightly stronger intention to participate in waste separation practices. The share of highly-educated residents also showed a positive and significant relationship with intention (β = 0.024, p < 0.05). With each one percentage point increase in the share of highly-educated residents, a resident's waste separation intention is expected to increase by 0.024 units. This finding suggests that neighborhoods with a higher percentage of educated residents are more likely to have a stronger intention to participate in waste separation behaviors. The share of tenure housing did not show a significant correlation with waste separation intention in this model. This means that the proportion of residents who own or rent their homes in the neighborhood did not appear to be significantly associated with waste separation intention, based on the data analyzed.

The estimated random intercept variance was virtually zero, suggesting that there was no variability in intentions across cities when accounting for the household- and neighborhood-level factors. The estimated residual ICC in this model was extremely low (4.98e-13), indicating that the variation in waste separation intention attributed to differences between cities was virtually negligible.

Table 4 Effects of ATT, SN, and PBC on the intention to separate waste (model 1)

Model	1A	1B	1C
VARIABLES	Intention	Intention	Intention
ATT	0.921***	0.824**	0.823**
	(0.304)	(0.334)	(0.334)
SN	0.344***	0.321**	0.322**
	(0.096)	(0.137)	(0.138)
PBC	0.264	0.277	0.277
	(0.216)	(0.256)	(0.257)
Household size		0.323**	0.324**
		(0.149)	(0.149)
Elderly		-0.089	-0.089
		(0.200)	(0.199)
Single-person household		-0.260**	-0.260**
		(0.109)	(0.110)
Housing value		-0.469***	-0.472***
		(0.164)	(0.163)
Past behavior		0.524***	0.524***
		(0.156)	(0.157)
Floor level		-0.068	-0.069
		(0.327)	(0.329)
Balcony		0.192	0.193
		(0.161)	(0.166)
Elevator		-0.163**	-0.163*
		(0.074)	(0.083)
Population density			-1.167**
			(0.509)
Share of non-western migrants			0.027***
			(0.003)
Share of tenure housing			-0.010
			(0.011)
Share of highly-educated residents			0.024***
			(0.004)
Constant	-2.003***	-1.499*	7.964
	(0.570)	(0.774)	(5.789)
Random effects			
σ_2	0.049	0.182	0.000
ICC	0.051	0.182	0.000
Households	982	982	982
Number of groups	5	5	5

Robust standard errors in parentheses (clustered at the city level)
*** p<0.01, ** p<0.05, * p<0.1

In sum, model 1A showed that attitudes and subjective norms have significant positive correlations with waste separation intention, while perceived behavioral control did not. Model 1B extended the analysis with household-level variables and confirmed the significance of attitudes and subjective norms on intentions. Model 1C further incorporated neighborhood-level factors, finding that attitudes and subjective norms continued to correlate with intentions, while perceived behavioral control remained insignificant. Household size and past behavior positively correlated with intentions, while

being a single-person household, higher housing value, and elevator presence showed negative correlations. Population density (-), share of non-western migrants (+), and share of highly-educated residents (+) at the neighborhood level were significantly correlated with intentions. However, the residual ICC suggested limited variability in intentions between cities when accounting for household and neighborhood characteristics.

4.2 Factors correlated with observed waste separation behavior

This section presents the findings of model 2, which investigated the effects of various factors on actual observed waste separation behavior.

4.2.1 Model 2A: Correlation of Waste Separation Intention with Observed Behavior

In model 2A, the correlation of waste separation intention with observed behavior was examined. The results, as shown in Table 4, indicate that intention had a significant and positive correlation with observed behavior, with a coefficient of 0.225 ($p < 0.01$). This suggests that individuals with stronger intentions to separate waste are more likely to engage in the behavior. Interestingly, the other components of the TPB, namely attitudes (ATT) and subjective norms (SN), showed insignificant correlations when the intention was included. σ_2 was estimated to be 0.052, which represents the variability of the behavior across different cities after accounting for the fixed effects (ATT, SN, PBC). The ICC of 0.109 suggested that approximately 10.9% of the total variance in the intention variable can be attributed to the differences between cities, while the remaining 91.1% of the variance was due to differences within cities.

4.2.2 Model 2B: Including Additional Household Characteristics

Model 2B extended the analysis by including additional household characteristics. In this specification, the coefficient for intention decreased slightly to 0.142 ($p < 0.05$), while the coefficient for perceived behavioral control (PBC) became significant ($\beta = 0.106$, $p < 0.01$). Attitudes (ATT) and subjective norms (SN) did not have significant direct effects on observed behavior in this model ($p > 0.05$). In model 2B, σ_2 was estimated to be 0.097, representing the variability of the behavior across different cities. The ICC of 0.231 indicated that approximately 23.1% of the total variance in the behavior can be attributed to the differences between cities.

4.2.3 Model 2C: Adding Neighborhood Characteristics

Model 2C further extended the analysis by adding neighborhood characteristics to the model. In this specification, intention continued to have a significant positive correlation to observed behavior, with a coefficient of 0.142 ($p < 0.05$). Perceived behavioral control (PBC) also exhibited a significant and positive association with observed behavior, with a coefficient of 0.106 ($p < 0.01$). This suggests that individuals who perceive greater control over their waste separation behavior are more likely to engage in the behavior. However, the direct correlations between attitudes (ATT) and subjective norms (SN), and observed behavior remained non-significant in this model ($p > 0.05$). As for model 1, after accounting for the household- and neighborhood-level factors, no variance was found between cities, indicating that all variance is due to differences between residents within cities.

