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Factors Affecting Contractors' Waste Reduction Behavior in China: An Integrated Theory of Planned Behavior and Norm Activation Model Approach

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Abstract

Construction waste reduction is crucial for conserving resources, protecting the environment, and promoting sustainable development. However, few studies have explored the factors that may prompt construction waste reduction behavior among contractors in the Chinese construction industry. To address this gap, this study aims to examine the psychological drivers of contractors' waste reduction behavior by integrating the Theory of Planned Behavior and the Norm Activation Model. This integrated approach allows for an analysis of motivations from both self-interested and altruistic viewpoints. Survey data were collected from 437 Chinese contractors and analyzed using Statistical Package for the Social Sciences (SPSS) and Analysis of Moment Structures (AMOS) to empirically test the proposed theoretical model. The findings of this study reveal that reduction intention and perceived behavioral control are the most critical drivers of contractors' waste reduction behavior. Subjective norms and personal norms also exert significant influence, with personal norms demonstrating a full mediation effect through reduction intention on behavior. Crucially, government monitoring significantly and positively moderates the relationship between reduction intention and actual behavior. This research not only deepens the theoretical understanding of contractors' waste reduction behavior but, more importantly, provides robust empirical support for developing composite governance strategies that can simultaneously activate contractors' internal norms and external motivations.

Keywords: construction waste reduction; waste reduction behavior; integrated behavioral model; influencing factors; China



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1. Introduction

Against the backdrop of new-type urbanization, the large volume and rapid growth of construction waste generation, coupled with low resource recovery rates, have imposed significant environmental and societal burdens [1]. In response to the growing challenge of construction and demolition waste, zero-waste management has emerged as a systemic strategy for advancing sustainable development and is gaining increasing attention worldwide [2]. Currently, the construction industry generates a substantial amount of construction waste, leading to a severe manifestation of “garbage siege” [3]. Digital and industrialized approaches, such as Building Information Modeling (BIM) and prefabrication technologies, are being widely applied in construction waste reduction practices. Bibliometric analyses indicate that these technologies have become a core theme in zero-waste research [4]. If properly managed, construction waste can be utilized as a resource [5].

Although approximately 80% of construction and demolition waste has high recycling value [6], the recycling rate of construction and demolition waste in China is only 5% [7]. This is considerably lower than the recycling and utilization rates in many developed countries and regions, such as over 90% in South Korea and the European Union [8], an average of 95% in Japan [9], and 67% in Australia [10]. Thus, construction waste generation in the construction industry has become one of the most significant challenges to sustainable development.

This realization has sparked an increasing amount of research to identify the social and psychological processes that underlie waste reduction behavior (WRB) among stakeholders in the construction industry. Li et al. [11] analyzed that the reason why designers have a positive attitude toward reduction and strong behavioral awareness but take little actual action is that they perceive their behavioral control to be low and lack the constraints of standards, regulations, and policies. In 2020, Yang et al. [12] used simulation models to pre-evaluate construction waste management policies and strategies for improving waste reduction effectiveness. They were also the first to use system dynamics to investigate the causal relationships underlying the waste reduction behaviors of construction workers. Sun [13] demonstrated that construction waste reduction (CWR) behavior is significantly influenced by the value views, working conditions, and self-interest of construction workers on the job site, as well as by project authorities' supervision and management. The role of altruistic motivation in the behavioral decision-making process has been largely overlooked in prior research, even though it has employed classical behavioral theories like the Theory of Planned Behavior (TPB) to examine the fundamental causes of reduction behavior [12], motivational factors of willingness to reduce behavior [14], and important determinants of reduction behavior among stakeholders [15]. TPB has been used in studies in sociology, economics, and environmental studies. The Norm Activation Model (NAM) was developed by Schwartz (1977) [16] and has been used extensively to characterize and forecast pro-social behavior on an individual basis. It was a significant discovery made by social psychologists studying altruism. It posits that individuals can be motivated to act altruistically through the activation of personal norms (PN). The decision-making behavior of Chinese construction contractors is characterized by an interplay of self-interested and altruistic motives. As market entities, their behaviors are motivated by economic rationality, which prioritizes cost control and profit maximization. This is consistent with the self-interested perspective of the TPB, namely its elements of personal interest and perceived behavioral control (PBC). At the same time, increased government monitoring (GM), industry standards, and societal expectations have increased their environmental obligations. Consequently, altruistic elements like environmental ideals and a sense of social responsibility also have an impact on their behavior with regard to reducing construction waste. This precisely falls within the explanatory domain of the NAM. However, a single theoretical framework struggles to fully elucidate their complex decision-making mechanisms: TPB may underestimate the influence of moral motives, whereas NAM tends to overlook real-world economic constraints. Therefore, an integrated approach incorporating both perspectives is necessary for a more accurate understanding of contractors' behavioral logic under the dual pressures of economic efficiency and environmental responsibility. In order to provide policymakers and construction companies with a reference for decision-making, this study intends to integrate the TPB and NAM in order to examine the impact of both egoistic and altruistic factors on CWR behavior among Chinese contractors.

This paper's remaining sections are arranged as follows: A thorough literature assessment is given in Section 2, and the research hypotheses are described in Section 3. The study technique is explained in Section 4, and the findings of the hypothesis testing are presented in Section 5. The study's main conclusions are presented in Section 6, with theoretical and

practical implications discussed in Sections 6.1 and 6.2, respectively. In Section 7, the paper concludes with a summary of key findings and recommendations for future research.

2. Literature Review

Understanding the connection between human factors and construction waste generation is essential for uncovering the key drivers of waste reduction and fostering sustainable practices among stakeholders [17]. Research shows that various stakeholders encounter multiple challenges in implementing CWR. For example, construction workers generally demonstrate inadequate knowledge of waste reduction due to insufficient education and environmental training, which impedes their capacity to comprehend and apply reduction tactics [18]. While contractors generally express willingness to minimize waste, their efforts are hindered by obstacles such as an immature market for recycled materials, inadequate recycling technologies, and weak regulatory enforcement [19]. Similarly, designers responsible for embedding waste reduction into the design process are influenced by issues like frequent design modifications, a lack of integration of waste reduction principles, ambiguous design specifications, insufficient expertise in sustainable design, and unclear accountability for CWR outcomes [20].

To better understand the psychological mechanisms behind stakeholders' CWR behaviors, scholars have increasingly applied established behavioral theories, particularly the TPB, which has been widely recognized for its effectiveness in explaining pro-environmental actions, including waste management practices [21,22]. This body of research demonstrates that factors such as attitudes, subjective norms, and perceived behavioral control are significant predictors of CWR intentions and behaviors. Nevertheless, relying solely on TPB provides an incomplete account, as contractors' CWR actions are also shaped by additional factors such as perceived consequences, sense of responsibility, personal norms, and government oversight, indicating gaps in current research.

