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Mechanism of attitude, subjective norms, and perceived behavioral control influence the green development behavior of construction enterprises

Xingwei Li [1,2], Jiachi Dai [1], Xiaowen Zhu[2,3], Jingru Li [1], Jinrong He [1], Yicheng Huang [1], Xiang Liu[1] & Qiong Shen [1✉]

The green development behavior of construction enterprises is an environmental behavior that contributes evidence from construction enterprises to the field of resource recycling and environmental protection. Revealing the mechanism of green development behavior of construction enterprises has become the key to guide construction enterprises to adopt green development behavior and improve the level of green development. However, existing studies on the mechanistic discussion of green development behavior of construction enterprises do not reach a consensus. In order to reveal the mechanism of the green development behavior of construction enterprises, this study examines how the green development behavior of construction enterprises is influenced by factors based on the Theory of Planned Behavior. Using partial least squares structural equation modeling (PLS-SEM), this study analyzed 306 questionnaire data points from construction enterprises in 28 provinces (cities) across China. The main conclusions are as follows. (1) Attitudes, subjective norms and perceived behavioral control have significant positive effects on the green development behavioral intentions of construction enterprises, with attitudes being the strongest predictor. (2) Intention intermediates the relationships between attitude, subjective norms, perceived behavioral control, and the green development behavior of construction enterprises to varying degrees. (3) Regional green development level and enterprise size positively moderate the four groups of the relationship between attitude, subjective norms, perceived behavioral control, intention and green development behavior of construction enterprises. This study provides theoretical guidance for promoting green transformation and upgrading construction enterprises and helps the construction industry achieve a balanced mode of development that supports both economic growth and environmental protection.

[1] College of Architecture and Urban-Rural Planning, Sichuan Agricultural University, 611830 Chengdu, China. [2] School of Management, Jiangsu University, 212013 Zhenjiang, China. [3] Centre for Design, Cranfield University, CranfieldBedford, MK43 0AL, UK. ✉email: swydong@sicau.edu.cn

Introduction

To alleviate the severe environmental situation, governments around the world have signed the Paris Agreement and actively changed to a green development model of energy conservation and emission reduction. Due to the economic value generated, the provision of a large number of jobs, and the related industries, the construction industry has become the economic pillar of many countries and regions (Zhang and Su, 2019). Specifically, in 2020, more than $1.5 trillion worth of buildings were built in the U.S., and the construction industry accounted for ~4.3% of the US GDP and created 7.5 million jobs (Kolmar, 2023). In the same year, the total output value of China's construction industry exceeded $4.1 trillion, accounting for 26.23% of GDP, and the number of employees exceeded 53 million (National Bureau of Statistics of China, 2021). Despite these efforts, reports have indicated that the global decarbonization of the building sector in 2020 is only 40% of the Paris Agreement target and is still far from reaching the target in 2021 (The Global Alliance of Construction, 2021). The construction industry's high-pollution, high-emissions and high-energy consumption model places considerable strain on global green development efforts.

The construction industry faces challenges in achieving green development due to its environmental impact and project characteristics. Green development behavior traps construction enterprises in a difficult and low level of environmental governance. On the one hand, the high pollution, emissions, and energy consumption of the construction industry pressure construction enterprises to adopt green development. On the other hand, the mobility and long periodicity of construction projects aggravate the challenge of green transition for construction enterprises. Moreover, there is still much room for upgrading the green technology innovation of construction enterprises (Li et al., 2022b; Li and Long, 2020). Therefore, it is imperative for construction enterprises to adopt green development behavior to cope with the green development challenge. This study has practical value because it helps the construction industry achieve a balanced mode of development that supports both economic growth and environmental protection. It also provides a more scientific and rational basis for the government to formulate policies and implement macrocontrol measures for green practices.