Among the socio-demographic and contextual variables, household size had a non-significant positive correlation with observed behavior in model 2B ($\beta = 0.099$, $p > 0.05$) and model 2C ($\beta = 0.100$, $p > 0.05$). Additionally, having an elderly household member showed a significant positive correlation in both model 2B ($\beta = 0.245$, $p < 0.01$) and model 2C ($\beta = 0.245$, $p < 0.01$). This suggests that households with elderly members are more inclined to engage in waste separation. On the other hand, being a single-person household was negatively associated with observed behavior in model 2B ($\beta = -0.210$, $p < 0.10$) and model 2C ($\beta = -0.210$, $p < 0.10$), indicating that individuals living alone are less likely to participate in waste separation programs. Furthermore, housing value exhibited a negative

correlation to observed behavior in model 2B (β = -0.097, p < 0.05) and model 2C (β = -0.096, p < 0.05), implying that residents in higher-valued housing are less engaged in waste separation. Having participated in waste separation behavior in the past had a strong and significant positive correlation to observed behavior in model 2B (β = 0.772, p < 0.01) and model 2C (β = 0.773, p < 0.01). This indicates that individuals who have previously participated in waste separation are more likely to continue engaging in the behavior.

The presence of specific dwelling characteristics, such as floor level, balcony, and elevator, had different relationships. The floor level was insignificant, whereas the presence of a balcony was positively correlated with observed waste separation behavior in model 2B (β = 0.222, p < 0.05) and model 2C (β = 0.219, p < 0.05). In contrast, the presence of an elevator was negatively correlated with observed behavior in model 2B (β = -0.418, p < 0.05) and model 2C (β = -0.427, p < 0.05).

In model 2C, neighborhood-level factors were introduced. Population density had a significant and positive association with observed behavior (β = 0.897, p < 0.01), indicating that residents in areas with higher population density are less likely to participate in waste separation. The share of highly-educated residents showed a significant, though small, negative correlation (β = -0.006, p < 0.05) with observed behavior. However, the share of non-western migrants and the share of tenure housing were not significantly correlated with observed behavior in this model.

Table 5 Effects of factors correlated with waste separation on actual observed behavior (model 2)

Model	2A	2B	2C
VARIABLES	Observed behavior	Observed behavior	Observed behavior
Intention	0.225***	0.142**	0.142**
	(0.082)	(0.069)	(0.069)
ATT	0.118	0.042	0.042
	(0.112)	(0.122)	(0.122)
SN	0.112	0.107	0.106
	(0.071)	(0.093)	(0.093)
PBC	0.175	0.106***	0.106***
	(0.107)	(0.035)	(0.035)
Household size		0.099	0.100
		(0.197)	(0.197)
Elderly		0.245***	0.245***
		(0.095)	(0.095)
Single-person household		-0.210*	-0.210*
		(0.121)	(0.121)
Housing value		-0.097**	-0.096**
		(0.041)	(0.041)
Past behavior		0.772***	0.773***
		(0.173)	(0.173)
Floor level		-0.020	-0.019
		(0.118)	(0.118)
Balcony		0.222**	0.219**
		(0.088)	(0.090)
Elevator		-0.418**	-0.427**
		(0.170)	(0.177)
Population density			0.897***
			(0.319)
Share of non-western migrants			0.001
			(0.003)

Share of tenure housing			-0.002
			(0.005)
Share of highly-educated residents			-0.006*
			(0.003)
Constant	-1.544***	-0.975**	-8.977***
	(0.375)	(0.414)	(2.727)
Random effects			
σ2	0.052	0.097	0.000
ICC	0.109	0.231	0.000
Households	982	982	982
Number of groups	5	5	5

Robust standard errors in parentheses (clustered at the city level)
*** p<0.01, ** p<0.05, * p<0.1

Concluding, in model 2A, waste separation intention was positively correlated to observed behavior, while attitudes and subjective norms showed insignificant correlations. Model 2B introduced additional household characteristics and found that perceived behavioral control became significant, whereas attitudes and subjective norms remained insignificant. The presence of an elderly household member and past behavior showed positive correlations to observed behavior while being a single-person household and having a higher housing value had negative correlations. Specific dwelling characteristics, such as the presence of a balcony, positively related to behavior, while elevators were negatively correlated. In model 2C, neighborhood-level factors were incorporated, showing that population density was positively associated with observed behavior, and the share of highly-educated residents had a small negative correlation.

4.3 Factors correlated with self-reported waste separation behavior

This section presents the results of model 3, focusing on self-reported waste separation behavior (see Table 5).

4.3.1 Model 3A: Correlation of Waste Separation Intention with Self-reported Behavior

In model 3A, the analysis revealed that intention ($\beta = 0.838$, $p < 0.01$) had a significant and positive association with self-reported behavior. This result suggests that individuals with stronger intentions to engage in waste separation tend to exhibit higher levels of self-reported organic waste separation behavior. Among the TPB constructs, perceived behavioral control (PBC) was the only predictor that was significantly associated with self-reported intention ($\beta = 0.338$, $p < 0.01$). This implies that individuals' perceptions of their ability had a positive relation to their self-reported intention. However, attitude (ATT) and subjective norm (SN) did not exhibit statistically significant correlations in this model. The random intercept variance was estimated to be 0.018, and the ICC for model 3A was 0.042, indicating that 4.2% of the variance in self-reported organic waste separation behavior can be attributed to differences between the five cities represented in the sample.

4.3.2 Model 3B: Including Additional Socio-Demographic Factors and Household Characteristics

Model 3B extended the analysis by including additional socio-demographic factors and household characteristics as independent variables. In this model, intention ($\beta = 0.824$, $p < 0.01$) remained a strong and significant predictor of self-reported organic waste separation behavior. Among the TPB constructs, perceived behavioral control (PBC) continued to show a significant positive association with self-reported behavior ($\beta = 0.341$, $p < 0.001$). However, attitude (ATT) and subjective norm (SN) remained non-significant predictors. Among the socio-demographic variables, past sorting behavior

was positively related to self-reported organic waste separation behavior (β = 0.380, p < 0.01). On the other hand, the presence of a balcony in the dwelling was negatively associated with self-reported behavior (β = -0.725, p < 0.001). The other socio-demographic variables, such as family size, the elderly population, single-person households, housing value, floor level, and elevator availability, did not show significant associations with self-reported organic waste separation behavior. σ2 was estimated to be 0.163, and the ICC for model 3B was 0.303, indicating that 30.3% of the variance in self-reported organic waste separation behavior can be attributed to differences between the five cities.

