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PAPER

Beyond rational choice: a comparative analysis of rational and moral psychological pathways to recycling intention

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Supplementary material for this article is available online

Abstract

Understanding how reasoned and moral psychological processes relate to recycling intention (RI) remains an important theoretical issue in environmental psychology. This study compared the theory of planned behavior (TPB) and the norm activation model (NAM) using three principal structural specifications and a parsimonious awareness of consequences (AC) benchmark. Data were collected from 1832 university students in Türkiye and analyzed using covariance-based structural equation modeling. The TPB specification accounted for 56.9% of the variance in RI, but substantial overlap among its predictors produced an inadmissible structural solution. The theoretically sequential NAM (AC → ascription of responsibility (AR) → personal norms (PN) → RI) explained 49.2% of the variance in intention but yielded a boundary solution characterized by a near-unit AR → PN coefficient and a slightly negative PN residual variance. The competitive TPB–NAM specification produced the highest descriptive R^2 (73.9%) but was also inadmissible because of poor fit, extreme standardized coefficients, and severe construct overlap. In contrast, the AC benchmark produced an admissible solution, with AC positively associated with RI ($\beta = 0.581$) and explaining 33.7% of its variance. Overall, the findings caution against interpreting higher explained variance as evidence of theoretical superiority or complementarity when construct distinctiveness and model admissibility are compromised.

1. Introduction

The unprecedented rapid advancement of urbanization, industrialization, and consumption-oriented lifestyles has made urban solid waste one of the most critical environmental challenges of the 21st century (Ugulu 2026). Governments, industries, and international institutions have implemented a wide range of strategies, including recycling policies, waste collection programs, disposal taxes, public awareness campaigns, circular-economy initiatives, and various incentives to alleviate environmental deterioration and encourage sustainable development (Wilson *et al* 2012, Tencati *et al* 2016). Nonetheless, the success of these programs depends substantially on individuals' willingness to engage in recycling activities. Although recycling is widely recognized as an effective means of conserving natural resources, reducing pollution, and supporting the transition toward a circular economy, actual participation often remains below policy expectations despite increasing environmental awareness (OECD 2014, Ugulu 2019). This inconsistency suggests that recycling behavior is shaped not only by environmental knowledge and institutional interventions but also by cognitive, social, motivational, and moral psychological processes.

Understanding the psychological mechanisms underlying recycling behavior has therefore become a fundamental objective of environmental psychology and sustainability research. Recycling is a voluntary behavior that may require individuals to invest additional time and effort, while its benefits are largely collective, long-term, and environmental rather than immediately personal. Numerous theoretical frameworks have been developed to explain pro-environmental intentions and behaviors, including the theory

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of planned behavior (TPB) (Ajzen 1991), the norm activation model (NAM) (Schwartz 1977), the Value-belief-norm theory (Stern 2000), and various integrated behavioral frameworks (Chan and Bishop 2013). Among these, the TPB has become one of the most widely applied frameworks for explaining behavioral intention and action. It has been extensively used to examine a wide range of pro-environmental behaviors, including recycling intention (RI) and behavior (Shaw *et al* 2000, Botetzagias *et al* 2015, Ugulu 2026). TPB conceptualizes behavioral intention as being shaped by attitude toward the behavior, subjective norm (SN), and perceived behavioral control (PBC) (Ajzen 1985, 1991), thereby emphasizing a reasoned and deliberative pathway to behavioral decision-making.

A substantial body of empirical research supports the utility of TPB across diverse environmental contexts, including domestic recycling, waste segregation, electronic-waste recycling, transport choices, energy conservation, and organic food consumption (Park and Ha 2014, Dong and Hua 2018, Lou *et al* 2022). Meta-analytic evidence also supports TPB as one of the dominant theoretical frameworks for understanding pro-environmental behavior (Armitage and Conner 2001). The flexibility of TPB has prompted researchers to incorporate additional variables such as environmental concern, environmental knowledge, environmental awareness, and situational factors into extended TPB specifications, often increasing explained variance while retaining reasoned evaluation as the framework's central explanatory logic (Chen and Tung 2009). Nevertheless, the adequacy of reasoned evaluation alone for explaining RI has increasingly been questioned. Recycling does not necessarily provide substantial direct benefits to the individual but often generates broader environmental and societal benefits. Individuals may therefore intend to recycle not only because they evaluate the behavior favorably or perceive it as feasible, but also because they experience a sense of moral obligation to act in an environmentally responsible manner. This has encouraged researchers to consider theoretical approaches emphasizing moral obligation, personal responsibility, and altruistic concerns.

Among the frameworks reflecting this perspective, the NAM proposed by Schwartz (1977) has become one of the most influential approaches for explaining environmentally responsible behavior. Whereas TPB emphasizes reasoned behavioral evaluation, NAM focuses on the activation of internalized moral obligation. According to the model, individuals first become aware of the environmental consequences of their actions (awareness of consequences (AC)), subsequently ascribe personal responsibility for those consequences (ascription of responsibility (AR)), and ultimately develop personal norms (PNs) that motivate environmentally responsible behaviors such as recycling, waste reduction, and energy conservation. Substantial empirical evidence supports the applicability of NAM across diverse environmental contexts, including recycling, household waste separation, food waste reduction, apparel recycling, battery recycling, and other sustainability-related behaviors (Wan *et al* 2017, Nketiah *et al* 2022, Pham *et al* 2023). These findings indicate that moral obligation and personal responsibility constitute theoretically important mechanisms that may complement or overlap with the reasoned processes emphasized by TPB, although the empirical relationship between these pathways remains an open question.

Despite their broad application, neither TPB nor NAM is expected to capture every psychological process involved in RI. TPB emphasizes behavioral evaluation, perceived social expectations, and perceived control while giving comparatively less explicit attention to internalized moral obligation, whereas NAM focuses primarily on moral activation and gives less attention to social expectations and PBC (Chan and Bishop 2013, Wan *et al* 2017, Liu and Yang 2022). The two frameworks therefore offer theoretically distinct, although potentially overlapping, explanations of RI. Many previous studies have responded to these differences by extending or integrating behavioral frameworks, most commonly by incorporating moral, environmental, or contextual variables into TPB or by combining constructs derived from multiple theories (Bamberg and Möser 2007, Chan and Bishop 2013, Wan *et al* 2017, Nketiah *et al* 2022, Pham *et al* 2023). Recent studies further illustrate this tendency across sustainability-related contexts, including the examination of environmental awareness and moral influences in consumer decision-making (Miquel-Romero *et al* 2025), extensions of TPB incorporating additional sustainability-related psychological determinants (Valizadeh *et al* 2026), and broader models integrating multiple psychological perspectives on sustainable behavior (Enginkaya and Sağlam 2025).

Although such studies demonstrate the value of combining reasoned, moral, and environmental determinants, the dominant approach has generally been model extension or integration rather than direct theory comparison. In extended models, improved explanatory power is often inferred from increases in explained variance after additional constructs are introduced. However, such increases do not necessarily demonstrate that the underlying theoretical mechanisms remain empirically distinct or that their simultaneous representation produces a stable and statistically admissible structural solution. Moreover, when NAM-derived constructs are incorporated into broader models primarily as additional predictors, the theoretically ordered activation process of NAM may receive less explicit attention. Consequently, existing integration studies provide more limited evidence regarding whether TPB and

NAM retain their internal theoretical structure and empirical distinctiveness when evaluated separately and simultaneously under comparable analytical conditions.

This distinction defines the central research gap addressed in the present study. Rather than asking only whether moral constructs add explanatory variance to a reasoned behavioral model, the study examines whether the reasoned pathway represented by TPB and the sequential moral pathway represented by NAM can be empirically differentiated when their theoretical structures are explicitly preserved. A further question is whether these pathways can be represented simultaneously without compromising construct distinctiveness, parameter stability, or statistical admissibility. In this respect, theoretical integration should not be evaluated solely by higher R^2 values or improved global fit, but also by whether the constituent constructs and structural mechanisms remain empirically separable and yield interpretable solutions.

Accordingly, the present study adopts a comparative theory-testing perspective. TPB is evaluated as a reasoned pathway to RI, whereas NAM is examined in its theoretically sequential form (AC $\rightarrow$ AR $\rightarrow$ PN $\rightarrow$ RI). A competitive specification then evaluates the simultaneous representation of the TPB predictors and the sequential NAM pathway, while a parsimonious AC $\rightarrow$ RI model serves as a reference benchmark rather than as an alternative behavioral theory. The contribution of the study therefore lies not in proposing another extended TPB–NAM model, but in comparing the empirical viability of theoretically distinct reasoned and moral pathways within a common analytical framework. Their performance is evaluated jointly in terms of explanatory capacity, construct distinctiveness, parameter stability, theoretical coherence, and statistical admissibility. In doing so, the study addresses whether apparent explanatory gains from broader models represent genuinely differentiated psychological mechanisms or instead reflect substantial shared variance among theoretically related constructs.