Green development requires top-down integrated green governance in the organization (Li, 2017). The green development behavior of construction enterprises (GDB-CE) is an organizational behavior that benefits their economic development and environmental protection to achieve their green development goals (Li et al. 2019b; Li et al. 2022a; Li et al. 2022c). Existing scholars mainly focus on the mechanism of enterprise green development behavior. Li et al. (2022d) used meta-analysis to classify the influencing factors of enterprise green development behavior into enterprise resources, public supervision, and environmental policies. However, this conclusion may not apply to specific industries such as construction. Li et al. (2020) introduced green development behavior into industrial enterprises, showing that it is affected by enterprise resources, the market environment, public supervision, and policy factors. In the construction industry, Li et al. (2022a) used the artificial neural network method to verify that GDB-CE is influenced by organization, technology, and the environment. Regrettably, Li et al.(2022a) only considered the effect of the enterprise environment on GDB-CE. Based on relevant studies, this paper finds that although existing research has provided a basis for understanding the GDB-CE mechanism, there are still some gaps. First, according to the theory of planned behavior, behavioral intention affects behavior. Consequently, GDB-CE may be affected by their intention. However, existing research has not studied this intention as an influencing factor of this behavior. Second, existing research has not discussed the moderators moderating GDB-CE. Without adequate theoretical guidance, construction enterprises may struggle to adopt energy-saving and emission-reducing practices. This could result in worsening environmental pollution. This study introduces GDB-CE, a framework that explains how construction enterprises can achieve resource recovery and environmental protection through their actions.

The TPB proposes that behavior is determined by a cognitive-intention–behavior framework. In other words, cognition (attitude, subjective norms, and perceived behavioral control) influences intention, and intention influences behavior. Therefore, whether the TPB can explain the driving factors of GDB-CE among construction enterprises also needs to be verified. How attitude, subjective norms, perceived behavioral control, and intention relates to GDB among construction enterprises needs to be investigated. Therefore, this paper intends to apply TPB to the field of enterprise green development behavior, construct a hypothesis model with this theory, and try to explore how attitude, subjective norms, and perceived behavioral control affect GDB-CE. Compared with conventional linear analysis techniques, partial least-squares structural equation modeling (PLS-SEM) handles both reflective and formative indicators and has more advantages in dealing with complex models (Hair et al., 2012). Using questionnaire data from construction enterprises in 28 provinces (cities) in China, PLS-SEM was used to test the paths of GDB−CE among construction enterprises and identify their moderating variables. The analytical framework of this study is shown in Fig. 1. The innovation of this study is as follows: First, it applies the theory of planned behavior (TPB) to uncover the underlying factors that influence GDB-CE, offering a novel theoretical framework and research perspective. Second, it examines how the regional green development level moderates the relationship between GDB-CE and its antecedents, providing new empirical evidence from construction enterprises for regional green development research. The practical implications of this study are that it provides specific suggestions for construction enterprise managers to enhance their green development practices and offers theoretical guidance for facilitating the green transformation and upgrading of construction enterprises, thus accelerating the global green development process.

The remainder of this study is organized as follows: Section "Theoretical basis and research hypothesis" presents the research hypothesis and develops the theoretical model based on the literature review. Section "Research methodology" describes the research methodology used in this study. Section "Results and discussion" reports and discusses the research results. Section "Discussion" presents the management implications, conclusions, and limitations of this study and future research directions.

Theoretical basis and research hypothesis

Theoretical basis. According to Ajzen (1985), behavior is controlled by intention. To explain and predict human behavior, Ajzen proposed the TPB with behavioral intention prediction as the core (Ajzen, 1991, 2011). TPB considers attitude, subjective norms, and perceived behavioral control (three factors independent of each other) as antecedent determinants and predictors of behavioral intention. TPB is mostly used to explain specific behaviors and has shown good explanatory power in several studies. The green development behavior of construction enterprises is an organizational behavior that is often affected by multiple aspects and angles. The TPB is an obvious explanatory choice for this study because it is a mature theory. TPB has been recognized in environmental science research. TPB has been widely used in construction waste treatment (Jain et al., 2020),