Government monitoring, along with related policies and regulations, has been shown to exert a significant influence on contractors' engagement in CWR. The role of government is especially critical in developing countries, where the construction sector plays a central role in economic growth [23,24]. To address escalating waste issues and advance sustainability, governments in developing regions have also taken active steps by introducing strategic initiatives to advance CWR in construction [8,25–27]. Yusof et al. (2017) asserted that regulatory requirements are the most powerful incentive for companies to adopt environmental measures, as compliance pressure motivates stakeholders to act [28,29]. Ding et al. (2016) emphasized that effective regulations, coupled with monitoring, significantly encourage positive contractor behavior, and that robust legal frameworks with strict oversight can foster the adoption of CWR practices [30]. Although contractors are primarily profit-driven and may favor economic over environmental priorities when trade-offs arise [31], government subsidies serve as an effective policy tool, providing positive reinforcement. Economic incentives can steer firms toward CWR strategies, and well-designed subsidy schemes can align corporate behavior with sustainability goals [32,33].

From a theoretical standpoint, TPB functions as a rational choice model of environmental behavior [34], primarily analyzing decisions through a self-interested cost-benefit lens, yet it fails to account for the motivational power of altruistic intentions in pro-environmental actions [35]. In contrast, the NAM has been widely applied to study various pro-environmental behaviors, which are often viewed as forms of pro-social behavior [36]. However, a major drawback of NAM is its exclusive focus on moral norms and social responsibility, overlooking the impact of rational and instrumental factors. Although both TPB and NAM offer strong explanatory value for understanding contractors' CWR behaviors, each emphasizes either self-interest or altruism in isolation, thus falling short

in capturing the full complexity of individual psychological processes [37]. While TPB centers on economic incentives and social influence, NAM focuses on personal environmental values and moral duties. This theoretical dichotomy limits the comprehensiveness of behavioral analysis. Therefore, integrating TPB and NAM is necessary to bridge their theoretical gaps and achieve a more unified understanding. The combined TPB-NAM has already been used to predict pro-environmental behaviors in construction, such as intentions to purchase prefabricated housing, willingness to sort and recycle waste, and on-site recycling of construction and demolition plastic waste [38–40]. As standalone models become increasingly inadequate for explaining green behavioral intentions, this study argues that combining TPB and NAM offers complementary theoretical insights, enabling a more thorough investigation of the psychological mechanisms underlying contractors' CWR behavior.

3. Research Hypothesis Development

3.1. TPB Model

Li et al. [21] emphasized that the constructors' intention to reduce waste was the primary influencing factor of their construction waste reduction behavior. Ramayah et al. [41] examined the determinants of university students' recycling behavior for urban solid waste, focusing on attitudes, perceived behavioral control, and subjective norms. To identify the key drivers of waste minimization behaviors, Yuan et al. [14] extended the TPB by examining various antecedent factors that influence individuals' attitudes, perceived behavioral control, and subjective norms. Accordingly, the following hypotheses are proposed:

- H1.** *Reduction intention (RI) is positively associated with CWR behavior.*
- H2.** *Perceived behavioral control is positively associated with CWR behavior.*
- H3.** *Subjective norms are positively associated with CWR behavior.*

Many researchers have investigated stakeholders' construction waste reduction behaviors. Attitude was the primary determinant of construction project managers' waste reduction intention [14]. Li et al. [15] indicated that subjective norms significantly affected the intention to reduce construction and demolition waste among contractors' employees. Swetha et al. [42] demonstrated that perceived behavioral control positively influenced the intention to implement construction waste management practices. Based on these findings, the following hypotheses are proposed:

- H4.** *The attitude to construction waste reduction has a positive influence on reduction intention.*
- H5.** *Subjective norms have a positive effect on the intention of reducing construction waste.*
- H6.** *Perceived behavioral control has a positive effect on the intention of reducing construction waste.*

3.2. Extending the TPB by Incorporating NAM

Yuan and Wang [43] indicated that personal norms played a crucial role in construction site managers' waste reduction behaviors, exerting a significant positive influence on behavioral intention. In 2021, Kopaei et al. [44] indicated in a study on residents' intentions toward household composting that awareness of consequences (AC) indirectly and positively influenced personal norms through ascription of responsibility (AR). Although this finding was based on research on residents' intentions toward household composting, the underlying cognitive mechanism, namely, the activation of moral norms via perceived

environmental harm and self-attribution of responsibility, was conceptually transferable to construction settings. Construction workers, like individual residents, operate within systems where waste generation has tangible environmental impacts, and internalized sustainability values increasingly shape their behavioral choices. Therefore, the following hypotheses are proposed:

H7. *Personal norms have a positive effect on construction waste reduction intention.*

H8. *Ascription of responsibility has a positive effect on personal norms.*

H9. *Awareness of consequences has a positive effect on ascription of responsibility.*

According to Bakshan et al. [45], effective on-site construction waste management is closely associated with workers' attitudes, professional experience, and perceived social norms. Furthermore, organized training courses and a workplace that encourages independent decision-making can help promote the adoption of such methods. This linkage arises from the role of training in strengthening workers' awareness of the environmental and operational consequences of waste, thereby fostering more favorable attitudes toward sustainable practices. The positive influence of awareness of consequences on attitudes has also been confirmed in other pro-environmental behavior studies worldwide, such as Kopaei et al.'s [44] study on household composting behavior in Iran, Park and Ha's [46] study on recycling behavior of consumers in the United States, and Dhirasasna et al.'s [47] study on binning behavior of visitors in Australian national parks. Building upon the preceding rationale, the following hypothesis is proposed:

H10. *Awareness of consequences positively influences attitude.*

Personal norms refer to an individual's internal expectations regarding their own behavior in a specific context. They reflect social norms that have been internalized as personal moral obligations. Such norms motivate contractors to consciously and voluntarily choose actions that reduce construction waste. Scholars have proposed that incorporating personal norms into the TPB can enhance its explanatory power in studies of certain morally relevant behaviors [48]. Wang [49] also demonstrated a positive influence of personal norms on behavior in a study on individual actions. Based on the norm activation process, the following hypothesis is formulated:

H11. *Personal norms positively influence CWR behavior.*

3.3. Waste Reduction Intention as a Mediating Mechanism

Within the framework of the TPB, behavioral intention serves as a mediator between perceived behavioral control, subjective norms, and actual behavior [50]. Gu et al. [51] differentiated subjective norms into injunctive and descriptive norms and demonstrated that intention mediates the effects of both types of norms on behavior. Wang et al. [52] found that the influence of subjective norms on behavior is mediated by behavioral intention, with personal norms being the most significant predictor. Therefore, the following hypotheses are proposed:

H12a. *Reduction intention positively mediates the effect of subjective norms on CWR behavior.*

H12b. *Reduction intention positively mediates the effect of perceived behavioral control on CWR behavior.*

H12c. *Reduction intention positively mediates the effect of personal norms on CWR behavior.*

3.4. The Moderating Effect of Government Monitoring

Yusof et al. [28] emphasized that government regulations serve as the primary driver compelling enterprises to adopt environmental practices, with regulatory pressure prompting stakeholders to implement environmental protection measures. Zhao [53] noted that compliance pressure for contractors to engage in construction waste management arises from effective legislation, regulations, and associated incentive mechanisms. When the government prioritizes waste management and enforces strong construction oversight, contractors' awareness of waste reduction is strengthened. Based on this, the following hypothesis is proposed:

H13. *Government monitoring has a positive moderating effect on the transformation from CWR intention to CWR behavior.*

Accordingly, grounded in prior studies and theoretical underpinnings, this study develops a conceptual model identifying key determinants of contractors' CWR behaviors through an integrated TPB and NAM, as depicted in Figure 1.