2. Theoretical framework and hypotheses development

2.1. Two psychological perspectives on RI

Environmental psychology has produced numerous theoretical explanations of pro-environmental behavior over the past several decades. Although these theories differ in their conceptual assumptions and explanatory mechanisms, many can be broadly classified into two major psychological traditions. The first emphasizes reasoned and deliberative decision-making, in which individuals evaluate behavioral outcomes, perceived social expectations, and their capacity to perform a behavior before forming behavioral intentions. The second emphasizes internalized moral obligation, ethical responsibility, and PNs as motivational forces underlying environmentally responsible action. These two traditions are exemplified by the TPB (Ajzen 1991) and the NAM (Schwartz 1977), respectively.

While TPB explains RI through behavioral evaluation, perceived social expectations, and PBC, NAM explains RI through a sequential moral activation process in which AC promotes AR, which subsequently activates PNs and behavioral intention. Although both theories have accumulated substantial empirical support, they differ in their theoretical accounts of why individuals intend to recycle. At the same time, their constituent constructs may capture related psychological processes and therefore need not be assumed to be fully distinct at the empirical level. Consequently, determining how adequately RI is explained by the reasoned pathway represented by TPB, the sequential moral pathway represented by NAM, or a specification in which both pathways are represented simultaneously remains an important theoretical challenge.

2.2. The reasoned pathway: TPB

The rational perspective assumes that individuals make behavioral decisions by systematically evaluating the expected outcomes of alternative actions before deciding whether to engage in a particular behavior. Within environmental psychology, this perspective is most comprehensively represented by the TPB, which has become one of the most influential theoretical frameworks for explaining pro-environmental behaviors, including recycling (Ajzen 1991). According to TPB, behavioral intention is the most immediate determinant of actual behavior and is itself shaped by three conceptually distinct but interrelated determinants: attitude toward the behavior, SN, and PBC (Ajzen 1985, 1991). These constructs capture individuals' cognitive evaluation of a behavior, the perceived expectations of significant others, and their perceived ability to perform the behavior.

The popularity of TPB stems from its strong theoretical foundation, broad applicability in behavioral contexts, and consistent empirical support. Numerous previous studies have successfully applied TPB to explain a wide range of environmentally conscious behaviors, including household recycling, waste

sorting, electronic waste recycling, energy conservation, public transport use, and sustainable consumption (Bamberg and Schmidt 2003, Chen and Tung 2009, Park and Ha 2014, Botetzagias *et al* 2015, Ugulu 2015a, 2015b, 2026). Many empirical studies have shown that the three basic constructs of TPB explain a significant portion of the variance in RI, making TPB one of the dominant theoretical frameworks in recycling research (Armitage and Conner 2001, Botetzagias *et al* 2015, Wan *et al* 2017).

2.2.1. Attitude toward recycling (ATR)

Within TPB, attitude refers to an individual's overall positive or negative evaluation of performing a particular behavior (Ajzen 1991). Attitudes are formed through behavioral beliefs concerning the anticipated outcomes of an action and the evaluation of those outcomes (Ugulu and Erkol 2013). Individuals who believe that recycling contributes to environmental protection, conserves natural resources, reduces pollution, or benefits future generations are expected to evaluate recycling more favorably and, consequently, develop stronger intentions to engage in recycling activities (Ugulu *et al* 2015).

The relationship between attitude and RI has been consistently supported across diverse cultural and environmental contexts. Studies examining household waste recycling, municipal recycling programs, and electronic waste management have repeatedly identified attitude as one of the strongest predictors of RI (Park and Ha 2014, Botetzagias *et al* 2015). Individuals with more favorable evaluations of recycling are generally more willing to participate in recycling programs and are more likely to translate these favorable evaluations into behavioral intentions. Meta-analytic evidence likewise confirms that attitude exerts a robust and positive influence on pro-environmental behavioral intentions across different settings (Armitage and Conner 2001). Based on the theoretical assumptions of TPB and the accumulated empirical evidence, the following hypothesis is proposed:

H1. ATR positively influences RI.

2.2.2. SN

The second determinant of behavioral intention within TPB is SN, defined as the perceived social pressure to perform or refrain from a particular behavior (Ajzen 1991). SNs arise from normative beliefs regarding whether important referent individuals or groups, including family members, friends, colleagues, and the broader community, approve or disapprove of performing the behavior. Individuals who perceive stronger social expectations supporting recycling are expected to develop stronger intentions to recycle to maintain social approval and conform to prevailing social norms.

The influence of SNs is particularly relevant in environmental behaviors because recycling frequently occurs within shared social environments where family practices, neighborhood culture, and community expectations shape individual decisions. Previous studies have consistently demonstrated that supportive social norms encourage recycling participation by reinforcing environmentally responsible behavior as socially desirable (Shaw *et al* 2000, Botetzagias *et al* 2015, Wan *et al* 2017). Empirical evidence further suggests that individuals are more likely to express RIs when they perceive that significant others expect them to recycle or when recycling is widely accepted within their social environment (Park and Ha 2014). Although the magnitude of SN has occasionally been reported to be weaker than that of attitude or PBC, it nevertheless remains a significant predictor of RI across numerous empirical studies (Ajzen 1991, Botetzagias *et al* 2015, Wan *et al* 2017). These findings indicate that recycling decisions are influenced not only by personal evaluations but also by perceived social expectations. Accordingly, the following hypothesis is proposed:

H 2. SN positively influences RI.

2.2.3. PBC

The third component of TPB, PBC, refers to individuals' perceptions of their capability and opportunity to perform a particular behavior (Ajzen 1991). The construct reflects both internal factors, such as knowledge, skills, confidence, and self-efficacy, and external factors, including the availability of recycling facilities, accessibility of collection systems, time constraints, and other situational conditions. Individuals who believe that recycling is convenient, feasible, and within their personal control are expected to develop stronger intentions to recycle. Among the three TPB constructs, PBC has received particular attention in recycling research because environmental behaviors often depend on the availability of external infrastructure and practical opportunities. Even individuals with favorable attitudes toward recycling may fail to develop strong behavioral intentions if they perceive recycling facilities as inaccessible or the recycling process as inconvenient (Chen and Tung 2009). Consequently, PBC captures an important dimension of behavioral feasibility that extends beyond personal attitudes and social expectations.

Previous empirical studies have consistently shown that PBC is one of the strongest determinants of RI. Research in household recycling, electronic waste recycling, battery recycling, and other environmental contexts has shown that individuals with higher perceived control have significantly higher intentions to recycle (Chen and Tung 2009, Dong and Hua 2018, Lou *et al* 2022). Furthermore, TPB-based studies have shown that improvements in the ease and accessibility of recycling infrastructure strengthen PBC, thereby increasing individuals' willingness to engage in recycling behaviors (Chen and Tung 2009, Lou *et al* 2022). Based on TPB and previous empirical findings, the following hypothesis is proposed:

H3. PBC positively influences RI.

2.3. The moral pathway: NAM

In contrast to the rational perspective represented by the TPB, the NAM explains pro-environmental behavior primarily through moral obligation and personal responsibility. Originally developed by Schwartz (1973, 1977) to explain prosocial behavior, NAM proposes that individuals do not necessarily act because they expect favorable personal outcomes or deliberately evaluate costs and benefits. Instead, prosocial and environmentally responsible actions may arise from an internalized sense of moral obligation. In the context of recycling, this perspective suggests that individuals may intend to recycle because they perceive it as the morally appropriate course of action, irrespective of immediate personal benefits.

The central motivational construct within NAM is PN, defined as an individual's internalized feeling of moral obligation to perform a particular behavior (Schwartz 1977). However, PNs are not assumed to emerge independently. Rather, NAM describes a sequential activation process in which individuals first become aware of the consequences associated with their behavior, subsequently ascribe responsibility for those consequences to themselves, and consequently develop PNs that motivate environmentally responsible action. Accordingly, the present study represents the moral pathway as a sequential process involving AC, AR, PN, and RI: AC $\rightarrow$ AR $\rightarrow$ PN $\rightarrow$ RI.

2.3.1. AC

AC refers to the extent to which individuals recognize that their actions or failure to act may generate adverse consequences for other people, society, or the natural environment (Schwartz 1977). In the context of recycling, AC reflects recognition of the environmental consequences associated with improper waste disposal, resource depletion, pollution, and related environmental problems. Such awareness constitutes the initial stage of norm activation because individuals must first recognize that environmentally harmful consequences exist before considering their own responsibility for preventing or reducing them.

Previous research has demonstrated the importance of consequence awareness in pro-environmental decision-making. Hunecke *et al* (2001) found that greater awareness of environmental consequences was associated with stronger pro-environmental orientations, while Wan *et al* (2017) reported that recognition of the adverse consequences of inadequate waste management was related to RI. More recent applications of NAM similarly emphasize AC as an important antecedent within the moral activation process (Nketiah *et al* 2022, Pham *et al* 2023). Within the sequential logic of NAM, however, recognizing environmental consequences is expected first to promote the attribution of personal responsibility for those consequences. Accordingly, the following hypothesis is proposed:

H4. AC positively influences AR.

2.3.2. AR

AR refers to the extent to which individuals attribute responsibility to themselves for the consequences associated with their behavior and perceive that their own actions can contribute to preventing or reducing undesirable outcomes (Schwartz 1977). In recycling contexts, individuals with stronger AR are more likely to perceive waste reduction and environmental protection as matters to which their own behavior contributes, rather than viewing such responsibilities exclusively as obligations of governments, industries, or other members of society.