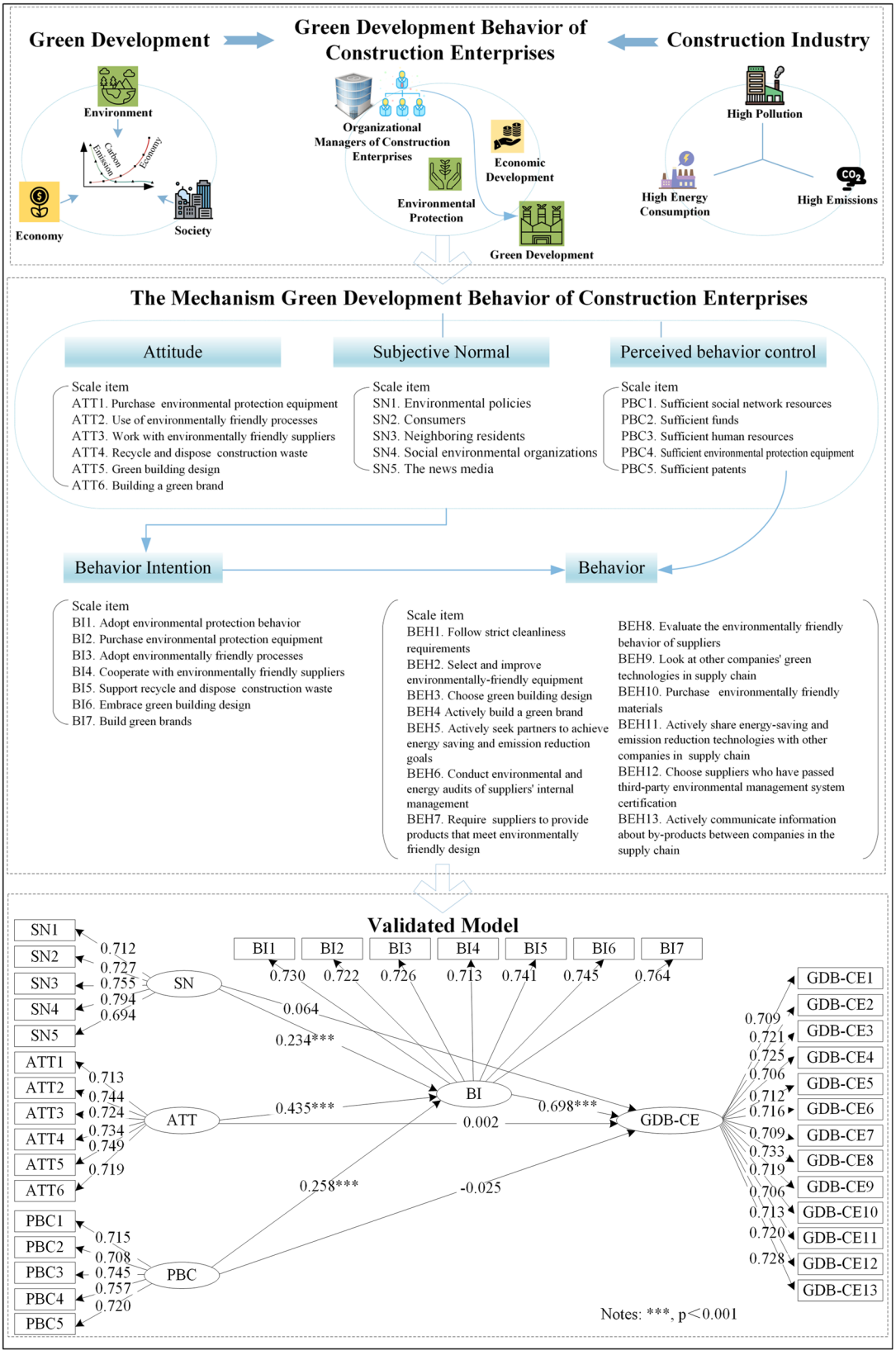

Fig. 1 Analysis framework of the green development behavior of construction enterprises. It shows the analysis process of the mechanism of green development behavior of construction enterprises. Firstly, the definition of green development behavior of construction enterprises is extended based on the background of green development and the construction industry. Secondly, five dimensions of attitude (6 items), subjective norms (5 items), perceived behavioral control (5 items), intention (7 items), and behavior (13 items) are used to describe the mechanism of green development of construction enterprises. Finally, the mechanism model of green development behavior of construction enterprises is constructed and validated.