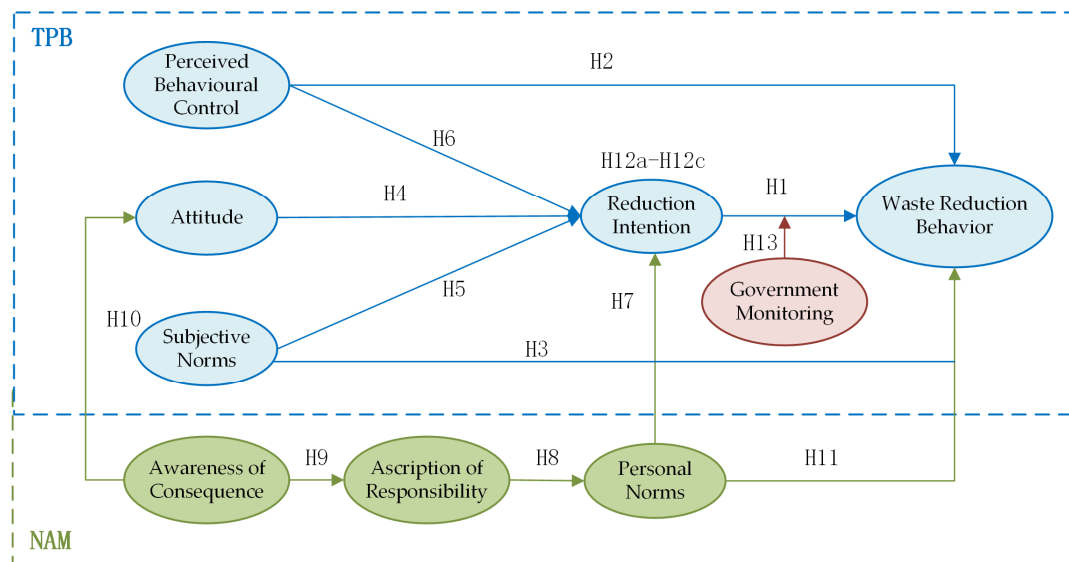


Figure 1. Research framework and hypothesized relationships. Note: Blue arrows = TPB paths; Green arrows = NAM paths; Red arrow = moderating effect.

4. Research Methods

4.1. Measurement Development

This study made specific modifications and optimizations based on the features of CWR behavior, drawing on established and current scales. A translation-back-translation procedure was employed for all English scale items to ensure the cultural appropriateness of the instrument in the Chinese context. The translated version was independently reviewed by five domain experts in construction management to assess content validity. Based on their feedback, the research team refined the wording of several items to enhance clarity and contextual relevance. The specific content is shown in Table 1. A seven-point Likert scale (1 = strongly disagree, 7 = strongly agree) was used to score each item, ensuring consistent and clear reflection of respondents' views.

Table 1. Instrument items for measuring model variables.

Variables	Code	Measurement Items	Sources
ATT	ATT1	Effective CWR can improve the environmental quality.	[31]
	ATT2	Effective CWR is necessary.	
	ATT3	Effective CWR is worthy of advocacy.	
SN	SN1	Other businesses in the same industry's CWR management will encourage the organization to implement CWR practices.	[21]
	SN2	The company will embrace CWR practices as a result of the government's mandated CWR policy.	
	SN3	The company will implement CWR processes in response to the owner's CWR requirements.	
	SN4	The company's implementation of CWR practices will be driven by market demand for items made from recycled construction waste.	
PBC	PBC1	The company is proficient in CWR management and has enough CWR experience.	[40]
	PBC2	The project schedule enables the company to implement CWR practices by providing sufficient time.	
	PBC3	The company is financially stable and has enough funds to complete CWR work.	
	PBC4	The project site provides spaces for recycling construction waste, including separation and temporary storage.	
AC	AC1	CWR can assist in establishing the company's green image.	[54]
	AC2	CWR can encourage social development that is sustainable.	
	AC3	CWR can facilitate the circular utilization of resources.	
PN	PN1	I should actively consider the evolution and innovation of CWR methods.	[55]
	PN2	If I do not implement CWR practices in a building project, I will feel guilty.	
	PN3	Implementing CWR measures in building projects is my moral obligation.	
AR	AR1	I have a responsibility in my role to promote the implementation of more effective CWR practices.	[40]
	AR2	I am accountable for ecological damage caused by the failure to implement CWR practices.	
	AR3	I have a responsibility to integrate the principles of CWR into my daily work practices.	
RI	RI1	I am willing to practice CWR.	[56]
	RI2	I plan to begin implementing CWR practices from now on.	
	RI3	I will encourage people around me to adopt CWR practices.	
	RI4	I'm open to learning more about CWR and spreading that knowledge.	
WRB	WRB1	In the past year, I have participated in CWR practices.	[56]
	WRB2	I have pushed those around me to adopt CWR practices in the past year.	
	WRB3	I often participate in knowledge dissemination and educational activities related to CWR.	
GM	GM1	Government rules on energy conservation and environmental preservation urge contractors to follow CWR practices.	[21]
	GM2	The government has implemented financial incentive mechanisms to support corporate adoption of CWR practices.	
	GM3	The government has implemented robust construction waste regulations to enforce CWR practice adoption by contractors.	
	GM4	The government has a comprehensive construction waste management regulation system.	

Note: attitude = ATT; subjective norms = SN; perceived behavioral control = PBC; awareness of consequence = AC; personal norms = PN; ascription of responsibility = AR; reduction intention = RI; waste reduction behavior = WRB; government monitoring = GM.

Exploratory factor analysis (EFA) was conducted to refine the scale items using the pre-test data before the main survey. This was necessary because the initial scale had undergone

modifications for translation and adaptation to the research context. 167 questionnaires in all were gathered for the pre-test. 158 valid questionnaires remained after invalid replies were removed, yielding an effective response rate of 94.61%. The factors that have eigenvalues higher than one were kept. Table 2 presents the findings. The result of Bartlett's test of sphericity was significant ($p < 0.001$), and the Kaiser–Meyer–Olkin (KMO) measure was 0.830. The analysis explained 75.77% of the total variance, indicating good construct validity. Additionally, all factors had Cronbach's alpha values greater than 0.7, indicating high internal consistency and reliability.