4.3.3 Model 3C: Incorporating Neighborhood-Level Variables

Model 3C further extended the analysis by incorporating neighborhood-level variables. In this model, intention (β = 0.824, p < 0.01) continued to exhibit a significant positive correlation to self-reported organic waste separation behavior. PBC remained the only significant predictor of self-reported behavior (β = 0.342, p < 0.001), and the results for the household-level factors were similar to those in model 3B. Among the neighborhood variables, higher population density showed a marginally significant positive relationship with self-reported behavior (β = 0.737, p = 0.1). However, other neighborhood variables, such as the share of migrants, the share of tenure housing, and the share of highly-educated residents, did not significantly correlate to self-reported organic waste separation behavior. The σ2 and ICC for model 3C were practically zero so the differences between cities had a negligible effect on self-reported organic waste separation behavior when accounting for household and neighborhood characteristics.

Table 6 Effects of factors correlated with waste separation on self-reported behavior (model 3)

Model	3A	3B	3C
VARIABLES	Self-reported behavior	Self-reported behavior	Self-reported behavior
Intention	0.838***	0.824***	0.824***
	(0.049)	(0.029)	(0.029)
ATT	0.086	0.002	0.002
	(0.198)	(0.191)	(0.191)
SN	0.003	-0.031	-0.031
	(0.092)	(0.078)	(0.078)
PBC	0.338***	0.341***	0.342***
	(0.101)	(0.102)	(0.102)
Household size		-0.065	-0.064
		(0.178)	(0.177)
Elderly		0.115	0.115
		(0.117)	(0.117)
Single-person household		0.094	0.095
		(0.058)	(0.058)
Housing value		-0.138	-0.137
		(0.101)	(0.101)
Past behavior		0.380***	0.380***
		(0.045)	(0.044)
Floor level		0.094	0.094
		(0.106)	(0.106)
Balcony		-0.725***	-0.727***
		(0.169)	(0.172)
Elevator		0.169	0.159
		(0.414)	(0.424)
Population density			0.737*
			(0.381)

Share of non-western migrants			0.013
			(0.012)
Share of tenure housing			-0.000
			(0.007)
Share of highly-educated residents			0.003
			(0.009)
Constant	-1.185**	-0.694*	-8.145*
	(0.532)	(0.363)	(4.727)
		Random effects	
σ2	0.018	0.163	0.000
ICC	0.042	0.303	0.000
Households	982	982	982
Number of groups	5	5	5

Robust standard errors in parentheses (clustered at the city level)
*** p<0.01, ** p<0.05, * p<0.1

Model 3A indicated that waste separation intention had a significant positive association with self-reported behavior, while perceived behavioral control (PBC) was the only TPB construct that significantly correlated to self-reported intention. In model 3B, after incorporating additional socio-demographic factors and household characteristics, intention and PBC remained strong predictors of self-reported behavior, while attitudes and subjective norms remained non-significant. Past sorting behavior was positively related to self-reported behavior, while the presence of a balcony in the dwelling was negatively associated with it. In model 3C, neighborhood-level variables were introduced, with intention and PBC still significantly relating to self-reported behavior. Among the neighborhood variables, higher population density showed a significant positive relationship with self-reported behavior.

4.4 The discrepancy between Self-Reported Behavior and Observed Behavior

Besides conducting the regression analyses, I visually examined the self-reported data in comparison to the objective data, as shown in Figure 3. In the figure, the dots represent the observed data, while the squares represent the self-reported data. To ensure comparability between the two types of behavioral data, I standardized the dataset using the mean value and standard deviation. This involved subtracting each value from its sample mean and dividing it by its sample standard deviation (Zhang et al., 2023). The resulting differences between the standardized values are depicted in the form of the grey bar graph.

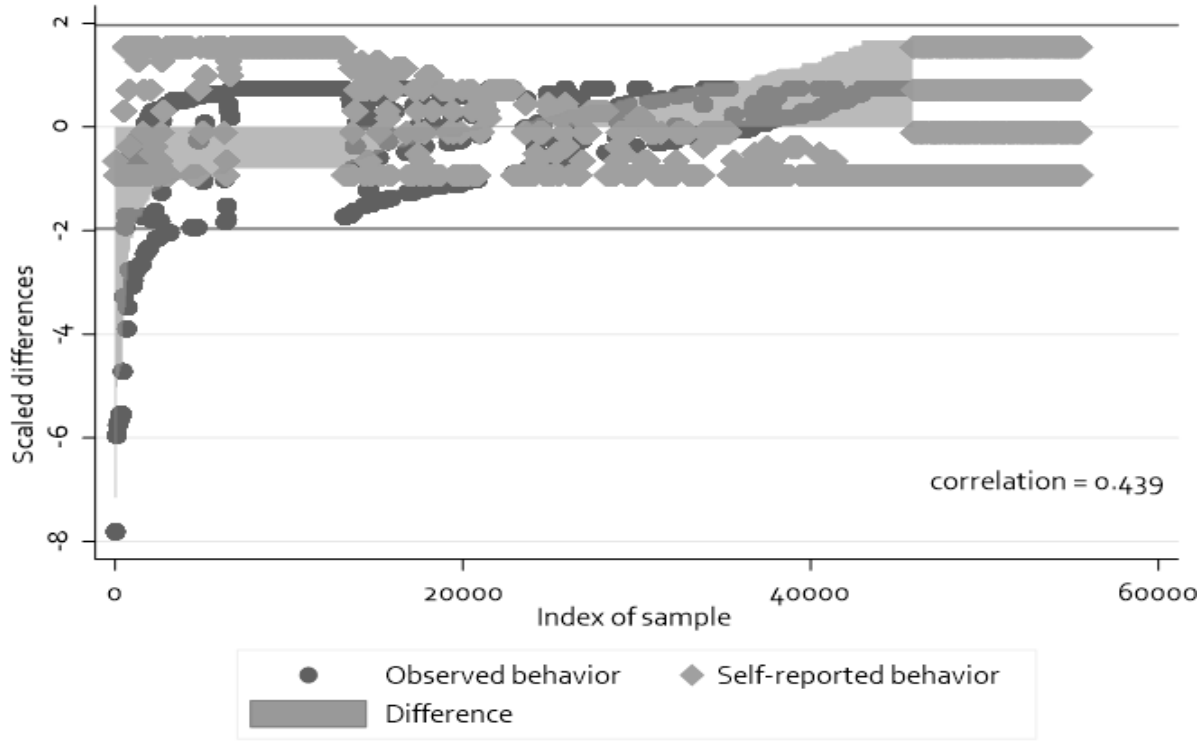

Figure 3 Scatter plot of observed and self-reported waste separation behavior with the grey bar indicating their scaled differences.