Within NAM, the recognition of adverse consequences alone is insufficient to activate a strong PN unless individuals also accept some degree of personal responsibility for those consequences. AR therefore represents the psychological link between awareness of an environmental problem and the development of moral obligation. Previous environmental research has supported the role of personal responsibility in strengthening pro-environmental norms and intentions (Schwartz 1977, Wan *et al* 2017, Nketiah

et al 2022). Individuals who perceive themselves as personally responsible for environmental protection should consequently experience a stronger moral obligation to recycle. Therefore:

H5. AR positively influences PN.

2.3.3. PN

PN represents the central motivational component of NAM and refers to an individual's internalized sense of moral obligation or ethical responsibility to perform a particular behavior (Schwartz 1977). Unlike attitude, which reflects a favorable or unfavorable evaluation of a behavior, or SN, which reflects perceived social expectations, PN originates from an individual's own moral standards. Individuals with strong PNs toward recycling therefore intend to recycle because they believe that doing so is personally and morally appropriate rather than simply socially desirable or instrumentally advantageous.

The importance of PNs in explaining pro-environmental intentions has been widely demonstrated. Chan and Bishop (2013) showed that moral norms provide an important motivational dimension beyond the conventional TPB constructs, while Bamberg and Möser (2007) identified PNs as an important determinant of pro-environmental intentions. More recent NAM-based research has similarly reported significant relationships between PNs and sustainability-related intentions, including waste-management and recycling behaviors (Nketiah *et al* 2022, Pham *et al* 2023). Accordingly, individuals who experience a stronger personal moral obligation to recycle are expected to report stronger RIs. Therefore:

H6. PN positively influences RI.

2.4. Rational and moral pathways: conceptual framework and research questions

The preceding sections indicate that the TPB and the NAM provide theoretically distinct explanations of RI. TPB conceptualizes intention primarily as the outcome of reasoned evaluation, whereas NAM emphasizes the activation of moral obligation. From the TPB perspective, individuals are expected to develop stronger RIs when they evaluate recycling favorably, perceive social support for the behavior, and believe that they possess sufficient opportunities and control to perform it (Ajzen 1991). RI is therefore understood as emerging from a deliberative process involving behavioral evaluation, perceived social expectations, and PBC.

In contrast, NAM explains environmentally responsible behavior through a sequential moral activation process. Individuals first become aware of the environmental consequences associated with their behavior, subsequently ascribe responsibility for those consequences to themselves, and consequently develop PNs that motivate environmentally responsible action (Schwartz 1977). Applied to recycling, this process implies a theoretically ordered pathway from AC to AR, PN, and ultimately RI. Thus, whereas TPB emphasizes reasoned behavioral evaluation, NAM emphasizes the progressive activation of personal moral obligation.

Despite these conceptual differences, previous research has more commonly combined constructs from TPB and NAM than directly compared the explanatory structures proposed by the two theories. In particular, moral constructs—most notably PNs—have frequently been incorporated into TPB-based models to improve the prediction of pro-environmental intentions (Bamberg and Möser 2007, Chan and Bishop 2013, Wan *et al* 2017). Other studies have similarly combined cognitive and moral determinants within broader integrative frameworks (Nketiah *et al* 2022, Pham *et al* 2023). Although such approaches have contributed substantially to understanding pro-environmental behavior, they provide more limited evidence concerning how the theoretically distinct TPB and NAM pathways perform when their original structural logic is explicitly retained and compared. Consequently, it remains important to examine whether RI is better explained by the reasoned pathway represented by TPB, the sequential moral pathway proposed by NAM, or a model in which both theoretical pathways operate simultaneously.

To address this question, the present study adopts a comparative theory-testing framework in which TPB and NAM are evaluated both separately and jointly, together with a parsimonious AC → RI benchmark. The specific structural specifications are described in section 3.6 and visually summarized in figure 1.

Accordingly, the comparative analysis is guided by the following research questions:

RQ1. To what extent does the TPB explain RI?

RQ2. To what extent does the theoretically sequential NAM explain RI?

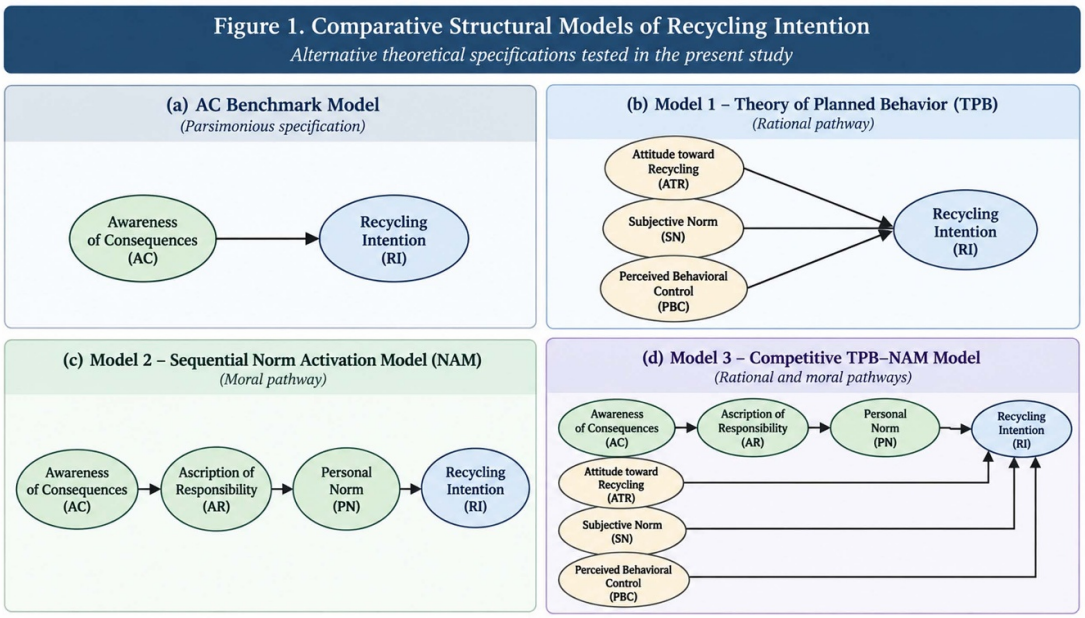

Figure 1. Comparative structural framework of the study. The AC benchmark model estimates the direct association between Awareness of Consequences and Recycling Intention. Model 1 represents the Theory of Planned Behavior (TPB), Model 2 represents the sequential Norm Activation Model (NAM; AC → AR → PN → RI), and Model 3 represents the competitive TPB–NAM specification in which the sequential NAM pathway is retained while Attitude toward Recycling, Subjective Norm, and Perceived Behavioral Control simultaneously predict Recycling Intention.

RQ3. Does a competitive TPB–NAM model that retains the sequential structure of NAM while simultaneously incorporating the TPB predictors provide a more adequate explanation of RI than either theoretical model considered separately?

3. Method

3.1. Research design

The present study employed a quantitative, cross-sectional survey design to compare two prominent theoretical perspectives on RI: the TPB and the NAM. Unlike studies that primarily extend one behavioral framework by incorporating selected constructs from another, the present research adopted a comparative theory-testing approach in which TPB and NAM were examined as theoretically distinct psychological pathways underlying RI. This design enabled the reasoned pathway represented by TPB and the sequential moral pathway proposed by NAM to be evaluated within a common analytical framework.

Covariance-based structural equation modeling (CB-SEM) was selected as the principal analytical approach because the primary objective was to evaluate theoretically specified relationships among latent constructs rather than to develop a prediction-oriented model. CB-SEM enables the simultaneous assessment of measurement quality and structural relationships while explicitly accounting for measurement error (Hair *et al* 2010, Kline 2023). It is therefore well suited to the evaluation of alternative theoretically specified structural models using global model fit, standardized parameter estimates, explained variance, and the admissibility of estimated solutions.

The empirical analyses proceeded in two stages. First, confirmatory factor analysis (CFA) was conducted to evaluate the measurement model. The structural specifications were then examined using CB-SEM, as described in detail in section 3.6. This analytical strategy allowed the empirical performance of the reasoned and moral pathways to be evaluated without presupposing that either framework, or their simultaneous representation, would provide a superior explanation of RI.

3.2. Participants and procedure

The study was conducted with undergraduate students enrolled at six public universities across five cities in Türkiye during the 2025–2026 academic year. A non-probability convenience sampling strategy was employed because participation was voluntary and eligible students were recruited through institutional communication channels at the participating universities. This sampling approach was consistent with the study's primary objective of examining theoretically specified relationships among latent constructs

Table 1. Demographic Characteristics of the Participants ($N = 1832$).