Table 2. Results of exploratory factor analysis for the pre-survey questionnaire.

Variables	Code	1	2	3	4	5	6	7	8	9
RI	RI1	0.773								
	RI2	0.705								
	RI3	0.787								
	RI4	0.808								
PBC	PBC1		0.881							
	PBC2		0.746							
	PBC3		0.776							
	PBC4		0.824							
GM	GM1			0.776						
	GM2			0.715						
	GM3			0.763						
	GM4			0.809						
SN	SN1				0.815					
	SN2				0.774					
	SN3				0.729					
	SN4				0.797					
WRB	WRB1					0.874				
	WRB2					0.842				
	WRB3					0.875				
PN	PN1						0.844			
	PN2						0.750			
	PN3						0.841			
AR	AR1							0.860		
	AR2							0.843		
	AR3							0.851		
ATT	ATT1								0.849	
	ATT2								0.787	
	ATT3								0.842	
AC	AC1									0.871
	AC2									0.797
	AC3									0.847

4.2. Data Collection

In the formal study, a total of 437 responses were received. After screening, 55 responses were excluded due to invariant response patterns or excessively short completion times, resulting in 382 valid responses for analysis. SPSS 27.0 was used for descriptive statistics and factor analysis, and AMOS 28.0 was used to test the study hypotheses and structural model.

The following were the demographic traits of the 382 responders. There were 134 female participants (35.08%), while the bulk of participants ($n = 248$, 64.92%) were

male. In terms of age, the largest group consisted of respondents in their 30 s ($n = 139$, 36.39%), followed by those in their 20 s ($n = 85$, 22.25%), 40 s ($n = 81$, 21.20%), and aged 51 or older ($n = 77$, 20.16%). Regarding educational attainment, 144 respondents (37.70%) held a junior college degree, 121 (31.68%) had an undergraduate degree, 61 (15.97%) possessed a graduate degree or higher, and 56 (14.66%) had a senior high school education or below. The distribution of job positions showed that 114 (29.84%) were construction workers, 106 (27.75%) were construction site managers, 71 (18.59%) were project managers, 66 (17.28%) were corporate executives, and the remaining 25 (6.54%) held other positions. In terms of work experience, most respondents ($n = 116$, 30.37%) had 10 to 20 years of experience, followed by those with 5 to 10 years ($n = 99$, 25.91%), more than 20 years ($n = 87$, 22.77%), and less than 5 years ($n = 80$, 20.94%). These demographic details are summarized in Table 3.

Table 3. Descriptive statistics. ($n = 382$).

Characteristics	Items	Number of Samples	Percentage
Gender	Female	134	35.08%
	Male	248	64.92%
Age	Aged 20 to 30 years	85	22.25%
	Aged 31 to 40 years	139	36.39%
	Aged 41 to 50 years	81	21.20%
	Above 51 years	77	20.16%
Education	Senior middle school and below	56	14.66%
	Junior college	144	37.70%
	Undergraduate	121	31.68%
	Graduate and above	61	15.97%
Position	Corporate executives	66	17.28%
	Project manager	71	18.59%
	Construction site manager	106	27.75%
	Construction worker	114	29.84%
	Other	25	6.54%
Working Experience	5 years and below	80	20.94%
	5–10 years	99	25.91%
	10–20 years	116	30.37%
	20 years and more	87	22.77%

4.3. Statistical Analysis

4.3.1. Assessment of Common Method Bias

Prior to hypothesis testing, the normality of the data was assessed to ensure it met the assumptions required for Structural Equation Modeling (SEM), as significant non-normality can bias the results. SPSS 27.0 was used to conduct the analysis, which included assessing the variables' skewness and kurtosis. According to established guidelines, absolute values for skewness less than 3 and for kurtosis less than 8 are indicative of acceptable normality. The results revealed that the absolute skewness values of all variables ranged from 0.113 to 0.89, and the absolute kurtosis values ranged from 0.028 to 1.149. As all coefficients were well within these recommended thresholds, the data were considered to be approximately normally distributed and therefore suitable for the subsequent SEM analysis.

Potential common method bias (CMB), which may artificially inflate the relationships between constructs and undermine the validity of the results, is a concern in this study because data were collected using an online self-report questionnaire. Therefore, several statistical methods were employed to assess this issue. First, Harman's single-factor test was

conducted [57]. An exploratory factor analysis on all items revealed nine factors with eigenvalues greater than 1. The first unrotated factor accounted for 34.6% of the total variance, which is below the recommended threshold of 50% [58]. Second, a confirmatory factor analysis (CFA) approach was used to compare the proposed nine-factor measurement model with a single-factor model where all items loaded onto one factor. The results showed that the single-factor model exhibited a very poor fit to the data ($\chi^2/df = 9.356 > 3$, CFI = 0.502 < 0.9, TLI = 0.466 < 0.9, RMSEA = 0.148 > 0.05, SRMR = 0.1100 > 0.05), suggesting that a single factor could not account for the majority of the variance. Lastly, an unmeasured latent method construct (ULMC) was added to the nine-factor measurement model to conduct a more rigorous test. The inclusion of this common method factor did not lead to a significant improvement in model fit. All of these findings point to the measurement in this study not being significantly impacted by common method bias. In addition, the potential influence of social desirability bias is acknowledged, as respondents may have a tendency to report more favorable waste reduction behaviors and intentions in line with perceived social expectations. Although this concern was mitigated by ensuring survey anonymity and emphasizing that the data would be used solely for academic purposes, the potential for such bias remains and is recognized as one of the limitations of this study.

4.3.2. Assessment of Reliability and Validity

SPSS 27.0 and AMOS 28.0 were utilized for analysis in order to assess the validity and reliability of the survey data. Tables 4 and 5 present the findings. The questionnaire had strong construct validity, as evidenced by the fact that all item factor loadings were above the 0.5 criterion. Additionally, all variables exhibited high reliability (Cronbach's $\alpha > 0.7$) and strong internal consistency, as indicated by Composite Reliability (CR > 0.7) and Average Variance Extracted (AVE > 0.5) values.

Table 4. Reliability and convergent validity assessment results.

Latent Variables	Measurement Items	Factor Loading	KMO	Cronbach's α	CR	AVE
Perceived Behavioral Control	PBC1	0.765	0.836	0.882	0.882	0.652
	PBC2	0.874				
	PBC3	0.781				
	PBC4	0.806				
Subjective Norms	SN1	0.793	0.835	0.885	0.885	0.659
	SN2	0.811				
	SN3	0.839				
	SN4	0.803				
Attitude	ATT1	0.870	0.733	0.868	0.869	0.689
	ATT2	0.793				
	ATT3	0.825				
Awareness of Consequence	AC1	0.765	0.725	0.842	0.837	0.632
	AC2	0.830				
	AC3	0.788				
Ascription of Responsibility	AR1	0.873	0.748	0.891	0.891	0.731
	AR2	0.862				
	AR3	0.830				
Personal Norms	PN1	0.839	0.722	0.843	0.844	0.643
	PN2	0.761				
	PN3	0.804				

Table 4. Cont.