Upon observing the figure, it becomes evident that the disparity between true and self-reported behaviors was relatively small for the households in the samples in the middle. Conversely, for the majority of samples on the left and right sides, the self-reported behaviors poorly represented the observed behaviors. There was a significant difference between the two measures if the difference exceeded the limits of (-) 1.96. Consequently, there existed a notable distinction between the two measurements, which was also indicated by a correlation coefficient of 0.439.

5 Discussion

The results obtained from the three models investigating organic waste separation intention, observed waste separation behavior, and self-reported waste separation behavior, respectively, provide valuable insights into the factors correlated with individuals' engagement in waste separation practices.

5.1 Waste Separation Intention

The application of the Theory of Planned Behavior (TPB) framework in all three models revealed the significance of attitude (ATT) and subjective norms (SN) concerning individuals' intentions to separate waste. These findings align with previous research, indicating that individuals with positive attitudes toward waste separation and perceived social support are more likely to express stronger intentions to engage in waste separation activities (Aguilar-Luzón et al., 2012; Ajzen, 2002; Armitage & Conner, 2001; De Leeuw et al., 2015; Wang et al., 2021). This consistency in results strengthens the validity of the TPB model in explaining waste separation intention. Interestingly, perceived behavioral control (PBC) did not show a significant association with waste separation intention contrasting the results from Morren and Grinstein (2016). This might suggest that individuals' beliefs about their ability to control waste separation behavior might be less influential in determining their intentions, compared to attitudes and social norms. PBC might more directly influence the behavior itself instead of the intention as proposed by Alshurideh (2019).

At the household level, the positive and high correlation of past behavior on waste separation intention in models 1B and 1C highlights the significance of habit formation. Individuals who have previously engaged in waste separation are more likely to maintain their intention to continue the behavior (Xu et al., 2017). Additionally, household size showed a positive association with intention, confirming previous findings (Nainggolan et al., 2019; Volschenk et al., 2021). It indicates that larger households may perceive greater benefits or responsibilities in waste separation practices. The negative correlation between single-person households and waste separation intention aligns with findings from existing literature (Gamba & Oskamp, 1994; Geiger et al., 2019; Hornik et al., 1995; Schultz et al., 1995; Volschenk et al., 2021). These studies have suggested that social norms and influence from household members are important determinants of pro-environmental behaviors and since single-person households typically have fewer social interactions within the household compared to larger families, their intentions to engage in waste separation might be weaker. Another explanation could be that single-person households typically have limited space and waste separation may be perceived as cumbersome or inconvenient for individuals living alone. They may prioritize other aspects of their daily lives over waste separation, leading to a lower intention to engage in the behavior. The negative correlation between housing value and waste separation intention is not consistent with existing literature (Kostakis & Tsagarakis, 2021; Oskamp, 1995; Saphores et al., 2006). A possible explanation could be that housing value is not a good proxy for wealth and therefore does not capture the correlation between wealth and waste separation intentions. The negative correlation between the presence of an elevator and intentions to separate waste contradicts my hypothesis that an elevator lowers the mental barrier for separate waste disposal. Further research into this mechanism is required to gain a better understanding.

At the neighborhood level, the negative correlation between population density and intention might be attributed to a more transient and less close-knit community. In such settings, residents may feel less accountable to their neighbors or have weaker social norms promoting waste separation, resulting in lower intention to participate (Derksen & Gartrell, 1993). The positive correlation between the share of non-western migrants and the intentions indicates that residents in neighborhoods with higher percentages of migrants report higher separation intentions. This is supporting the findings of

Owens et al. (2000). The lack of a significant correlation of tenure housing could suggest that the proportion of residents who own or rent their homes does not strongly influence individual waste separation intentions in the studied context. Other factors, such as individual attitudes, convenience, or awareness, might have a more substantial impact on waste separation intentions than housing tenure. The positive correlation between the education-level of the neighborhood and the individual intention to separate suggests that highly-educated residents have a positive influence on household-level separation intentions (Kurz et al., 2007; Xiaoping et al., 2016).

5.2 Observed Waste Separation Behavior

Consistent with Ajzen's theory (Ajzen, 1991, 2002), the results from model 2A demonstrated that waste separation intention is the strongest construct of the TPB correlated to observed waste separation behavior (Briguglio, 2017; Geiger et al., 2019; Hornik et al., 1995). This finding highlights the importance of translating intention into observable actions, supporting the validity of the TPB framework in explaining waste separation behavior.

The inclusion of household-level and neighborhood-level factors provided a comprehensive understanding of observed waste separation behavior. Perceived behavioral control (PBC) consistently emerged as a significant predictor of observed behavior, indicating that individuals who believe they have control over their waste separation actions are more likely to act accordingly. Surprisingly, attitudes (ATT) and subjective norms (SN) did not directly correlate with observed behavior in both models. This might be explained by the fact that attitudes and social norms include both affective and cognitive parts, whereas the questions used in the survey mainly capture the cognitive part. Affective questions are about how behaviors make residents feel, whereas cognitive questions are focused on whether behaviors seem like a good thing to do to residents (Sheeran & Taylor, 1999). A difference might exist between affective and cognitive attitudes and social norms concerning waste separation (Burger & Bless, 2016), which should be further investigated. The lack of direct correlations between ATT and SN and observed behavior suggests that while attitudes and social norms may influence intention, other factors might be more influential in driving actual waste separation behavior. It is essential to consider that observed behavior is influenced by a complex interplay of individual, household, and neighborhood-level factors.