Characteristic	Category	*n*	%
Gender	Female	1301	71.0
	Male	531	29.0
Age	19 years	288	15.7
	20 years	345	18.8
	21 years	345	18.8
	22 years	292	15.9
	23 years	231	12.6
	24 years	331	18.1
Year of study	First year	497	27.1
	Second year	429	23.4
	Third year	424	23.1
	Fourth year	420	22.9
	Fifth year	52	2.8
	Sixth year	10	0.5
Monthly income	<100 USD	341	18.6
	100–150 USD	467	25.5
	150–200 USD	251	13.7
	200–250 USD	236	12.9
	250–300 USD	160	8.7
	>300 USD	377	20.6
Place of residence	City	972	53.1
	District	568	31.0
	Village	292	15.9
Academic discipline	Education	1120	61.1
	Economics and Administrative Sciences	201	11.0
	Health Sciences	195	10.6
	Engineering	89	4.9
	Law	55	3.0
	Theology	44	2.4
	Other	127	6.9

rather than estimating population parameters (Hair *et al* 2010). Nevertheless, the use of a university-based convenience sample limits the extent to which the findings can be generalized beyond the population represented in the study.

Prior to the main survey, the questionnaire was pilot-tested with 42 undergraduate students to assess the clarity, comprehensibility, and administration of the instrument. Based on participant feedback, minor editorial revisions were made to improve item wording and readability, while the conceptual content and measurement structure of the questionnaire remained unchanged (Yorek *et al* 2010). The final questionnaire was subsequently administered online to students at the participating universities.

A total of 1832 valid questionnaires were obtained and retained for analysis. The sample size was considered adequate for the planned CFA and CB-SEM procedures (Hair *et al* 2010, Kline 2023). As shown in table 1, the sample was predominantly female, reflecting an uneven gender distribution that should be considered when interpreting the findings. More broadly, because the participants were undergraduate students from public universities in Türkiye, the results should be interpreted within the demographic, educational, and cultural context of the sample rather than assumed to represent the wider population.

University students were selected as the target population because they constitute a relevant group for examining RI and its psychological antecedents, including environmental awareness, moral obligation, attitudes, social expectations, and PBC. As future professionals, consumers, and decision-makers, they also represent an important population for understanding emerging patterns of environmentally responsible behavior. Participation was voluntary and anonymous. Before completing the questionnaire, participants were informed about the purpose of the study, the voluntary nature of participation, the confidentiality of their responses, and their right to withdraw at any time without penalty. Electronic informed consent was obtained from all participants prior to data collection. The demographic characteristics of the participants are presented in table 1.

3.3. Measures

The questionnaire consisted of two sections. The first section collected demographic information, including gender, age, year of study, monthly income, place of residence, and academic discipline. The second section comprised 28 items measuring the seven latent constructs included in the theoretical framework: ATR, SN, PBC, AC, AR, PN, and RI. Each construct was initially measured using four items. All items were rated on a five-point Likert scale ranging from 1 (*Strongly Disagree*) to 5 (*Strongly Agree*), with higher scores indicating higher levels of the corresponding construct.

The measurement instrument was assembled and refined through a systematic multi-stage process. An initial item pool was developed on the basis of an extensive review of the recycling, TPB, and NAM literature, with items adapted, where appropriate, from previously validated measures. Items assessing ATR, SN, PBC, and RI were primarily drawn from the TPB literature, including Ajzen (1991), Tonglet *et al* (2004), Arli *et al* (2020), and Fan and Ye (2024). Items assessing AC, AR, and PN were adapted from the NAM literature, particularly Schwartz (1977), Chan and Bishop (2013), Arli *et al* (2020), and Fan and Ye (2024).

The preliminary questionnaire was reviewed by eight experts in environmental education, educational sciences, and measurement and evaluation. The experts evaluated the items in terms of clarity, relevance, representativeness, and consistency with their intended constructs (Ugulu *et al* 2008). Minor wording revisions were made on the basis of their evaluations while preserving the conceptual meaning of the items. Following expert review, the instrument was pilot-tested as described in section 3.2; no changes to its conceptual or measurement structure were required. The finalized questionnaire therefore retained the original 28-item, seven-construct structure. A complete list of the measurement items, their corresponding constructs, and original sources is provided in Table SM1 in the Supplementary Material.

3.4. Preliminary analyses

Before model estimation, the dataset was screened for missing values and univariate normality to evaluate its suitability for CB-SEM. Missing values were examined to assess data completeness. Univariate normality was evaluated using skewness and kurtosis statistics. Following the recommendations of Hair *et al* (2010) and Kline (2023), skewness values within ± 3 and kurtosis values within ± 10 were considered indicative of acceptable univariate normality for maximum likelihood estimation.

3.5. Measurement model

The measurement model was evaluated using CFA with maximum likelihood estimation within the CB-SEM framework. The assessment focused on indicator reliability, internal consistency reliability, convergent validity, discriminant validity, and overall model fit.

Internal consistency reliability was evaluated using Cronbach's alpha (α) and McDonald's omega (ω). Convergent validity was assessed using standardized factor loadings and average variance extracted (AVE). Reliability coefficients of 0.70 or higher and AVE values of at least 0.50 were considered indicative of satisfactory measurement quality, while factor loadings were evaluated together with the overall reliability and convergent validity of the corresponding construct (Hair *et al* 2010). Where necessary, measurement-model refinement was guided by indicator performance, model diagnostics, and theoretical plausibility. Residual covariances were considered only between indicators belonging to the same construct when shared wording or item-specific content provided a substantive justification.

Discriminant validity was assessed primarily using the heterotrait–monotrait ratio of correlations (HTMT). Following Henseler *et al* (2015), HTMT values below 0.85 were regarded as evidence of satisfactory discriminant validity, whereas higher values were interpreted as indicating substantial empirical overlap between the corresponding latent constructs. Latent correlations and the admissibility of the latent covariance matrix were also examined when evaluating construct distinctiveness.

Overall model fit was assessed using the chi-square statistic (χ^2), the chi-square to degrees of freedom ratio (χ^2/df), the Comparative Fit Index (CFI), the Tucker–Lewis Index (TLI), the root mean square error of approximation (RMSEA), and the standardized root mean square residual (SRMR). These indices were considered jointly rather than relying on any single criterion when evaluating the adequacy of the measurement model (Hair *et al* 2010, Kline 2023).

3.6. Structural model comparison

Following evaluation of the measurement model, three principal structural models were estimated using CB-SEM with maximum likelihood estimation. The models were specified to compare the reasoned pathway represented by the TPB, the sequential moral pathway proposed by the NAM, and a competitive

specification in which both theoretical pathways were represented simultaneously. In addition, a parsimonious AC benchmark model was estimated as a reference specification. The structural specifications examined in the primary analyses are visually compared in figure 1.

The structural models were evaluated using the goodness-of-fit indices described for the measurement model, together with standardized path coefficients (β), their statistical significance, and the proportion of explained variance (R^2) in endogenous constructs. Model admissibility was also explicitly examined, including the presence of negative latent variances, standardized coefficients outside plausible bounds, and problems in the latent covariance structure. Because the specifications differed in structural complexity and, in some cases, in the latent variables included, model fit indices and R^2 values were interpreted comparatively but not as stand-alone evidence of theoretical superiority. Instead, conclusions were based on the joint consideration of model fit, parameter stability, explained variance, theoretical consistency, and statistical admissibility.

4. Results

4.1. Preliminary data screening

Prior to the main analyses, the dataset was examined for missing values and the assumption of univariate normality. No missing values were identified, and all 1832 questionnaires were retained for subsequent analyses. Descriptive statistics indicated that skewness values ranged from −1.97 to 0.48, whereas kurtosis values ranged from −1.72 to 5.55. These values were within the recommended thresholds for maximum likelihood estimation, indicating that the assumption of univariate normality was adequately satisfied. Therefore, the dataset was considered suitable for subsequent CFA and SEM.

4.2. Measurement model assessment

The measurement model was evaluated using CFA with maximum likelihood estimation. During model refinement, three indicators (SN4, PBC4, and PN2) were removed because of inadequate psychometric performance. In addition, four theoretically justified residual covariances (AR1–AR2, ATR1–ATR2, ATR3–ATR4, and RI1–RI2) were specified to account for shared item-specific variance between similarly worded indicators within the same latent construct. These modifications were restricted to indicators of the same construct and did not alter the conceptual structure of the measurement model.

The final measurement model consisted of seven latent constructs measured by 25 observed indicators and showed broadly acceptable global fit to the data ($\chi^2 = 2481.00$, df = 250, $p < .001$, $\chi^2/\text{df} = 9.92$, CFI = 0.924, TLI = 0.908, SRMR = 0.060, RMSEA = 0.070, 95% CI [0.067, 0.072]). Although the chi-square statistic was statistically significant and the χ^2/df ratio was relatively high, these indices are sensitive to large sample sizes. Taken together, the CFI, TLI, RMSEA, and SRMR indicated broadly acceptable global fit. However, the measurement solution also exhibited limitations in the latent covariance structure, as discussed below.

All freely estimated factor loadings were statistically significant ($p < .001$), and standardized loadings ranged from 0.570–0.898. Most loadings exceeded 0.60, indicating generally satisfactory relationships between the observed indicators and their intended latent constructs. Detailed standardized factor loadings for all retained indicators are provided in Table SM2 in the Supplementary Material.