Latent Variables	Measurement Items	Factor Loading	KMO	Cronbach's α	CR	AVE
Reduction Intention	RI1	0.785	0.845	0.900	0.888	0.664
	RI2	0.822				
	RI3	0.829				
	RI4	0.822				
Waste Reduction Behavior	WRB1	0.857	0.748	0.891	0.884	0.717
	WRB2	0.858				
	WRB3	0.825				

Table 5. Results of discriminant validity.

	Mean	WRB	RI	PN	AR	AC	ATT	SN	PBC
WRB	5.069	0.847							
RI	4.433	0.507 ***	0.815						
PN	4.740	0.422 ***	0.483 ***	0.802					
AR	4.785	0.333 ***	0.377 ***	0.339 ***	0.855				
AC	4.527	0.266 ***	0.456 ***	0.458 ***	0.282 ***	0.795			
ATT	4.671	0.293 ***	0.471 ***	0.388 ***	0.292 ***	0.316 ***	0.830		
SN	4.569	0.451 ***	0.539 ***	0.491 ***	0.360 ***	0.417 ***	0.451 ***	0.812	
PBC	4.704	0.460 ***	0.481 ***	0.485 ***	0.300 ***	0.319 ***	0.373 ***	0.421 ***	0.807

Note: The values on the diagonal represent the square roots of the Average Variance Extracted (AVE) for each latent variable. *** $p < 0.001$. The same significance notation is used in subsequent tables.

To evaluate the measurement model, confirmatory factor analysis (CFA) was conducted using AMOS 28.0. The measurement model and its standardized path coefficients are presented in Figure 2, while the model fit indices are reported in Table 6, indicating a good model fit. Subsequently, convergent and discriminant validity were assessed. As shown in Table 4, all standardized factor loadings exceeded 0.5, the AVE for each construct was greater than 0.5, and CR values were above 0.7, supporting satisfactory convergent validity. Table 5 presents the results for discriminant validity, which were found to be adequate based on the inter-construct correlation coefficients. In summary, the scale demonstrates acceptable reliability and validity, supporting its use in subsequent structural model analysis.

Table 6. Results of CFA.

Indices	Indicators	Fit Criteria	Fitted Values	Evaluation
Absolute Fit Indices	χ^2/df	<3 (good); <5 (acceptable)	1.189	satisfactory fit
	RMSEA	<0.05 (good); <0.08 (acceptable)	0.022	satisfactory fit
	GFI	>0.9 (satisfactory)	0.938	satisfactory fit
Relative Fit Indices	IFI	>0.9 (satisfactory)	0.991	satisfactory fit
	CFI	>0.9 (satisfactory)	0.991	satisfactory fit
	TLI	>0.9 (satisfactory)	0.989	satisfactory fit
	NFI	>0.9 (satisfactory)	0.946	satisfactory fit

Note: χ^2/df : Chi-square to degrees of freedom ratio; RMSEA: Root Mean Square Error of Approximation; GFI: Goodness-of-Fit Index; IFI: Incremental Fit Index; CFI: Comparative Fit Index; TLI: Tucker–Lewis Index; NFI: Normed Fit Index. The definitions in this note also apply to Table 7.

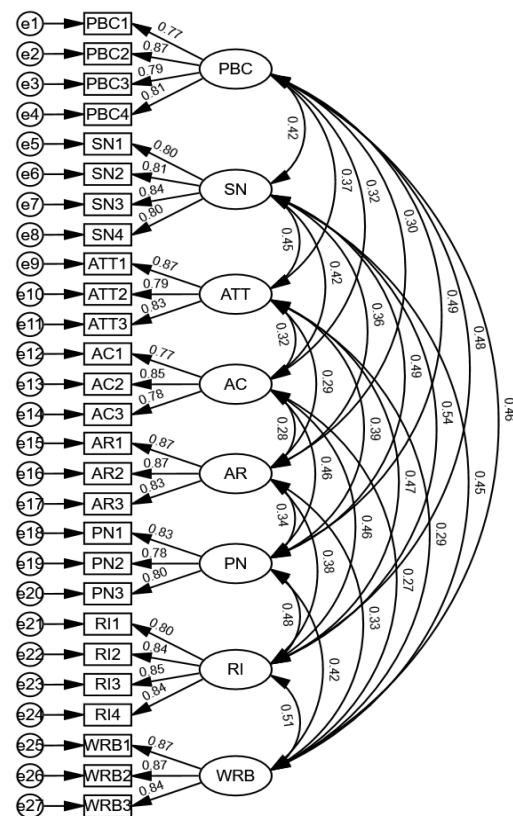


Figure 2. CFA model and path coefficients. Note: Single-headed arrows = factor loadings; double-headed arrows = correlations between constructs.

Table 7. Model Fit Indices for the SEM.

Indices	Indicators	Fit Criteria	Fitted Values	Evaluation
Absolute Fit Indices	χ^2/df	<3 (good); <5 (acceptable)	1.815	satisfactory fit
	RMSEA	<0.05 (good); <0.08 (acceptable)	0.046	satisfactory fit
	GFI	>0.9 (satisfactory)	0.906	satisfactory fit
Relative Fit Indices	IFI	>0.9 (satisfactory)	0.959	satisfactory fit
	CFI	>0.9 (satisfactory)	0.959	satisfactory fit
	TLI	>0.9 (satisfactory)	0.953	satisfactory fit
	NFI	>0.9 (satisfactory)	0.913	satisfactory fit

5. Results

5.1. Testing of Research Hypotheses

The SEM was tested in this work using AMOS 28.0, and Table 7 shows the overall model fit indices, which show a strong model fit.

The hypothesis testing results are shown in Table 8, and the standardized path coefficients of the SEM are presented in Figure 3. Perceived behavioral control and reduction intention were significant at the 0.1% level, while the path coefficients for subjective norms, personal norms, reduction intention, and perceived behavioral control were 0.173, 0.136, 0.253, and 0.219, respectively, among the factors influencing CWR behavior. Thus, it was determined that reduction intention and perceived behavioral control have the greatest impact on CWR behavior, supporting hypotheses H1, H2, H3, and H11. Contractors' engagement in reduction practices not only depends on their cognitive assessment of resource control capabilities but is also strongly driven by their behavioral intentions. With path coefficients of 0.237, 0.308, 0.228, and 0.195, respectively, attitudes, subjective

norms, perceived behavioral control, and personal norms all positively impacted reduction intention and were all significant at the 0.1% level. Among these, subjective norms exhibited the most prominent influence on waste reduction intention. Thus, hypotheses H4, H5, H6, and H7 were supported. This indicates that external normative pressures, such as those from industry peers and government policies, are core drivers in stimulating contractors' intentions to reduce waste, while individual attitudes and moral obligations provide supplementary motivation. There was a significant positive relationship between responsibility attribution and personal norms. Furthermore, consequence awareness had significant positive effects on both responsibility attribution and attitudes toward waste reduction, with all effects being significant at the 0.1% level. Thus, hypotheses H8, H9, and H10 were supported. This indicates that contractors' moral duty is strengthened and their appreciation of waste reduction measures is significantly enhanced when they fully understand the environmental effects of construction waste.