The positive association between past behavior and observed behavior aligns with findings in previous studies (Fogt Jacobsen et al., 2022; Lanzini & Khan, 2017; Sheeran et al., 2017; Xu et al., 2017). Individuals who have previously participated in waste separation are more likely to continue engaging in the behavior, demonstrating the power of habit in shaping sustainable actions. For often repeated behaviors, such as waste separation, the influence of intentions decreases over time, while the influence of habits (and thus past behavior) increases (Aarts et al., 1998; Limayem et al., 2007; Ouellette & Wood, 1998). This can explain the higher correlation between past behavior and observed behavior than between intention and behavior. This finding supports the importance of the development of habits in the context of organic waste separation behavior. Having an elderly household member is positively correlated to observed waste separation behavior which provides support for the hypothesis that elderly household members are more pro-environmentally active or simply produce less organic waste (Hage et al., 2018; Volschenk et al., 2021).

Notably, the presence of a balcony showed a positive correlation with observed waste separation, indicating that physical features within households might impact the ease of waste separation. In contrast, the presence of an elevator showed a negative association with observed behavior, which seems to counter this assumption of ease as a stimulating factor. Although most studies find positive associations between ease of performing a behavior and participation in the behavior (Ando &

Gosselin, 2005; Bernstad et al., 2013; Fogt Jacobsen et al., 2022; Wan & Wan, 2020; Zaharudin et al., 2021), further research in the context of waste separation is required to investigate their relationships.

Contrary to the expectations, at the neighborhood level, I found a positive relationship between population density and observed behavior. This could be explained by the fact that urban residents generate more organic waste and thus have a higher disposal frequency (Johnstone & Labonne, 2004; Owens et al., 2000). The negative correlation between the share of highly-educated residents and disposal frequency is so small (-0.006), that their correlation can be considered non-existent.

5.3 Self-Reported Waste Separation Behavior

The application of the TPB framework to self-reported waste separation behavior in models 3A, 3B, and 3C provided valuable insights into the factors correlated with individuals' self-reported engagement in waste separation.

Consistent with the TPB, intention and perceived behavioral control (PBC) were significantly and positively correlated to self-reported waste separation behavior. This finding supports the idea that self-reported behaviors are driven by individuals' intentions and perceptions of their ability to perform the behavior, aligning with previous research (Ajzen, 2002; Rhodes & de Bruijn, 2013; Rosenthal, 2018; Sniehotta et al., 2005).

Household-level factors, such as past behavior, remained a strong correlation with self-reported behavior, emphasizing the role of habit in determining individuals' self-reported waste separation practices. The presence of a balcony displayed a negative association with self-reported behavior, suggesting a potential discrepancy between self-reported and actual observed waste separation behavior. This negative correlation could be explained by the fact that balconies provide additional outdoor storage spaces, that decrease the negative experiences such as unpleasant odors related to organic waste. Therefore, residents might feel less urge to dispose of their organic waste often, resulting in a lower disposal frequency.

At the neighborhood level, population density showed a significant positive correlation with self-reported behavior. This could be explained by the fact that in densely populated neighborhoods, waste separation and recycling practices might become social norms due to the high visibility of such behaviors. Observing neighbors and fellow residents engaging in waste separation could positively influence others to follow suit, or at least report high waste separation rates as there might be a social desirability bias (Derksen & Gartrell, 1993; Pires et al., 2019).

5.4 Comparing the Models

The results of this study reveal interesting insights into the factors correlated with waste separation intentions and behaviors among residents living in high-rise buildings. It is important to note that the correlations between the variables differ when examining waste separation intentions (model 1) compared to observed behavior (model 2) and self-reported behavior (model 3). An overview of the correlations can be found in Table 7.

Table 7 Comparison of the correlations of the variables across models 1, 2 and 3

Model	1 (Intention)	2 (Observed behavior)	3 (Self-reported behavior)
Intention	NA	+	+
ATT	+		
SN	+		
PBC		+	+

Household size	+		
Elderly		+	
Single-person household	-	-	
Housing value	-	-	
Past behavior	+	+	+
Floor level			
Balcony		+	-
Elevator	-	-	
Population density	-	+	+
Share of non-western migrants	+		
Share of tenure housing			
Share of highly-educated residents	+	-	

+ showing a significant positive correlation, - showing a significant negative correlation

5.4.1 Factors of the TPB

Regarding attitudes (ATT) and subjective norms (SN), both were found to have a strong positive correlation with waste separation intention (model 1). However, these positive associations did not translate directly into observed behavior (model 2) or self-reported behavior (model 3). This finding aligns with existing literature on the intention-behavior gap, which suggests that positive attitudes and social norms may not be enough to drive actual waste separation practices. This phenomenon has been reported in various studies (ElHaffar et al., 2020; Husin & Rahman, 2013; Rhodes & de Bruijn, 2013; Sheeran & Webb, 2016; Sniehotta et al., 2005)), indicating that individuals may have good intentions but encounter barriers or constraints that hinder the translation of intentions into action.

Perceived behavioral control (PBC) showed a different pattern. While it did not significantly correlate with waste separation intention (model 1), it exhibited a strong positive association with observed behavior (model 2) and self-reported behavior (model 3). This suggests that individuals with a higher sense of control over their waste separation practices are more likely to engage in such behaviors, consistent with previous research (Ajzen, 1991; Hagger et al., 2002). The finding supports the idea of including PBC as a direct predictor of behavior, rather than merely mediating through intentions (Ajzen, 2002; De Leeuw et al., 2015; Yuriev et al., 2020).

The correlation between intention and behavior was much higher for self-reported behavior than for observed behavior, which is in line with previous findings (Chao & Lam, 2011; Huffman et al., 2014; Zhang et al., 2023). The disparities between the intentions and observed and self-reported behavior highlight the presence of the intention-behavior gap in waste separation practices. Individuals may express positive intentions toward waste separation, but when it comes to actual behaviors, various internal and external factors might hinder their full engagement. Social desirability bias, contextual constraints, and habitual practices are some of the factors that can contribute to the differences between observed and self-reported behavior (ElHaffar et al., 2020; Zhang et al., 2023).

5.4.2 Household-level factors

Larger household sizes showed a positive correlation with waste separation intentions (model 1). However, this influence did not translate into significant correlations with observed behavior (model 2) or self-reported behavior (model 3). This may indicate that although individuals from larger households intend to separate waste, other factors might hinder or limit their actual waste separation practices.