green supply chain management practices (Lee et al., 2021), and green technology innovation (Zhang et al., 2018) to explain or predict enterprise environmental behavior. These studies also provide references for this paper to explore the green development behavior of construction companies using TPB.

Attitude (ATT). Eagly and Chaiken (1993) suggest that attitude is a measure of how individuals assess a psychological object based on their behavior. This study operationalizes the attitude toward the green development behavior of construction enterprises as the level of favorability or unfavorability toward such behavior, which varies from extremely negative to extremely positive. This level is determined by the prior experience and knowledge base of the organization's personnel. Based on their existing experience and the knowledge base of their personnel, construction enterprises have different levels of approval or disapproval of green development behavior. Attitude toward behavior can more accurately predict different types of behavioral intention. Behavior attitude can more accurately predict different types of behavioral intention (Ajzen, 1991). Previous studies have shown that attitude has a strong and positive effect on enterprise environmental behavioral intention. Zhang et al. (2013) used structural equation modeling to verify the significant and positive relationship between attitude toward cleaner production and behavioral intention toward cleaner production. Wang et al. (2022b) examined environmental behavior in the construction industry and found that Chinese construction enterprises' intention to cut carbon emissions was strongly and positively influenced by their attitude towards carbon emission reduction. Therefore, the following research hypothesis is proposed in this study:

H1: Attitude significantly and positively influences the green development behavioral intention of construction enterprises.

Subjective norms (SN). According to Ajzen (1991), subjective norms refer to perceived social pressure that shapes one's behavior. In this study, the subjective norms of the green development behavior of construction enterprises are conceptualized as the social pressure that construction enterprises perceive as a result of perceived social pressure from various stakeholders who expect them to adopt GDB-CE. These stakeholders include the government, residents, news media, consumers, competing peers, and nongovernmental environmental organizations. Ajzen (2011) also suggested that subjective norms influence behavioral intention. This was supported by Judge et al. (2019), who investigated the factors that affect consumers' buying behavior for housing with green certification labels and found that subjective norms had a significant and positive effect on consumers' intention to purchase such housing. Li et al. (2019a) and Peng et al. (2021b) examined the relationship between the subjective normative pressure of enterprises and the government. Using hierarchical regression analysis on data from different industries in China, Li et al. (2019a) found that government-mandated regulations related to green innovation significantly positively influenced enterprise researchers' behavioral intention of green innovation. Peng et al. (2021b) demonstrated that both controlling and incentive-based government environmental regulations had significant positive effects on enterprises' behavioral intention of green innovation. Based on empirical evidence, Wang et al. (2022a) showed that news media environmental reporting positively influenced the environmental protection intentions of leaders in construction enterprises, leading to more green innovation behaviors among them. Therefore, this study proposes the following research hypothesis:

H2: Subjective norms significantly and positively influence the green development behavioral intention of construction enterprises.