Table 8. Structural model analysis results: path coefficients and hypothesis testing.

Category	C.R.	S.E.	<i>p</i>	Estimate	Results
PBC → WRB	3.648	0.073	***	0.219	supported
RI → WRB	3.965	0.075	***	0.253	supported
SN → WRB	2.791	0.065	**	0.173	supported
PN → WRB	2.522	0.057	*	0.136	supported
ATT → RI	4.591	0.042	***	0.237	supported
SN → RI	5.296	0.052	***	0.308	supported
PBC → RI	4.017	0.059	***	0.228	supported
PN → RI	3.82	0.046	***	0.195	supported
AR → PN	6.234	0.053	***	0.361	supported
AC → AR	5.786	0.065	***	0.341	supported
AC → ATT	6.229	0.067	***	0.371	supported

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

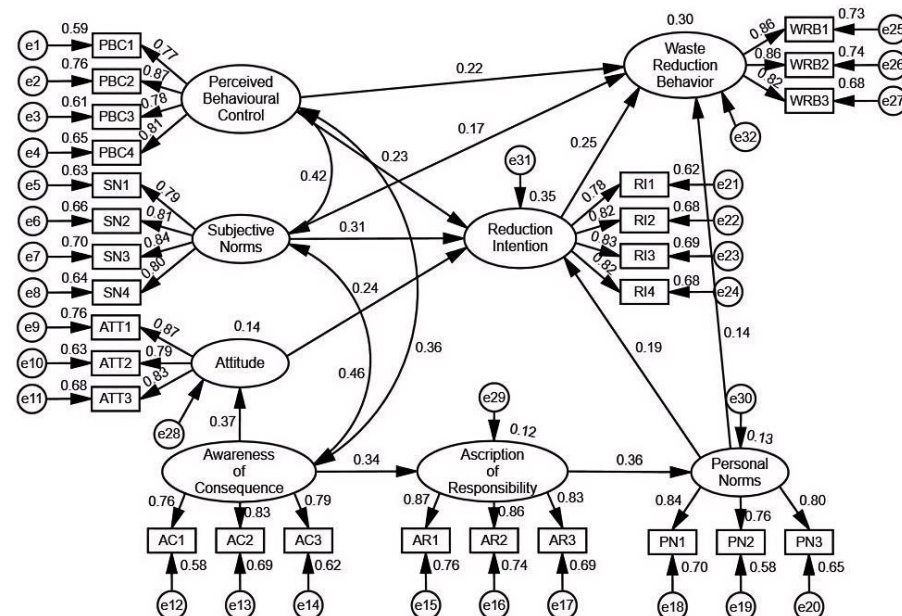


Figure 3. SEM path diagram. Note: Single-headed arrows represent standardized path coefficients; double-headed arrows indicate correlations between latent constructs. All values are standardized estimates.

5.2. Mediation Analysis Results

The most common approaches for investigating mediation effects are Sobel, Bootstrap, and causal. Bootstrap is the most popular approach for analyzing mediation effects because it is not only the most efficient but also makes no assumptions about the sample distribution [59]. Therefore, this study employed the Bootstrap method in AMOS 28.0 to conduct the mediation analysis, with the number of replications $K = 5000$ and confidence interval $CI\% = 95\%$. As shown in Table 9, the mediation effect tests revealed that reduction intention partially mediated the associations between subjective norms and construction waste reduction behavior, as well as perceived behavioral control and construction waste reduction behavior. Reduction intention completely mediated the link between personal norms and construction waste reduction behavior. This implies that perceived behavioral control may directly promote practice by improving behavioral feasibility, but subjective norms may directly impact behavior through a social learning mechanism. Personal norms, on the other hand, as an internal moral constraint, only have an effect through reduction intention, emphasizing that motivating internalization is a critical step in converting ethical awareness into behavior. Thus, hypotheses H12a–H12c were all supported.

Table 9. Results of mediation analysis using the Bootstrap method.

Path	Effect	SE	S.E.	Bias-Corrected 95% Confidence Interval			Results
				Lower	Upper	<i>p</i>	
SN → RI → WRB	Total	0.251	0.065	0.121	0.377	***	Partial Mediation
	Direct	0.173	0.069	0.039	0.308	0.016	
	Indirect	0.078	0.028	0.033	0.147	***	
PBC → RI → WRB	Total	0.276	0.066	0.149	0.403	0.001	Partial Mediation
	Direct	0.219	0.065	0.093	0.348	0.001	
	Indirect	0.058	0.022	0.022	0.112	***	
PN → RI → WRB	Total	0.185	0.075	0.038	0.335	0.012	Full Mediation
	Direct	0.136	0.075	−0.007	0.289	0.060	
	Indirect	0.049	0.022	0.015	0.105	0.002	

Note: *** $p < 0.001$.

5.3. Test of the Moderating Effect of Government Monitoring

This study employed the PROCESS macro in SPSS 27.0 to examine the moderating effect of government monitoring. The results, presented in Table 10 (Model 4), revealed that the interaction term between reduction intention and government monitoring was statistically significant. To further illustrate this moderating effect, a simple slope plot is presented in Figure 4. The findings indicate that the positive effect of reduction intention on CWR behavior increases as the level of government monitoring rises. Specifically, the relationship is significantly stronger under high regulation compared to low regulation. This provides robust evidence that government monitoring positively moderates the translation of reduction intention into actual CWR behavior. Consequently, H13 is supported.

Table 10. Results of the moderating effect test of government monitoring.

Variables		CWR behavior			
		M 1	M 2	M 3	M 4
Control variables	Gender	−0.071	−0.037	−0.033	−0.028
	Age	−0.068	−0.024	−0.043	−0.029
	Education	−0.105 *	−0.111 *	−0.063	−0.049
	Position	0.084	0.063	0.029	0.035
	Working Experience	0.022	0.064	0.039	0.041

Table 10. Cont.

Variables		CWR behavior			
		M 1	M 2	M 3	M 4
Independent Variable	RI		0.471 ***	0.267 ***	0.281 ***
Moderator Variable	GM			0.324 ***	0.352 ***
Interaction effect	GM × RI				0.134 **
Indicators	R2	0.027	0.240	0.301	0.317
	Δ R2	0.027	0.213	0.061	0.016
	F	1.744	16.899 ***	20.067 ***	19.178 ***

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. The significance of the moderation effect is assessed based on the statistical significance of the interaction term in Model 4.