Interestingly, the presence of elderly residents displayed no significant correlation with waste separation intention (model 1). However, it exhibited a significant positive association with observed behavior (model 2), which may indicate that social norms or external influences do not play a significant role in the reporting of the elderly of their behavior, and their actions could be more driven by habits or more positive attitudes.

Single-person households and higher housing values were both negatively correlated with waste separation intention (model 1) and observed behavior (model 2). However, these negative correlations were not significant in self-reported behavior (model 3). This suggests that individuals in single-person households and higher-value housing might have lower intentions and observed behavior of waste separation, but they are not less likely to self-report their waste separation practices. This could be explained by the social desirability bias which causes people to overreport their behavior (Derksen & Gartrell, 1993; Pires et al., 2019).

Past behavior consistently showed a significant positive correlation with waste separation intentions (model 1), observed behavior (model 2), and self-reported behavior (model 3). In both models, past behavior has a strong positive correlation with observed and self-reported waste separation behavior. This finding reinforces the expected role of habit formation in driving consistent waste separation practices (Aarts et al., 1998; Ouellette & Wood, 1998).

Regarding the building-specific factors, the presence of a balcony exhibited a significant positive correlation with observed behavior (model 2) but displayed a significant negative correlation with self-reported behavior (model 3). Residents with balconies might be separating waste without being fully aware of it, especially if it has become a routine for them. As a result, when asked to self-report their waste separation behavior, they might not accurately recall or recognize their actual waste disposal frequency (Elimelech et al., 2019). Another explanation could be that they perceive their behavior as less compared to their neighbors which causes them to report lower frequencies. Floor level did not exhibit significant correlations with waste separation intentions (model 1), observed behavior (model 2), or self-reported behavior (model 3). This implies that the level at which a resident lives within a high-rise building does not play a substantial role in waste separation practices. Surprisingly, the presence of an elevator in high-rise buildings showed a negative correlation with waste separation intentions (model 1). However, this correlation was not significant in observed behavior (model 2) or self-reported behavior (model 3). This suggests that the presence of an elevator in a high-rise building may be a barrier to waste separation intentions but does not significantly impact the actual waste separation practices.

5.4.3 Neighborhood-level factors

Regarding neighborhood-level factors, population density displayed a significant negative correlation with waste separation intentions (model 1). However, it showed a significant positive correlation with observed behavior (model 2), indicating that a higher population density may foster waste separation practices. There was no significant correlation with self-reported behavior (model 3), suggesting that the correlation with population density might be more apparent when waste separation is directly observed rather than relying on self-reports. The shift in correlations can be explained by the influence of external factors that may come into play when individuals' intentions are translated into actual behavior. In high-density areas, social norms and community pressure may encourage waste separation behavior as part of community-wide sustainability efforts (Derksen & Gartrell, 1993; Oliphant et al., 2020).

The share of non-western migrants showed a positive correlation with waste separation intentions (model 1). However, this correlation is not significant in observed behavior (model 2) or self-reported

behavior (model 3). This suggests that while the presence of non-western migrants may influence waste separation intentions, it does not directly impact observed or self-reported waste separation practices.

The share of tenure housing did not exhibit significant correlations with waste separation intentions (model 1), observed behavior (model 2), or self-reported behavior (model 3). This suggests that the type of housing tenure in a neighborhood does not play a substantial role in residents' waste separation practices.

The share of highly-educated residents displayed a positive correlation with waste separation intentions (model 1). However, it displayed a negative correlation with observed behavior (model 2), suggesting that neighborhoods with a higher proportion of highly-educated residents may have lower observed waste separation rates. There is no significant correlation in self-reported behavior (model 3), indicating that the educational background of neighbors may influence residents' intentions but not necessarily their self-reported waste separation practices. This could be due to a heightened awareness and concern for environmental issues in the neighborhood, leading to a greater individual intention to participate in waste separation. However, in reality, other factors may hinder the translation of this intention into observed behavior.

5.5 Implications of the findings

The findings of this study have several implications for waste management initiatives and interventions aimed at promoting waste separation behavior. Firstly, the significant correlation of attitudes and subjective norms with waste separation intention highlights the importance of educational campaigns and social norming strategies to promote positive attitudes towards waste separation and create a culture of environmental responsibility.

Secondly, the positive association between waste separation intention and observed behavior underscores the significance of fostering strong intentions among individuals. Waste management programs should focus on increasing individuals' motivation and commitment to engage in waste separation behaviors through targeted messaging and awareness campaigns.

Thirdly, household-level factors, such as household size and past behavior, were found to significantly correlate with both intentions and observed behavior. Tailored interventions targeting specific household types, such as single-person households, and promoting habit creation could enhance participation in organic waste separation programs.

Finally, the observed discrepancy between intentions and behavior, and between self-reported and observed behaviors highlights the need for caution when relying solely on self-reported data to assess waste separation practices. Individuals tend to overestimate their engagement in waste separation when self-reporting their behavior, possibly due to social desirability biases. This suggests that self-reported data may not accurately reflect actual behavior and can lead to biased conclusions. To address this, multiple data sources and measurement methods should be employed, including direct observations of behavior. Triangulating data from different sources provides a more comprehensive understanding of the intention-behavior relationship. Researchers and policymakers need to be cautious when relying solely on self-reported data and should consider minimizing bias and using objective measures whenever possible. By doing so, more accurate assessments of interventions and targeted strategies can be developed to promote sustainable waste management practices.

5.6 Limitations

Despite the valuable insights gained from this study, certain limitations should be acknowledged. Firstly, the study adopted a cross-sectional design, which only allowed for the collection of data at a

single point in time. As a result, it becomes challenging to establish causal relationships between variables. Future research using longitudinal designs could provide a more robust understanding of the dynamic nature of waste separation behavior over time and offer insights into how these behaviors may change in response to interventions or changes in environmental conditions.

Secondly, the data for this research were collected from five municipalities in the Netherlands, limiting the generalizability of the findings to other regions or housing types. While efforts were made to include diverse municipalities, there might still be variations in waste management practices and waste separation behaviors across different geographical and cultural contexts. Replication studies in various settings can enhance the external validity of the results.