Internal consistency and convergent validity were evaluated using Cronbach's alpha (α), McDonald's omega (ω), and AVE. Reliability coefficients indicated generally acceptable internal consistency across the constructs, although the omega estimates for ATR were marginally below 0.70. AVE values exceeded 0.50 for AC, PN, SN, and PBC, whereas AR, ATR, and RI showed AVE values below 0.50. Accordingly, convergent-validity evidence was stronger for AC, PN, SN, and PBC and comparatively weaker for AR, ATR, and RI. Construct-level reliability and AVE statistics are also reported in Table SM2.

Discriminant validity was examined using the HTMT together with the latent correlation structure. Although several construct pairs exhibited acceptable HTMT values, elevated values were observed among AR, PN, ATR, SN, and PBC, indicating substantial empirical overlap among these constructs. Consistent with this pattern, the latent covariance matrix was non-positive definite, raising concerns regarding the empirical separability of several theoretically distinct constructs. These findings were therefore treated as a substantive measurement limitation rather than as evidence of full discriminant validity. Nevertheless, the constructs were retained because they represent theoretically distinct components of the TPB and NAM and were required for testing the prespecified theoretical models. Accordingly, subsequent structural analyses were interpreted cautiously, with particular attention to model admissibility, parameter stability, and the effects of substantial shared variance among the latent constructs. The implications of this construct overlap are considered further in the Discussion.

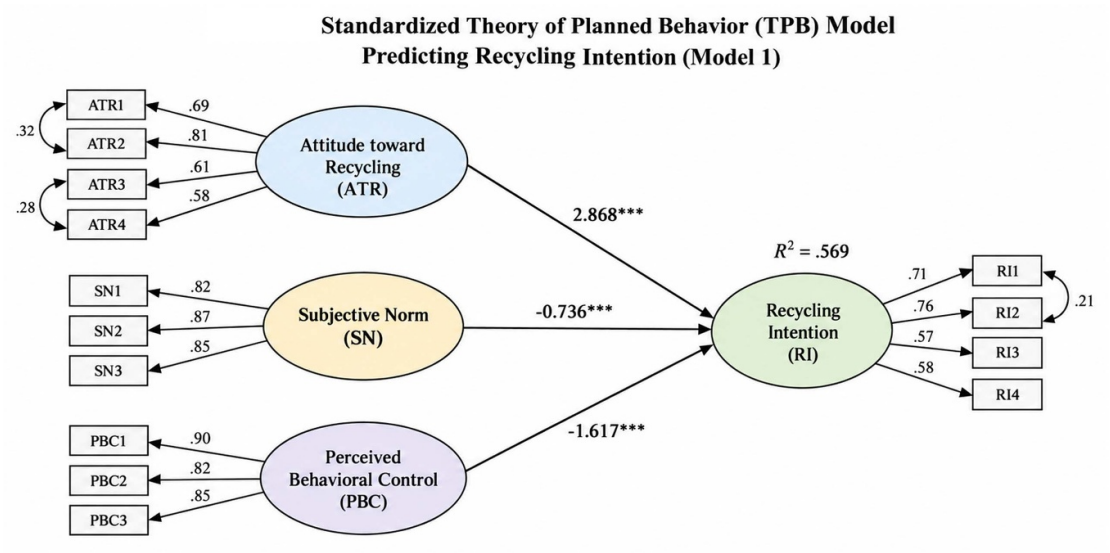

Figure 2. Standardized structural model of the TPB showing the measurement and structural components. **Note.** Standardized estimates are shown. All structural paths were statistically significant at $p < .001$. The model produced a non-positive definite latent covariance matrix, and several standardized structural coefficients exceeded conventional bounds; therefore, the path coefficients should be interpreted cautiously and not as conventional effect-size estimates. For visual clarity, only the TPB constructs and their structural paths to RI are displayed; the full seven-construct measurement specification established in the CFA was retained during estimation.

4.3. Structural model assessment

4.3.1. Model 1 (TPB)

Model 1 evaluated the TPB specification in which ATR, SN, and PBC were specified as direct predictors of RI. The full seven-construct measurement specification established in the CFA was retained, while only ATR, SN, and PBC were specified as structural predictors of RI. The model yielded $\chi^2 = 2670.00$, df = 253, $p < .001$, $\chi^2/df = 10.55$, CFI = 0.917, TLI = 0.902, SRMR = 0.062, and RMSEA = 0.072, 95% CI [0.070, 0.075]. The three TPB predictors collectively accounted for 56.9% of the variance in RI ($R^2 = 0.569$).

The standardized structural estimates were positive for ATR ($\beta = 2.868$, $p < .001$) and negative for SN ($\beta = -0.736$, $p < .001$) and PBC ($\beta = -1.617$, $p < .001$). However, the model produced a non-positive definite latent covariance matrix, and the absolute values of several standardized coefficients exceeded unity. Accordingly, despite the broadly acceptable global fit indices and substantial explained variance, the structural solution was not considered statistically admissible. The anomalous coefficients are consistent with the substantial empirical overlap among ATR, SN, and PBC identified in the measurement model and indicate severe shared variance and suppression when the three predictors are entered simultaneously.

The negative coefficients for SN and PBC were not attributable to reverse coding or indicator directionality. All retained TPB indicators were coded in the theoretically intended direction, and their CFA loadings were positive and statistically significant. Thus, the unexpected signs are more plausibly interpreted in the context of the high overlap among the latent predictors than as coding artifacts. Although the positive direction of the ATR–RI coefficient was consistent with H1, its magnitude should not be interpreted as a conventional effect size because of the inadmissible solution. The observed negative coefficients did not support the hypothesized positive relationships specified in H_2 and H3. Overall, the TPB model therefore provided descriptive evidence of substantial explained variance in RI, but its individual structural coefficients require considerable caution. Figure 2 presents the standardized estimates for Model 1.

4.3.2. Model 2 (NAM)

Model 2 evaluated the theoretically sequential structure of the NAM, specifying the pathway AC → AR → PN → RI. The measurement specification established in the CFA was retained, including the removal of PN2 and the correlated residuals between AR1–AR2 and RI1–RI2.

The model converged successfully but showed suboptimal overall fit ($\chi^2 = 1331.00$, df = 85, $p < .001$, $\chi^2/df = 15.66$, CFI = 0.905, TLI = 0.883, SRMR = 0.098, RMSEA = 0.089, 95% CI [0.085, 0.094]). In addition, the solution produced a slightly negative residual variance for PN (−0.00024)

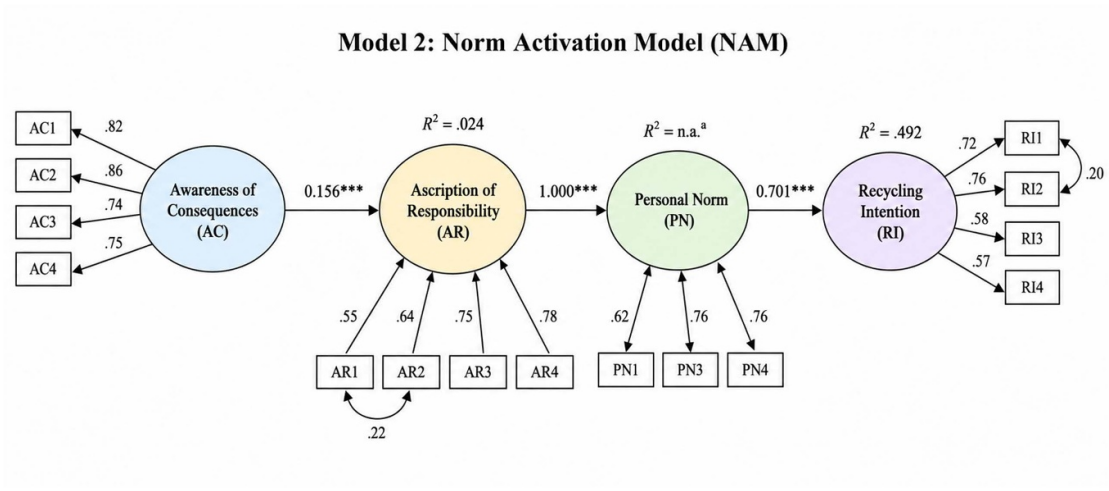

Figure 3. Standardized sequential Norm Activation Model (NAM) predicting recycling intention. **Note.** Standardized path coefficients (β) are shown. All structural paths were statistically significant at $p < .001$. Correlated residuals were specified between AR1–AR2 and RI1–RI2. R^2 for PN is not reported because its residual variance was estimated at a slightly negative boundary value, indicating an inadmissible/boundary solution.

and a near-unit standardized path from AR to PN, indicating a boundary or inadmissible solution. Accordingly, the structural estimates were interpreted cautiously.

The standardized path from AC to AR was positive and statistically significant (AC → AR: $\beta = 0.156$, $p < .001$). AR was also positively associated with PN (AR → PN: $\beta = 1.000$, $p < .001$), while PN showed a positive association with RI (PN → RI: $\beta = 0.701$, $p < .001$). The model explained 2.4% of the variance in AR ($R^2 = 0.024$) and 49.2% of the variance in RI ($R^2 = 0.492$). An interpretable R^2 value for PN was not obtained because its residual variance was estimated at the boundary.