Perceived behavioral control (PBC). Perceived behavioral control is defined by Ajzen (1991) as an individual's perception of how easy or hard it is to enact a specific behavior based on their past experience, resources, and capabilities. Perceived behavioral control is an individual's perceived ease of achieving a particular behavior based on experience, which is mainly reflected in the resources and capabilities that the individual has to achieve the behavior. In this study, the perceived behavioral control of the green development behavior of construction enterprises is the assessment of the resources and capabilities of construction enterprises to achieve green development behavior, such as the social network resources, capital, and human resources that they possess. Perceived behavioral control complements the explanation of behavioral intention (Ajzen, 2011). For instance, Luo et al.(2017) investigated sustainable production behavior in cement enterprises from an empirical perspective and discovered that perceived behavioral control could positively and significantly predict their intention to engage in sustainable production practices. Ajzen (1991) argued that the resources and capabilities possessed by an individual directly affect the likelihood of achieving a desired behavior. Similarly, Li et al. (2022d) suggested that green development behavior among enterprises is driven by both tangible and intangible resources within the organization. The green development behavior of enterprises is driven by both tangible and intangible resources within the organization (Li et al., 2022d). Hong et al. (2022) also revealed the role of organizational culture as an intermediator between drivers and practices of sustainable supply chain management, showing that internal management capability had a significant positive influence on sustainable supply chain management practices. Based on these findings, this study proposes the following research hypotheses:

H3: Perceived behavioral control significantly and positively influences the green development behavioral intention of construction enterprises.

H4: Perceived behavioral control significantly and positively influences the green development behavior of construction enterprises.

Behavioral intention (BI). According to Ajzen (1991), there is usually a positive relationship between the strength of behavioral intention as a motivator for adopting a behavior and the likelihood of performing that behavior. In this study, the green development behavioral intention of construction enterprises refers to the intensity of the intention of construction enterprises to perform the behavior. The green development behavioral intention of construction enterprises is measured by three indicators: their intention to adopt environmentally friendly behaviors, their collaboration with eco-friendly suppliers, and their recycling and disposal of waste. Using an extended version of TPB, Tommasetti et al. (2018) examined how various factors affect consumers' choices of sustainable restaurants. They found that consumers' behavioral intentions to choose sustainable restaurants positively influenced their actual choices. Jain et al. (2020) investigated how construction contractors in India recycle their waste materials. They discovered that contractors' recycling behaviors were driven by their intention to recycle. Moreover, previous studies have confirmed that environmental behavioral intention plays an intermediating role in various industries. In the manufacturing industry, Tian et al. (2022) constructed a "capability-intent-behavior" intermediating effect model to examine how the green innovation intention of manufacturing enterprises