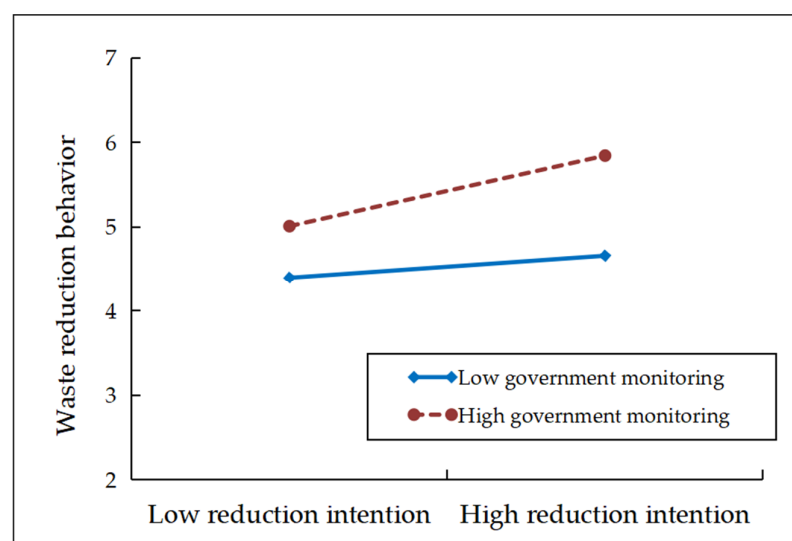


Figure 4. Moderating role of government monitoring.

6. Discussion

SEM results validated the integrated TPB-NAM's explanatory power, showing that both egoistic and altruistic psychological factors strongly influenced Chinese contractors' intention to reduce construction waste. The primary theoretical contribution of this integrated framework lies in uncovering complex interrelationships that cannot be fully captured by any single theory. For instance, behavioral intention mediates the translation of personal norms into actual behavior, revealing a distinct pathway through which moral motivation is converted into action within the institutional and operational constraints of China's construction industry. Contractors' reduction intention had the greatest influence on construction waste reduction behavior. This is consistent with a study on waste reduction behavior by Ertz et al. (2021) [60], which found that consumers' intention to engage in waste reduction behavior increases with their level of awareness and that behavioral intention accounts for about half of the variance in waste reduction behavior. By raising contractors' awareness of the need for conserving natural resources and reducing waste, their intention to minimize waste can be strengthened during the implementation of construction waste management initiatives. Thus, by receiving the proper instruction and training, contractors can gain the necessary knowledge and abilities to comprehend the environmental risks associated with waste, strengthening their resolve to cut waste

while encouraging CWR behavior in the building sector, thus reducing the production of construction waste.

The results show that perceived behavioral control had a large beneficial impact on CWR behavior, which is consistent with the findings of Li et al. (2022) [21], who showed that contractors are much more likely to apply waste reduction measures if they believe they are feasible. As per the TPB, the intention to undertake a behavior can only be established when perceived behavioral control reaches a certain threshold. Hence, perceived behavioral control significantly influences contractors' engagement in CWR behavior.

Additionally, the study discovered that personal norms had less of an impact on waste reduction behavior than subjective norms. The stratified governance structure prevalent in the construction sector, together with the collectivistic cultural context of Chinese society, is closely linked to this finding. In China, organizational hierarchies are clearly defined, and contractors' employees typically comply with directives from managers and clients. Moreover, in the fiercely competitive construction industry, clients often hold a dominant position, creating strong incentives for contractors to meet client-driven environmental requirements. As a result, external normative pressures—such as expectations from managers, clients, and government authorities (i.e., subjective norms)—exert a more direct influence on behavior than internalized moral obligations (i.e., personal norms). This is consistent with research by Li et al. [15], who discovered that subjective norms significantly surpass personal norms in determining construction workers' CWR behavior. Ramayah et al. [41] also noted that social pressure exerts a particularly significant influence on behavior in regions where collectivist culture is prevalent. Furthermore, the recognition of one's behavioral impacts positively influences the ascription of responsibility and indirectly reinforces personal norms through this pathway. When contractors acknowledge their responsibility for reducing waste, they are more inclined to uphold higher standards and fulfill their obligations during project execution.

The institutional environment plays a crucial role in enabling the conversion of waste reduction intentions into actual CWR behavior, as demonstrated by the examination of the moderating influence of government monitoring. Under high levels of government monitoring, the promoting effect of reduction intention on behavior was significantly stronger than under low monitoring conditions, which contrasts with the finding of Wu et al. [31] that the absence of government monitoring leads to illegal dumping of construction waste. Effective government monitoring is essential for motivating stakeholders to embrace waste reduction practices [29]. Therefore, the government should actively establish and enhance regulations and laws regarding construction waste, as well as set up a dedicated monitoring body. Kim et al. [61] proposed that governmental oversight of environmental practices not only enhances companies' environmental capabilities but also facilitates their investment in and utilization of innovative technologies. This not only supports a circular economy but also contributes significantly to reducing environmental pollution. Government monitoring positively moderates the transformation of reduction intention into behavior, likely through two potential mechanisms. First, there is legitimacy pressure: when regulations are clear and strictly enforced, waste reduction behaviors become a prerequisite for organizational legitimacy, prompting contractors to institutionalize environmental practices. Second, the mechanism involves the deterrence effect: high penalties or reputational sanctions raise the costs associated with non-compliance, thereby transforming waste reduction from a "moral choice" into a "rational avoidance" of adverse consequences. Future research could differentiate the psychological pathways of "incentive-based" versus "punitive" regulation to provide a more nuanced basis for the optimal combination of policy instruments.

This study not only contributes to the behavioral theory of construction waste reduction but also provides actionable insights for policymakers and industry stakeholders.

6.1. Theoretical Implications

- (1) Reduction intention, perceived behavioral control, subjective norms, and personal norms were all confirmed to have a significant positive impact on CWR behavior, with reduction intention and perceived behavioral control exhibiting the most prominent effects. This demonstrates that the application of behavior necessitates both external resource assistance and subjective motivational drive. It implies that contractors' efforts to cut down on construction waste are mostly motivated by self-interest. Meanwhile, awareness of consequences considerably and positively increased ascription of responsibility, and indirectly affected personal norms through this pathway.
- (2) Reduction intention was strongly positively impacted by subjective norms, attitude, perceived behavioral control, and personal norms; reduction behavior was directly predicted by subjective norms and perceived behavioral control. This illustrates how contractors' behaviors are heavily reliant on outside restrictions and resource assistance due to the construction industry's stringent regulations and resource-intensive features. However, personal norms influenced behavior through the mediating role of reduction intention, indicating the importance of translating moral awareness into actual action.
- (3) Between TPB and NAM, personal norms played a key role in affecting contractors' willingness to reduce construction waste in China, while greater awareness of consequences could foster more positive attitudes toward waste reduction practices.
- (4) This study advances the theoretical foundation of the literature regarding construction waste reduction or management. Previous studies have mostly looked at how each variable affects stakeholders' actions exclusively from a TPB or NAM perspective. In contrast, this study employs an integrated TPB-NAM to evaluate contractors' CWR behaviors, thereby advancing our understanding of such behaviors.