Although the directions of the three structural paths were consistent with H4, H5, and H6, the near-unit AR → PN coefficient and the negative PN residual variance preclude treating these estimates as robust evidence of the hypothesized sequential NAM mechanism. The results therefore indicate that the theoretically specified NAM sequence could be estimated, but its empirical representation in the present data was not statistically admissible. Figure 3 presents the standardized structural estimates for Model 2.

4.3.3. Model 3: competitive TPB–NAM model

Model 3 evaluated the competitive TPB–NAM specification in which the sequential NAM pathway (AC → AR → PN → RI) was retained while ATR, SN, and PBC were simultaneously specified as direct predictors of RI. The measurement specification established in the CFA was retained, including the removal of PN2, SN4, and PBC4 and the correlated residuals between AR1–AR2, ATR1–ATR2, ATR3–ATR4, and RI1–RI2.

Although the model converged, its overall fit was unsatisfactory ($\chi^2 = 4504.00$, df = 259, $p < .001$, χ^2/df = 17.39, CFI = 0.855, TLI = 0.832, SRMR = 0.239, RMSEA = 0.095, 95% CI [0.092, 0.097]). The model accounted for 73.9% of the variance in RI ($R^2 = 0.739$); however, this relatively high explained variance should not be interpreted as evidence of superior explanatory performance because the structural solution was statistically inadmissible.

Within the sequential NAM pathway, AC positively predicted AR ($\beta = 0.113$, $p < .001$), AR strongly predicted PN ($\beta = 1.003$, $p < .001$), and PN positively predicted RI ($\beta = 0.544$, $p < .001$). Among the TPB predictors, ATR showed an extremely large positive coefficient ($\beta = 9.700$, $p < .001$), whereas SN ($\beta = -3.470$, $p = .004$) and PBC ($\beta = -6.235$, $p = .001$) showed large negative coefficients. These estimates fall well outside the range expected for stable standardized structural coefficients and should therefore not be interpreted as conventional effect sizes.

Several diagnostics confirmed the inadmissibility of the solution. The residual variance of PN was slightly negative (−0.00167), the standardized AR → PN coefficient exceeded unity, and the TPB predictors exhibited extremely high latent correlations (ATR–SN = 0.969, ATR–PBC = 0.989, and SN–PBC = 0.930). These findings indicate severe empirical overlap and suppression among the predictors, consistent with the discriminant-validity concerns identified in the measurement model. Accordingly, neither the large standardized coefficients nor the R^2 value for RI provide reliable evidence of the relative contribution of the rational and moral pathways.

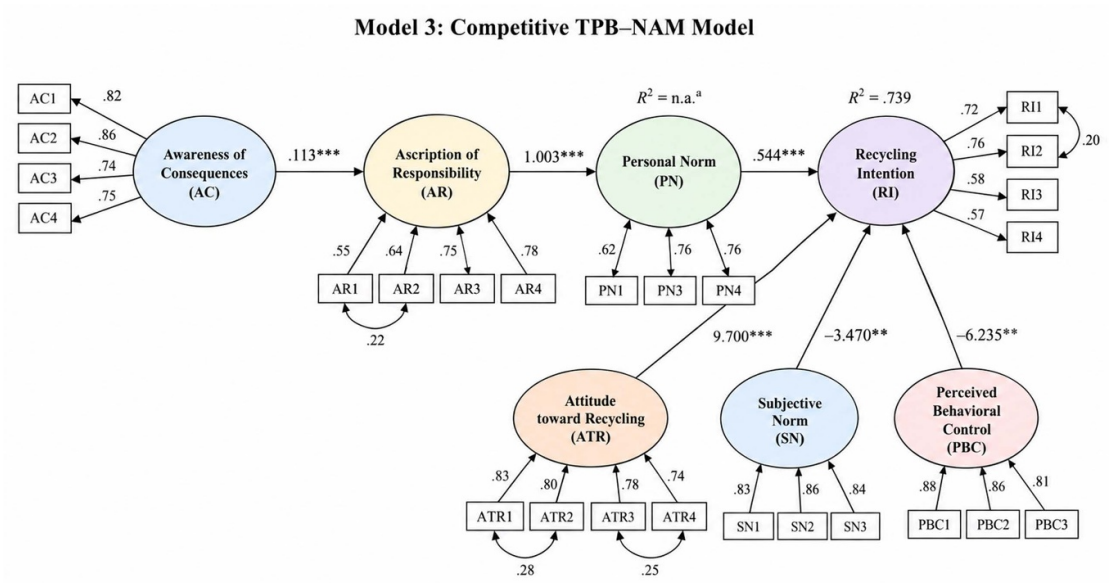

Figure 4. Standardized competitive TPB–NAM model predicting recycling intention. **Note.** Standardized path coefficients (β) are shown. $^{**}p < .01$; $^{***}p < .001$. Correlated residuals were specified between AR1–AR2, ATR1–ATR2, ATR3–ATR4, and RI1–RI2. R^2 for PN is not reported because its residual variance was estimated at a slightly negative boundary value. The model produced an inadmissible solution, including a standardized AR → PN coefficient exceeding unity and extremely large TPB path coefficients; therefore, the structural estimates and R^2 for RI should be interpreted cautiously and not as evidence of model superiority.

Although several structural paths were statistically significant and some were in the hypothesized direction, the inadmissible solution precludes interpreting these results as robust support for the corresponding hypotheses or for the superiority of the combined TPB–NAM specification. Model 3 therefore demonstrates that simultaneously representing the sequential NAM mechanism and the highly overlapping TPB predictors does not yield a stable empirical solution in the present sample. Figure 4 presents the standardized structural estimates for the competitive TPB–NAM model.

4.3.4. AC benchmark model

A parsimonious benchmark model was estimated to examine the direct association between AC and RI. The model specified AC as the sole predictor of RI and retained the correlated residual between RI1 and RI2 identified in the measurement model.

The benchmark model converged without estimation warnings and yielded mixed but generally interpretable fit indices ($\chi^2 = 300.00$, df = 18, $p < .001$, CFI = 0.954, TLI = 0.929, SRMR = 0.053, RMSEA = 0.093, 95% CI [0.083, 0.102]). Although the CFI and SRMR indicated good fit and the TLI was close to conventional acceptability, the RMSEA remained elevated. Accordingly, the model was treated as an admissible parsimonious reference specification rather than as a fully satisfactory theoretical model.

AC showed a positive and statistically significant association with RI ($\beta = 0.581$, $p < .001$) and accounted for 33.7% of the variance in RI ($R^2 = 0.337$). This result indicates that AC alone was strongly associated with RI. However, the benchmark was not intended to compete as an alternative behavioral theory, and its R^2 should therefore be interpreted descriptively rather than as direct evidence of superiority or inferiority relative to the broader TPB and NAM specifications.

Table 2 summarizes the fit indices, explained variance in RI (R^2), and statistical admissibility of the three principal structural models and the parsimonious AC benchmark specification.

5. Discussion

5.1. The TPB accounted for substantial variance but yielded unstable structural estimates

The first objective of the present study was to evaluate the TPB as a representation of the rational psychological pathway underlying RI. The model accounted for 56.9% of the variance in RI, indicating that the TPB constructs collectively captured a substantial proportion of variation in intention. This descriptive result is broadly consistent with previous recycling research in which attitude, SN, and PBC

Table 2. Goodness-of-Fit Indices, Explained Variance, and Admissibility of the Structural Specifications.

Specification	Theoretical representation	χ^2/df	CFI	TLI	RMSEA	SRMR	R^2 (RI)	Interpretation
Model 1	TPB	10.55	0.917	0.902	0.072	0.062	0.569	Inadmissible
Model 2	Sequential NAM	15.66	0.905	0.883	0.089	0.098	0.492	Inadmissible/boundary solution
Model 3	Competitive TPB–NAM	17.39	0.855	0.832	0.095	0.239	0.739	Inadmissible
AC benchmark	AC → RI	16.67	0.954	0.929	0.093	0.053	0.337	Admissible

Note. TPB = Theory of Planned Behavior; NAM = Norm Activation Model; AC = Awareness of Consequences; RI = Recycling Intention; CFI = Comparative Fit Index; TLI = Tucker–Lewis Index; RMSEA = Root Mean Square Error of Approximation; SRMR = Standardized Root Mean Square Residual. Model 1 produced a non-positive definite latent covariance matrix and standardized coefficients exceeding conventional bounds. Model 2 yielded a slightly negative residual variance for Personal Norm (PN) and a near-unit AR → PN coefficient. Model 3 yielded a slightly negative PN residual variance, an AR → PN coefficient exceeding unity, and extreme standardized TPB coefficients associated with very high latent predictor correlations. The AC benchmark converged without estimation warnings and was statistically admissible, although its global fit was mixed. R^2 values are presented descriptively and should not be interpreted independently as evidence of theoretical or model superiority.

have been associated with RIs (Ajzen 1991, Park and Ha 2014, Botetzagias *et al* 2015, Wan *et al* 2017). However, the explained variance should not be interpreted as evidence that the TPB was empirically confirmed in the present study because the structural solution was statistically inadmissible.