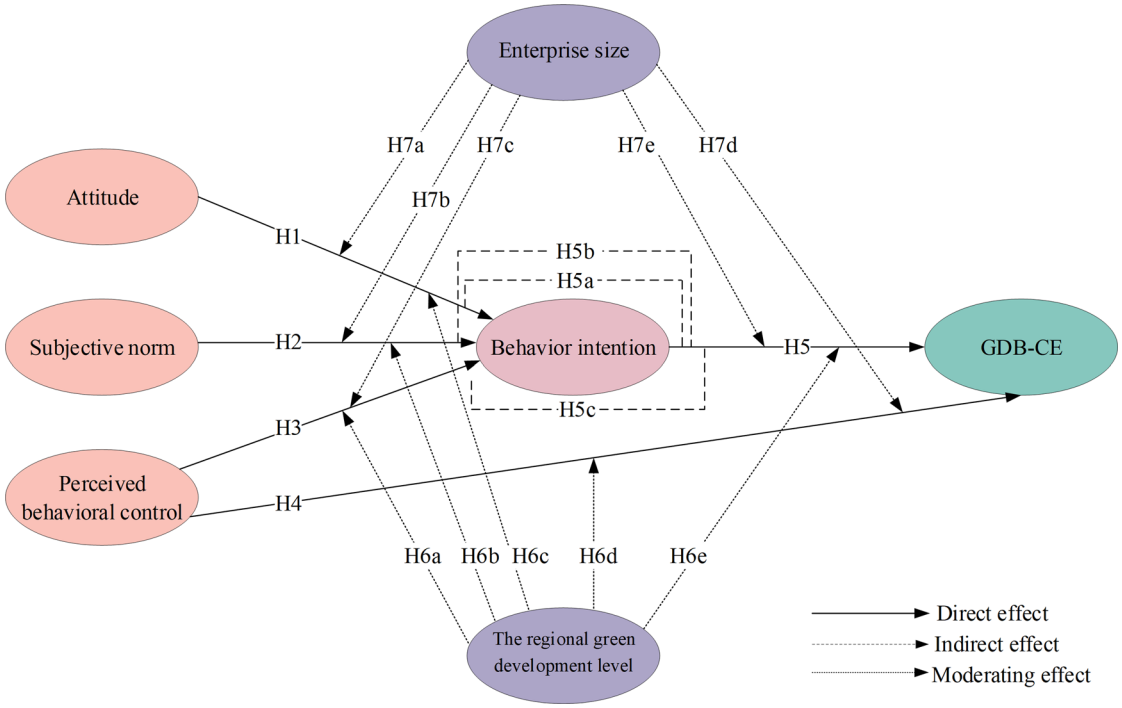

Fig. 2 A theoretical model of the green development behavior of construction enterprises. It shows 7 groups of hypothetical relationships of green development behavior of construction enterprises. Among them, H1–H3 explores the direct relationship between attitude, subjective norms, and perceived behavioral control and intention, respectively, and the intermediating effect of intention (H5) in the three groups of relationship: attitude–behavior (H5a), subjective norms–behavior (H5b) and perceived behavior control–behavior (H5c). H4 explores the direct effect of perceived behavior control and behavior. And the moderating effect of regional green development level (H6a, H6b, H6c, H6d, H6e) and enterprise-size (H7a, H7b, H7c, H7d, H7e) on the above relationship.

intermediates their capabilities and behaviors. In the direction of agriculture, Yu et al. (2018) used TPB to test how farmers' cognition (attitude, subjective norms, and perceived behavioral control) influences their intention to participate in environmental governance behavior and their actual participation in agriculture. This study builds on these findings and formulates the following hypotheses:

H5: Behavioral intention significantly and positively affects the green development behavior of construction enterprises.

H5a: Behavioral intention plays an intermediating role between attitude and the green development behavior of construction enterprises.

H5b: Behavioral intention plays an intermediating role between subjective norms and the green development behavior of construction enterprises.

H5c: Behavioral intention plays an intermediating role between perceived behavioral control and the green development behavior of construction enterprises.

Moderator. It has been shown that behavioral intention sometimes fails to predict behavior effectively in the presence of external circumstances (Ajzen, 2011). Thus, this study considers introducing an external environmental variable: the level of regional green development where the enterprise is located. This variable captures the development of various elements such as environmental efficiency, industrial structure, green production and consumption, and urbanization level in the region. Following Wu et al. (2020), who measured the level of green development in 30 provinces divided into 2 levels of regional green development. Moreover, enterprise size plays a moderating role in enterprise green development behavior and influencing factors (Li et al., 2022d). In summary, this study sets up a multi-group category of enterprise size and the level of regional green development to explore their moderating effects. The following hypotheses were developed for this study:

H6a: The regional green development level positively moderates the relationship between attitude and intention. H6b: The regional green development level positively moderates the relationship between subjective norms and intention. H6c: The regional green development level positively moderates the relationship between perceived behavioral control and intention. H6d: The regional green development level positively moderates the relationship between perceived behavioral control and behavior. H6e: The regional green development level positively moderates the relationship between intention and behavior.

H7a: Enterprise size positively moderates the relationship between attitude and intention. H7b: Enterprise size positively moderates the relationship between subjective norms and intention. H7c: Enterprise size positively moderates the relationship between perceived behavioral control and intention. H7d: Enterprise size positively moderates the relationship between perceived behavioral control and behavior. H7e: Enterprise size positively moderates the relationship between intention and behavior.

In summary, this study constructs a TPB theoretical model, as shown in Fig. 2.