6.2. Practical Implications

The results of the study can guide the creation of strategies and policies for promoting the reduction in construction waste. The data analysis results show that egoistic factors significantly influence CWR behavior, indicating that contractors should place greater emphasis on tangible benefits such as financial returns, cost control, and resource efficiency in their decision-making. Although altruistic factors have a relatively smaller impact, they still play a non-negligible role in fostering long-term sustainable behavioral patterns. From a practical standpoint, this study offers important implications for decision-makers.

First, the most critical factor in promoting CWR behavior is individuals' intention to reduce construction waste. Therefore, to enhance such intentions, government agencies, universities, and research centers should develop targeted training programs focused on construction waste minimization strategies. Governmental organizations should strengthen public awareness campaigns about the dangers of construction and demolition waste to encourage sustainable practices in the sector. Such efforts are essential to inform contractors that improper waste management not only leads to environmental degradation and deteriorated air quality but also increases human susceptibility to respiratory diseases [62]. This would ultimately facilitate the implementation of waste reduction practices by enhancing industry practitioners' waste reduction intention.

Secondly, contractors' perceived behavioral control significantly influenced their CWR behavior. To facilitate the adoption of effective waste reduction practices, complementary strategies may include: disseminating proven minimization technologies, enabling organizational shifts in management approaches, providing access to technical support, and implementing incentive-based financing mechanisms to address financial barriers.

Additionally, the subjective norm significantly influenced contractors' involvement in CWR behavior. To decrease construction waste, it is essential for governments to implement comprehensive, systematic, and actionable guidelines and management regulations that delineate the duties and accountabilities of all parties involved. This would promote the development of unified industry standards. Fostering a societal culture that supports "green construction, resource conservation, and environmental protection" is essential. This would strengthen normative pressures within the industry and enhance public expectations for oversight, thereby promoting waste reduction as a widely accepted industry consensus and mainstream value.

Fourth, individual norms significantly influenced CWR behavior through the full mediating effect of reduction intention, highlighting the crucial role of intrinsic moral responsibility. This result clearly illustrates the theoretical benefit of combining the TPB and the NAM: TPB clarifies how moral norms are translated into action through behavioral intention, especially when faced with practical and contextual constraints, whereas NAM takes into account the activation of moral norms. It is therefore essential for market stakeholders, in the design of incentive mechanisms and industry evaluation frameworks, to promote sustainable development by cultivating environmental values and professional ethics within corporate cultures and embedding them in employee training initiatives. To enable contractors to internalize the necessity and legitimacy of waste reduction practices as stable personal norms, thereby strengthening their intention to reduce waste and translating this intention into actual behavior.

Finally, government monitoring effectively facilitated the translation of the intention to reduce waste into behavior that reduces construction waste. The greater the level of government oversight, the more probable it is that contractors will turn their intentions into concrete actions to reduce waste. The government should enhance regulations, but this would undoubtedly add to its administrative workload. Under these circumstances, offering financial incentives to contractors who take waste reduction actions would boost their initiative in cutting down on construction waste and motivate them to proactively incorporate waste-reduction techniques into their work. As a result, administrative burdens would be reduced and government monitoring would be far more effective. As a result, both the government and contractors will benefit from the combination of strict government monitoring and financial assistance.

The findings of this study carry significant implications for macro-level sustainable development. Effective construction waste reduction behaviors by contractors, as a form of resource conservation and environmentally responsible practice, objectively contribute to reducing dependence on virgin resources and mitigating energy consumption and pollution emissions associated with waste landfilling and transportation. This behavioral shift at the micro level not only provides foundational momentum toward advancing a circular economy in the construction industry but also serves as a critical pathway for achieving Sustainable Development Goal (SDG) 12 on Responsible Consumption and Production. Furthermore, in the context of China's national strategy to achieve carbon peak and carbon neutrality, promoting waste reduction behaviors among key stakeholders in the construction sector holds profound policy significance for building green and low-carbon urban-rural development models.

7. Conclusions

It is crucial to concentrate on the main elements influencing contractors' adoption of CWR practices and their decision-making processes to accomplish sustainable development in China's construction industry and slow down global warming. To begin with, CWR procedures offer significant environmental advantages, including the conservation of

resources, protection of the environment, and the advancement of sustainable development, while also serving the personal interests of contractors. In order to develop a research model for analyzing CWR behavior among Chinese contractors while simultaneously taking into consideration both egoistic and altruistic factors, this study combines the TPB with the NAM. Second, SEM was used to examine the data from a survey of 382 Chinese contractors. The findings suggested that contractors' CWR behavior was influenced by both egoistic and altruistic motivations. It clarified the effects of subjective norms, personal norms, perceived behavioral control, and waste reduction intention on CWR behavior, showing that waste reduction intention had the biggest influence on CWR behavior. Subjective norms, perceived behavioral control, and personal norms were found to directly predict CWR behavior. Subjective norms and perceived behavioral control had the strongest effects, while personal norms only had an impact on behavior through the mediating function of waste reduction intention. Awareness of consequences significantly enhanced ascription of responsibility, which in turn positively influenced personal norms, serving as a mediating mechanism. Consequence awareness also influenced contractors' attitudes toward CWR. Finally, government monitoring exerted a positive moderating effect on the process of translating waste reduction intention into CWR behavior. A core theoretical contribution of this study lies in its clear revelation, through the integration of TPB and NAM, that personal norms must operate via the mediation of behavioral intention to influence behavior, thereby highlighting the unique advantage of the integrated model in dissecting complex decision-making processes.

Notwithstanding the study's theoretical and practical significance, there are several shortcomings that call for further development. First, this study focused on contractors' perceived influencing factors for CWR behavior, not their actual activities. Future research should incorporate actual behavior for a more comprehensive understanding of its drivers. Second, while focusing on Chinese contractors, this study notes that significant internal division of labor (e.g., general, specialized, labor subcontractors) creates systematic differences in capabilities and perceptions regarding CWR. Future research should target specific contractor types to enhance applicability. Lastly, this study used cross-sectional data, limiting causal inference; future work should consider longitudinal data. Furthermore, sample selection may restrict industry-wide generalizability due to regional and project scale differences. Future research should broaden the sample to comprehensively investigate CWR drivers and behaviors across different regions, contractor types, and project kinds, also exploring the impact of the construction waste management supply chain to develop a more systematic and nuanced theoretical framework. Future studies could also examine behavioral driver differences among contractor roles or use dynamic game theory models to analyze long-term policy effects.

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