Specifically, ATR showed a large positive standardized coefficient, whereas SN and PBC exhibited negative coefficients that were contrary to their hypothesized positive relationships. Several standardized coefficients also exceeded conventional bounds, and the model produced a non-positive definite latent covariance matrix. These results indicate substantial empirical overlap among the TPB predictors and instability in their unique structural estimates. Importantly, the unexpected negative coefficients were not attributable to reverse coding or indicator directionality; the retained indicators were coded consistently with their theoretical meaning and showed positive, statistically significant factor loadings. The anomalous coefficients are therefore more plausibly attributable to severe shared variance and statistical suppression among the highly correlated latent predictors.

Accordingly, the positive direction of the ATR–RI relationship was consistent with H1, whereas the negative coefficients for SN and PBC did not support H_2 and H3. Nevertheless, even the ATR coefficient should not be interpreted as a conventional effect-size estimate because of the inadmissible covariance structure. The findings therefore do not provide reliable evidence that the three TPB constructs exert distinct independent effects on RI. Rather, they suggest that, in the present sample, attitude, SN, and PBC were empirically difficult to separate when entered simultaneously as predictors. Such instability is consistent with structural equation models in which conceptually related latent variables share substantial variance (Hair *et al* 2010, Kline 2023).

From the perspective of the comparative framework adopted in this study, Model 1 therefore provides evidence that the reasoned pathway is associated with substantial explained variance at the aggregate level, while also revealing important limitations in estimating the unique contribution of its constituent constructs. This distinction is critical for the subsequent comparison with the sequential NAM and competitive TPB–NAM specifications: differences in R^2 or global fit cannot be interpreted as evidence of theoretical superiority without also considering parameter stability, construct distinctiveness, and model admissibility.

5.2. The sequential NAM was theoretically consistent but empirically unstable

The second objective of the present study was to evaluate the NAM in its theoretically sequential form. Consistent with the original formulation of NAM, Model 2 specified a progression from AC to AR, from AR to PN, and from PN to RI (AC → AR → PN → RI). This specification directly reflects the norm-activation process proposed by Schwartz (1977), according to which awareness of adverse consequences activates a sense of personal responsibility, which in turn strengthens personal moral obligations and ultimately motivates pro-environmental intention.

At the level of individual structural paths, all three associations were positive and statistically significant. AC positively predicted AR, AR strongly predicted PN, and PN positively predicted RI. The model also accounted for 49.2% of the variance in RI. These results indicate that the observed associations were directionally consistent with the theoretical sequence proposed by NAM and with previous research emphasizing the role of moral obligation and responsibility in pro-environmental decision-making (Schwartz 1977, Bamberg and Möser 2007, Chan and Bishop 2013).

However, the structural solution was not statistically admissible. The AR → PN coefficient was approximately unity, and the residual variance of PN was estimated at a slightly negative value. In addition, overall model fit was only moderate to weak, particularly with respect to TLI, RMSEA, and SRMR. These features indicate that AR and PN were empirically difficult to distinguish within the sequential specification. Accordingly, the statistically significant path coefficients cannot be interpreted as robust confirmation of H4–H6, because their magnitudes were obtained within a boundary solution characterized by insufficient empirical separation between key moral constructs.

The findings therefore provide only qualified support for the theoretical ordering proposed by NAM. The direction of the estimated relationships was consistent with the expected activation sequence, but the model did not yield a stable empirical representation of that process in the present sample. This distinction is important because statistical significance alone does not establish the validity of a structural mechanism when the solution itself is inadmissible. Rather than rejecting NAM as a theoretical framework, the results suggest that the constructs of AR and PN may have been too strongly overlapping in this sample to support a clearly differentiated sequential pathway. This measurement and structural overlap becomes particularly important when the moral pathway is estimated alongside the TPB constructs in the competitive model examined next.

5.3. The competitive TPB–NAM model revealed substantial construct overlap rather than clear complementarity

The third objective of the present study was to examine whether the rational and moral pathways could be represented simultaneously within a competitive structural framework. Model 3 retained the sequential NAM pathway (AC → AR → PN → RI) while simultaneously specifying ATR, SN, and PBC as direct predictors of RI. In descriptive terms, the model accounted for 73.9% of the variance in RI, which was higher than the variance explained by either the TPB or sequential NAM model considered separately. However, this increase in R^2 cannot be interpreted as evidence that the combined model provided a superior or more comprehensive explanation of RI because the structural solution was statistically inadmissible.

The source of this instability was evident in the parameter estimates. Within the NAM sequence, the AR → PN coefficient exceeded unity, while the residual variance of PN was slightly negative. At the same time, the TPB predictors produced extremely large standardized coefficients, with a strongly positive coefficient for ATR and large negative coefficients for SN and PBC. These anomalous estimates coincided with very high latent correlations among the TPB constructs, particularly between ATR and PBC, indicating severe empirical overlap and suppression. Accordingly, the statistically significant coefficients observed in Model 3 should not be interpreted as stable estimates of the unique psychological effects of the individual constructs.

These findings do not provide empirical support for the claim that TPB and NAM make clearly separable and complementary contributions to RI. Instead, they indicate that several rational and moral constructs were difficult to distinguish empirically when estimated within the same structural system. This pattern is consistent with the discriminant-validity concerns identified in the measurement model and suggests that the increase in explained variance may largely reflect shared psychological variance rather than the addition of distinct explanatory mechanisms. In this sense, the competitive model is more informative about the limits of empirical separability between the two theoretical pathways than about their complementarity.

The findings therefore call for caution in interpreting increases in R^2 as evidence for theoretical integration. Previous studies have often extended TPB by incorporating moral constructs and have interpreted improvements in explained variance as support for broader integrative models (Bamberg and Möser 2007, Chan and Bishop 2013, Wan *et al* 2017). The present results show that such increases should be evaluated together with construct distinctiveness, parameter stability, and model admissibility. In the present sample, the combined TPB–NAM specification did not yield a stable representation of distinct rational and moral influences. Rather than demonstrating that the two pathways are either clearly competing or clearly complementary, the results point to substantial empirical overlap among several of their constituent constructs.

5.4. AC emerged as a parsimonious and stable predictor of RI

The additional benchmark analysis examined whether AC, considered independently of the broader TPB and NAM structures, was associated with RI. Unlike the three principal theoretical models, the AC benchmark produced an admissible solution without estimation warnings. AC showed a substantial positive association with RI ($\beta = 0.581$, $p < .001$) and alone accounted for 33.7% of the variance in intention ($R^2 = 0.337$). Although the overall fit of the benchmark model was mixed, with an elevated

RMSEA despite favorable CFI and SRMR values, the parameter estimate itself was stable and readily interpretable.

This finding reinforces the theoretical relevance of consequence awareness in environmentally responsible decision-making. Within the NAM tradition, awareness that one's actions may have adverse environmental consequences represents an early cognitive condition for the activation of responsibility and personal moral obligation (Schwartz 1977). Previous research has similarly emphasized environmental consequence awareness as an important antecedent of pro-environmental intentions and behavior (Bamberg and Möser 2007, Chan and Bishop 2013). In the present study, however, the importance of AC extended beyond its position within the sequential NAM pathway: when modeled alone, it retained a clear and substantial association with RI without producing the estimation difficulties observed in the more complex structural specifications.

The benchmark should not be interpreted as evidence that AC constitutes a sufficient theoretical explanation of RI or that it supersedes either TPB or NAM. Its explained variance was descriptively lower than that obtained in the broader structural models, which incorporated multiple psychological determinants. More importantly, the models differed in their predictor sets and structural complexity, precluding simple conclusions about theoretical superiority from differences in R^2 or global fit alone. The value of the benchmark instead lies in demonstrating that a comparatively simple specification involving AC and RI could be estimated without the severe construct-overlap and parameter-instability problems observed in the multivariate models.

Taken together with the results of Models 1–3, the benchmark analysis suggests that AC represents one of the clearest empirical signals in the present data. At the same time, the instability of the broader TPB and NAM specifications indicates that the difficulty was not simply a lack of association with RI, but rather the limited empirical separability of several theoretically distinct predictors when modeled simultaneously. Thus, the benchmark provides a useful reference point for distinguishing a stable bivariate association from the substantially more demanding task of establishing distinct multivariate psychological pathways.

5.5. Theoretical implications

The present study offers several theoretical implications for research on RI and pro-environmental decision-making. First, it advances a theory-comparison perspective rather than assuming from the outset that constructs derived from different behavioral theories should be combined into an extended model. The TPB was evaluated as a reasoned pathway, whereas the NAM was tested in its theoretically sequential form (AC $\rightarrow$ AR $\rightarrow$ PN $\rightarrow$ RI). A competitive TPB–NAM specification was then examined while preserving this sequential NAM structure. This approach differs from studies that incorporate selected moral variables directly into TPB and interpret incremental explained variance as evidence for theoretical extension (Bamberg and Möser 2007, Chan and Bishop 2013, Wan *et al* 2017). The findings illustrate the value of evaluating the internal empirical viability of each theoretical pathway before drawing conclusions about their integration.