Research methodology

Questionnaire design and sample data. This study forms a structured research questionnaire based on the theoretical model of TPB and the established scales (Ajzen, 2002; Li et al., 2020). The index description of the dimension is shown in Table 1. Then, the initialized research questionnaire is revised continuously based on the opinions of five professors and PhDs in the field of

Table 1 Index characterization of dimensions.

Main factors	Code	Sub-factors	Reference
ATT	ATT1	Purchase environmental protection equipment	(Li et al., 2020; Yang et al., 2019)
	ATT2	Use of environmentally friendly processes	(Li et al., 2020; Luo et al., 2017)
	ATT3	Work with environmentally friendly suppliers	(Li et al., 2020; Schulze-Ehlers et al., 2014)
	ATT4	Recycle and dispose of construction waste	(Li et al., 2020; Ramos and Martinho, 2021)
	ATT5	Green building design	(Abdelaal and Guo, 2021; Li et al., 2020)
	ATT6	Building a green brand	(Li et al., 2020; Simão and Lisboa, 2017)
SN	SN1	Environmental policies	(Li et al., 2020; Li et al., 2022c)
	SN2	Consumers	(Li et al., 2020; Liao et al., 2018)
	SN3	Neighboring residents	(Li et al., 2020; Li et al., 2022d)
	SN4	Social environmental organizations	(Lee, 2019; Li et al., 2020)
	SN5	News media	(Li et al., 2020; Tang et al., 2020)
PBC	PBC1	Sufficient social network resources	(Bai et al., 2022; Li et al., 2020)
	PBC2	Sufficient funds	(Li et al., 2020; Wang et al., 2021)
	PBC3	Sufficient human resources	(Li et al., 2020)
	PBC4	Sufficient environmental protection equipment	(Li et al., 2020)
	PBC5	Sufficient patents	(Li et al., 2020; Wei et al., 2021)
BI	BI1	Adopt environmental protection behavior	(Li et al., 2020; Peng et al., 2021a)
	BI2	Purchase environmental protection equipment	(Li et al., 2020)
	BI3	Adopt environmentally friendly processes	(Li et al., 2020; Luo et al., 2017)
	BI4	Cooperate with environmentally friendly suppliers	(Li et al., 2020; Schulze-Ehlers et al., 2014)
	BI5	Support recycling and dispose of construction waste	(Li et al., 2020; Ramos and Martinho, 2021)
	BI6	Embrace green building design	(Abdelaal and Guo, 2021; Li et al., 2020)
	BI7	Build green brands	(Li et al., 2020; Simão and Lisboa, 2017)
BEH	BEH1	Follow strict cleanliness requirements	(Li et al., 2020)
	BEH2	Select and improve environmentally friendly equipment	(Li et al., 2020)
	BEH3	Choose green building design	(Abdelaal and Guo, 2021; Li et al., 2020)
	BEH4	Actively build a green brand	(Li et al., 2020; Schulze-Ehlers et al., 2014)
	BEH5	Actively seek partners to achieve energy saving and emission reduction goals	(Li et al., 2020; Simão and Lisboa, 2017)
	BEH6	Conduct environmental and energy audits of suppliers' internal management	(Johnson, 2015; Li et al., 2020)
	BEH7	Require suppliers to provide products that meet environmentally friendly design	(Abdelaal and Guo, 2021; Li et al., 2020)
	BEH8	Evaluate the environmentally friendly behavior of suppliers	(Li et al., 2020; Schulze-Ehlers et al., 2014)
	BEH9	Look at other companies' green technologies in the supply chain	(Li et al., 2020)
	BEH10	Purchase environmentally friendly materials	(Li et al., 2020)
	BEH11	Actively share energy-saving and emission reduction technologies with other companies in the supply chain	(Li et al., 2020; Li et al., 2022b)
	BEH12	Choose suppliers who have passed third-party environmental management system certification	(Li et al., 2020; Wu et al., 2020)
	BEH13	Actively communicate information about by-products between companies in the supply chain	(Baratsas et al., 2021; Li et al., 2020a)