Thirdly, while the study explored various individual, household, and neighborhood-level factors, certain contextual factors that may correlate with waste separation behaviors were not considered. Factors such as local waste management policies, infrastructure, and availability of waste separation facilities could also play a significant role in shaping residents' behaviors. Future research could expand the scope of variables to encompass a more comprehensive range of contextual influences.

Finally, while the Theory of Planned Behavior (TPB) provided a suitable theoretical framework for understanding waste separation intentions and behaviors, it is essential to acknowledge that this theory makes certain assumptions about human behavior. Alternative theoretical perspectives could offer complementary insights and enrich the understanding of waste separation behavior.

5.7 Recommendations for future research

In light of the aforementioned limitations, several recommendations are proposed to enhance the research and address potential areas of improvement. These recommendations aim to bolster the validity and applicability of the study's findings, contributing to the field of waste management and behavioral change.

Firstly, this study did not find direct correlations between attitudes, subjective norms, and observed and self-reported behavior. This might be due to the survey questions mainly capturing the cognitive aspect of attitudes and social norms, while the affective aspect, relating to how behaviors make residents feel, was not fully explored. Further investigation into the distinction between affective and cognitive attitudes and social norms regarding waste separation is needed. Also, conflicting findings regarding the ease of separation were found as balcony presence showed a positive correlation with observed waste separation, suggesting that physical features within households might influence the ease of waste separation. On the other hand, the presence of an elevator was negatively associated with observed behavior, challenging this assumption. To better understand these relationships, further research is required, specifically in the context of waste separation.

Secondly, to overcome the constraint imposed by the cross-sectional design, future research should consider adopting longitudinal designs. Longitudinal studies enable the collection of data over an extended period, allowing researchers to examine changes in waste separation behavior and its determinants over time. By establishing causal relationships between variables, longitudinal studies can provide a more nuanced understanding of the factors that drive residents' intentions and behaviors in waste separation.

Thirdly, to enhance the generalizability of the findings, conducting replication studies in diverse regions and housing types is recommended. Previous research found that residents in developed and individualistic countries are more likely to translate their pro-environmental intentions into behavior, further highlighting the importance of the contextual setting (Morren & Grinstein, 2016). Expanding the research to include municipalities with varying waste management practices and cultural

backgrounds can strengthen the external validity of the results. Researchers could apply spatial analysis techniques to examine the spatial distribution of waste separation behavior in high-rise buildings and its relationship with neighborhood or region characteristics. Interesting research in this field has been conducted by Hage et al. (Hage et al., 2008; Hage et al., 2018; Hage & Söderholm, 2008; Hage et al., 2009) for Sweden, but for the Netherlands, no similar studies have been conducted. This could help identify spatial patterns, disparities, and potential hotspots for targeted interventions.

Fourthly, to capture a broader spectrum of influences on waste separation behavior, future research should encompass additional contextual factors. These may include local waste management policies, the presence and accessibility of waste separation facilities, and the level of environmental awareness within the community. Incorporating these variables into the research framework can provide valuable insights into the interplay between individual, household, and neighborhood-level factors, and the external environment.

Lastly, while the Theory of Planned Behavior (TPB) served as a valuable theoretical foundation for this study, it is prudent to acknowledge the existence of alternative theoretical perspectives. Exploring complementary theories and frameworks may offer a more comprehensive understanding of waste separation behavior, accounting for unique psychological, social, and environmental factors that influence residents' actions. Integrating multiple theoretical perspectives can enrich the analysis and interpretation of research findings.

6 Conclusion

In conclusion, this study has aimed to examine the factors that are correlated with residents' intentions and behaviors toward organic waste separation in high-rise buildings. Through a comprehensive analysis of the Theory of Planned Behavior (TPB) and its extended version, combined with household- and neighborhood-level variables, I sought to shed light on the complexities of waste separation behavior in this specific context.

Addressing the first research question, I found that attitudes, and subjective norms toward organic waste separation were significantly correlated with residents' intentions to engage in waste separation. Positive attitudes towards waste separation, and perceived social norms supporting the behavior were associated with higher intention levels among residents.

The second research question revealed that behavioral intentions had a substantial positive correlation with residents' organic waste disposal behavior in high-rise buildings. Those with stronger intentions were associated with more active engagement in the correct disposal of organic waste, indicating a direct link between intentions and behavior in this context.

Regarding the third and fourth research questions, my findings highlighted the importance of both household-level and neighborhood-level factors in shaping waste separation intention and behavior. Household-level characteristics such as household size and past behavior experience played a role in influencing residents' intentions and actions. Additionally, neighborhood factors, such as population density and the share of non-migrants, were found to be significant predictors of waste separation intentions and behavior.

Lastly, addressing the fifth research question, I uncovered a noteworthy discrepancy between intentions and behavior on the one hand and self-reported and observed behavior on the other hand. Therefore, it is important to consider the choice of outcome variable studied. Preferably, objective outcome variables are used, making use of observed behavioral data.

Overall, this thesis contributes to closing the knowledge gap in understanding the intention-behavior relationship, particularly in the context of waste separation in high-rise buildings. By integrating psychological constructs from the TPB with household and neighborhood-level variables, valuable insights were gained into the factors that are correlated with residents' intentions and actions in this specific setting. Ultimately, understanding and promoting organic waste separation behavior in high-rise buildings are crucial steps toward achieving sustainable waste management and a greener future.