These conclusions should, however, be interpreted in relation to the characteristics of the study population and the context in which the data were collected. The participants were undergraduate students aged 19–24 from public universities in Türkiye, and the sample was predominantly female. This relatively homogeneous demographic and educational profile may partly help explain the substantial overlap observed among several TPB and NAM constructs, because participants may share similar educational experiences, exposure to environmental information, and institutional settings. This possibility was not directly tested and should therefore be regarded as a contextual interpretation rather than a demonstrated explanation. The national context may also matter, as recycling opportunities, environmental communication, social expectations, and perceptions of personal responsibility can vary across societies. Consequently, the strength and distinctiveness of the relationships observed here may differ in older, less highly educated, more heterogeneous, or culturally different populations. Cross-cultural and population-based replication is therefore needed to determine whether the observed construct overlap and structural instability are characteristic of the theoretical models themselves or partly contingent on the demographic and cultural context of the present sample.

Second, the results challenge the assumption that greater explained variance necessarily indicates stronger theoretical integration. Although the competitive TPB–NAM model accounted for a large proportion of variance in RI, it produced an inadmissible solution characterized by extreme standardized coefficients, a negative residual variance, and very high correlations among several latent predictors. Similarly, the sequential NAM model reproduced the theoretically expected ordering of relationships but yielded a boundary solution because AR and PN were not sufficiently distinguishable empirically. These findings indicate that statistically significant paths and increases in R^2 should not, by themselves,

be interpreted as evidence that theoretically distinct psychological mechanisms make stable and complementary contributions. Theoretical integration requires not only explanatory capacity but also adequate construct distinctiveness, parameter stability, and an admissible structural solution.

Third, the findings draw attention to AC as a theoretically important and empirically comparatively stable component of RI. In the parsimonious benchmark model, AC showed a substantial positive association with RI and accounted for 33.7% of its variance without producing estimation warnings. This does not imply that AC constitutes a sufficient alternative theory of RI or that it supersedes TPB or NAM. Rather, it suggests that awareness of environmental consequences represents a robust psychological signal within the present data, whereas the additional differentiation of closely related moral and reasoned constructs becomes substantially more difficult in multivariate structural models. This distinction may be theoretically important for understanding how relatively general environmental cognitions relate to more differentiated motivational processes.

Finally, the study highlights the importance of empirical separability as a prerequisite for theory comparison and integration. The substantial overlap observed among AR, PN, ATR, SN, and PBC suggests that constructs that are theoretically distinguishable may not always be sufficiently distinct at the measurement level to support stable estimates of their unique structural effects. Consequently, future research integrating established behavioral theories should give greater attention to discriminant validity and model admissibility before interpreting differences in model fit, path significance, or explained variance as evidence of theoretical superiority or complementarity. In this respect, the present study contributes not by identifying a single superior framework, but by demonstrating that meaningful theory comparison requires simultaneous consideration of theoretical coherence, measurement distinctiveness, explanatory performance, and statistical admissibility.

5.6. Practical implications

The findings offer several cautious practical implications for recycling education and communication. The clearest empirical signal in the present study was the association between AC and RI. AC showed a substantial positive association with intention in the parsimonious benchmark model and remained theoretically central to the moral pathway examined in the study. This suggests that recycling initiatives may benefit from helping individuals understand the environmental consequences of waste generation, improper disposal, and low recycling participation, rather than limiting communication to procedural information about how or where to recycle.

For educational institutions, this finding supports the use of learning activities that make the consequences of everyday consumption and waste-management decisions more concrete and personally meaningful. Environmental education programs may, for example, connect individual disposal choices with resource depletion, pollution, waste accumulation, and the potential environmental benefits of recycling. Such approaches may help strengthen awareness of why recycling matters, while avoiding the assumption that information alone will necessarily translate into sustained behavioral change.

The findings provide less secure guidance regarding interventions specifically targeting attitudes, social norms, PBC, responsibility, or PNs. Although these constructs are theoretically relevant to recycling behavior, their substantial empirical overlap in the present study produced unstable structural estimates when they were modeled simultaneously. Consequently, the anomalous coefficients observed for several predictors should not be used to conclude that normative appeals, infrastructure improvements, PBC, or moral responsibility are unimportant intervention targets. Their practical effects cannot be reliably differentiated on the basis of the present structural estimates.

For policymakers, local authorities, and universities, the results therefore favor a cautious evidence-based approach rather than a prescriptive multidimensional intervention derived directly from the combined TPB–NAM model. Increasing awareness of environmental consequences represents the most clearly supported communication target in the present data, whereas broader strategies addressing attitudes, social influence, perceived control, and moral obligation remain theoretically plausible but require further empirical validation with more clearly differentiated measures and, preferably, longitudinal or intervention-based designs. Because the present study examined RI rather than observed recycling behavior, these recommendations should be viewed as implications for program design and future testing rather than as evidence of established intervention effectiveness.

6. Conclusion

The present study compared reasoned and moral explanations of RI by evaluating the TPB, the theoretically sequential NAM, and a competitive TPB–NAM specification, together with a parsimonious AC

benchmark. The findings showed that the TPB, sequential NAM, and competitive TPB–NAM models each captured substantial variance in RI, but all three produced estimation problems associated with strong empirical overlap among several latent constructs. In particular, the sequential NAM yielded a boundary solution, while the competitive model produced poor fit and extreme standardized coefficients despite its high descriptive R^2. These results demonstrate that greater explained variance should not be interpreted as evidence of theoretical superiority or complementarity when construct distinctiveness, parameter stability, and model admissibility are compromised.

In contrast, the parsimonious AC benchmark produced an admissible solution and identified AC as the clearest and most stable empirical correlate of RI in the present data. This finding does not imply that AC alone constitutes a sufficient theory of recycling behavior, but it highlights the importance of consequence awareness while drawing attention to the difficulty of empirically separating closely related reasoned and moral constructs. From a methodological perspective, the findings further demonstrate that theory comparison based on cross-sectional intention data requires particular attention to construct distinctiveness, response variability, and model admissibility, especially when data are obtained from relatively homogeneous samples. Because the present study examined self-reported RIs among undergraduate students from public universities in Türkiye, the observed relationships should not be assumed to represent actual recycling behavior or to generalize directly to broader, more heterogeneous populations. The relatively specific demographic and educational profile of the sample may also have constrained variability in responses and contributed to the empirical overlap observed among several constructs, although this possibility was not directly tested.

Overall, the study suggests that theory comparison in pro-environmental behavior research should move beyond reliance on fit indices and explained variance alone and place greater emphasis on discriminant validity, structural admissibility, and the characteristics of the population and outcome being studied. Future research should therefore combine more clearly differentiated measures with more heterogeneous and cross-cultural samples and, where possible, include observed recycling behavior alongside intention. Longitudinal, experimental, and intervention-based designs would provide a stronger basis for testing whether theoretically distinct reasoned and moral processes can be empirically differentiated and whether their associations with intention translate into actual pro-environmental behavior.

6.1. Limitations and future research

The present study has several limitations that should be considered when interpreting the findings. First, the cross-sectional design precludes causal or temporal inferences regarding the relationships among the psychological constructs. Second, the sample consisted exclusively of undergraduate students from public universities in Türkiye and was predominantly female, limiting the generalizability of the findings to older, less highly educated, more gender-balanced, or culturally different populations. Third, the study relied on self-reported RIs rather than observed recycling behavior; consequently, the findings cannot establish whether the identified associations translate into actual recycling practices.

A further limitation concerns the substantial empirical overlap among several latent constructs, particularly AR, PN, ATR, SN, and PBC. Elevated HTMT values, the non-positive definite latent covariance structure, and the inadmissible solutions obtained in the structural models indicate that some theoretically distinct constructs were not sufficiently differentiated in the present measurement context. This limits the interpretation of their unique structural effects and should be regarded as an important measurement and modeling constraint. Future research should therefore refine the operationalization of these constructs, examine their discriminant validity in more heterogeneous and cross-cultural samples, and test their temporal ordering using longitudinal, experimental, or intervention-based designs. Incorporating observed recycling behavior alongside behavioral intention would also provide a stronger basis for evaluating how rational and moral processes relate to actual pro-environmental action.

Data availability statement

The data cannot be made publicly available upon publication because they are not available in a format that is sufficiently accessible or reusable by other researchers. The data that support the findings of this study are available upon reasonable request from the authors.

Supplementary data 1 available at https://doi.org/10.1088/2515-7620/aeb2ac/data1.

Supplementary data 2 available at https://doi.org/10.1088/2515-7620/aeb2ac/data2.

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Ethical statement

This study was conducted in accordance with established ethical guidelines for research involving human participants, including the principles of the Declaration of Helsinki. Ethical approval was obtained from the Usak University Social and Human Sciences Scientific Research and Publication Ethics Committee (Decision No: 2024-81, dated 04.04.2024). All participants were university students aged between 19 and 24 years and were therefore legally adults. Accordingly, informed consent was obtained directly from the participants, and no parental or guardian consent was required. Participation was voluntary, and participants were informed of their right to withdraw at any stage without any consequences. Confidentiality and anonymity were ensured throughout the study, and all data were used solely for research purposes.

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