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Appendix A

Table 8 Descriptions and scales of variables included in the extended TPB models

Variable	Description	Scale
Dependent variables		
Waste separation intention (WSI)	Self-reported answer to: Do you plan to separate your organic waste for the coming year?	1 = very unlikely, 2 = unlikely, 3 = likely, 4 = very likely
Waste separation behavior (WSB) [observed]	Number of unique organic waste disposal days per week	0 - 7
Waste separation behavior (WSB) [self-reported]	Self-reported answer to Thinking about the past 3 months, how often did you separately storage and dispose of organic waste?	1 = never, 2 = sometimes, 3 = mostly, 4 = always
TPB variables		
Attitude (ATT)	Self-reported attitude toward waste separation	1 = very undesirable, 2 = undesirable, 3 = desirable, 4= very desirable
Subjective norm (SN)	Self-reported subjective norm on waste separation	1 = fully disagree, 2 = disagree, 3 = agree, 4 = fully agree
Perceived behavioral control (PBC)	Self-reported perceived behavioral control on waste separation	1 = very hard to separate, 2 = hard 3 = easy, 4 = very easy
Waste separation intention (WSI)	Self-reported answer to: Do you plan to separate your organic waste for the coming year?	1 = very unlikely, 2 = unlikely, 3 = likely, 4 = very likely
Extended TPB		
Household-level		
Household size	Binary variable that takes the value 1 if there are more than 3 household members	0 = no, 1 = yes
Elderly household (presence of member >65 years)	Binary variable that takes the value 1 if the household contains a member older than 65 years	0 = no, 1 = yes

Single-person household	Binary variable that takes the value 1 if it is a one-person household	0 = no, 1 = yes
Housing value	Binary variable that takes the value 1 if the value of the home is above the median (€300 k)	0 = no, 1 = yes
Past behavior	Binary variable that takes the value 1 if the household separated organic waste during the baseline period of the measurement	0 = no, 1 = yes
Floor level	Binary variable that takes the value 1 if the household floor level is above 3	0 = no, 1 = yes
Balcony	Binary variable that takes the value 1 if there is a balcony	0 = no, 1 = yes
Elevator	Binary variable that takes the value 1 if there is an elevator	0 = no, 1 = yes
Neighborhood level		
Population density	Natural log of the population density in the neighborhood	Continuous
Share of non-western migrants	Share of non-western migrants in the neighborhood (%)	Continuous
Share of tenure housing	Share of tenure housings in the neighborhood (%)	Continuous
Share of highly-educated residents	Share of highly-educated households in the neighborhood (%)	Continuous

Appendix B

Table 9 Validity analyses of the TPB constructs

Constructs	Survey question	Cronbach's alpha	CR	AVE	KMO
ATT	Do you think it's desirable that Dutch residents separate their waste?	0.684	0.722	0.427	0.672
	Do you think it's desirable that you separate waste at home?				
	Do you think it's desirable to separate organic waste (vegetables, fruit, food rests, and plants)?				
	Do you think it's desirable that new products are being produced from the collected waste?				
SN	I feel at home in this neighborhood.	0.695	0.707	0.261	0.725
	I have many social contacts in the neighborhood.				
	People in this neighborhood live alongside each other.				
	People in this neighborhood take each other into account.				
	My neighbors expect me to separate my waste.				
	Most neighbors separate their waste.				
	In my household, everyone is expected to separate their waste.				
PBC	*How easy do you think it is…*				
	To remember what does and does not belong in each bag or container?	0.794	0.797	0.288	0.818
	To recognize what material your waste is from?				
	To transport your bag or container to your collection point?				
	To find the right container?				
	to get enough information to separate waste properly?				
	To find a good place in your home for temporary storage of your waste?				
	To store your kitchen waste separately?				
	To gain insight into how well you separate your waste?				
	To set aside enough time to separate waste?				
	To not forget to separate waste?				

Appendix C

Table 10 Correlation matrix of variables

	Intention	Observed behavior	Self-reported behavior	ATT	SN	PBC	Household size	Elderly	Single-person household	Housing value	Past behavior	Floor level	Balcony	Elevator	Population density	Share of non-western migrants	Share of tenure housing	Share of highly-educated residents
Intention	1.000																	
Observed behavior	0.340*	1.000																
Self-reported behavior	0.830*	0.416*	1.000															
ATT	0.489*	0.182*	0.456*	1.000														
SN	0.203*	0.213*	0.216*	0.216*	1.000													
PBC	0.391*	0.231*	0.453*	0.440*	0.368*	1.000												
Household size	0.096*	-0.015*	0.000	0.042*	-0.043*	-0.065*	1.000											
Elderly	0.037*	0.258*	0.125*	-0.055*	0.183*	0.151*	-0.302*	1.000										
Single-person household	-0.131*	-0.122*	-0.054*	-0.029*	0.045*	-0.010*	-0.442*	0.228*	1.000									
Housing value	0.137*	-0.076*	0.081*	0.100*	-0.018*	0.054*	-0.003	-0.137*	-0.049*	1.000								
Past behavior	0.144*	0.442*	0.182*	0.077*	0.148*	0.135*	-0.102*	0.192*	0.082*	0.003	1.000							
Floor level	0.006	-0.118*	-0.002	0.021*	-0.056*	-0.006	-0.008	-0.056*	0.038*	-0.061*	-0.093*	1.000						

Balcony	-0.159*	0.107*	-0.112*	-0.112*	0.045*	-0.075*	-0.128*	0.124*	0.019*	-0.004	0.026*	-0.275*	1.000				
Elevator	-0.086*	0.102*	-0.020*	-0.086*	0.037*	-0.052*	-0.147*	0.107*	0.057*	0.111*	-0.081*	-0.169*	0.785*	1.000			
Population density	-0.102*	0.110*	-0.059*	-0.011*	0.048*	-0.061*	-0.046*	-0.067*	-0.045*	-0.034*	-0.163*	-0.316*	0.717*	0.797*	1.000		
Share of non-western migrants	0.046*	-0.169*	0.057*	-0.063*	-0.120*	-0.048*	-0.060*	0.079*	0.047*	0.229*	-0.491*	0.123*	0.162*	0.308*	0.029*	1.000	
Share of tenure housing	-0.158*	0.244*	-0.101*	-0.150*	0.139*	-0.023*	-0.176*	0.278*	0.188*	-0.402*	0.636*	-0.154*	0.187*	0.015*	-0.066*	-0.549*	1.000
Share of highly-educated residents	-0.051*	0.158*	-0.049*	0.072*	0.092*	0.005	-0.049*	-0.151*	-0.046*	0.218*	0.282*	-0.301*	0.428*	0.441*	0.660*	-0.558*	0.191*	1.000

Sign * at 5% level