environmental management in construction enterprises. The first part is the demographic information of the interviewed employees of construction enterprises and enterprise characteristics (gender, age, education level, position, region, and enterprise size). The second part is the scale items corresponding to five predictive latent variables: attitude, subjective norm, perceived behavioral control, behavioral intention, and GDB-CE. The questions are in the form of a five-point Likert scale, ranging from "strongly disagree" (1 point) to "strongly agree" (5 points). The researchers conducted a prestudy of construction firms in two extremely tabulated regions (Shanghai and Chengdu) and returned 50 questionnaires (Cronbach's $\alpha = 0.949$, KMO = 0.738). The questions of the questionnaire are revised based on the results of the prestudy, and the official questionnaire is developed (Supplementary A).

This study uses a random sampling strategy and distributed questionnaires to construction enterprises in the form of electronic questionnaires, and the research period is from January to March 2022. The selection criteria of the sample are as follows: (1) Type of enterprise. The research enterprises are mainly construction enterprises. Specifically, construction contracting companies, building installation companies, building decoration companies, mechanized construction companies, engineering companies, and other specialized construction companies. (2)

Enterprise size. Enterprise size can be large (revenue ≥ 80 million yuan or total assets ≥ 80 million yuan), medium (60 million yuan ≤ revenue < 80 million yuan or 50 million yuan ≤ total assets < 80 million yuan), small and micro enterprises (revenue < 60 million yuan or total assets < 50 million yuan) in any category. (3) Position type. Positions for senior leadership, middle management, and grassroots employees in any category. Finally, 419 questionnaires were collected. After excluding invalid questionnaires with errors, 306 valid questionnaires were finally obtained. The effective return rate of the questionnaire was 73.03%. The sample is distributed in 28 provinces (cities) in China. Considering the availability of data, the sample in this paper excludes Hong Kong, Macao, Taiwan, Hainan Province, Qinghai Province, and Tibet Autonomous Region. The characteristics of the study sample are shown in Table 2.

Table 2 Descriptive statistics of demographic variables and enterprise characteristics.

Variable	Item	Frequency	Percentage
Gender	Male	133	43.46
	Female	173	56.54
Age	≥50	3	0.98
	40–49	4	1.31
	30–39	130	42.48
	<30	169	55.23
Education	Master's/Ph.D.	25	8.17
	Specialized/ Undergraduate	275	89.87
	High school and below	6	1.96
Position	Senior	16	5.23
	Mid–level	101	33.01
	Grassroots	189	61.76
Level of regional green development	High	197	64.38
	Low	109	35.62
Enterprise size	Large	112	36.60
	Medium	119	38.89
	Small and micro	75	24.51

PLS-SEM. The second-generation statistical technique structural equation model (SEM) overcomes the limitations of being able to deal only with simple model structures and observable variables (Haenlein and Kaplan, 2004). SEM can be used to estimate multivariate interactions and consists of a measurement model and a structural model. SEM is available in CB-SEM and PLS-SEM methods. Compared to CB-SEM, PLS-SEM has more advanced algorithms and flexible modeling techniques and can handle small data samples with different degrees of normality and skewness (Chin, 2010; Hair et al., 2016). Furthermore, PLS-SEM is suitable for empirical studies with small samples and is now widely used in construction and business management (Malik and Khan, 2021; Zeng et al., 2021). Therefore, it is reasonable to use PLS-SEM as the analysis method in this study.

As shown in Fig. 3, the multigroup structural equation model of the green development behavior of construction enterprises has two parts: a measurement model and a structural model. The measurement model has five latent variables: attitude (ATT), subjective norm (SN), perceived behavior control (PBC), behavioral intention (BI), and green development behavior of construction enterprises (GDB-CE). Each latent variable has several measurement indicators. The structure model shows how the latent variables (ATT, SN, PBC, BI, GDB-CE, regional green development behavior, and firm size) relate to each other.

This study uses Harman's single-factor test (Podsakoff and Organ, 1986) to examine the severity of common method

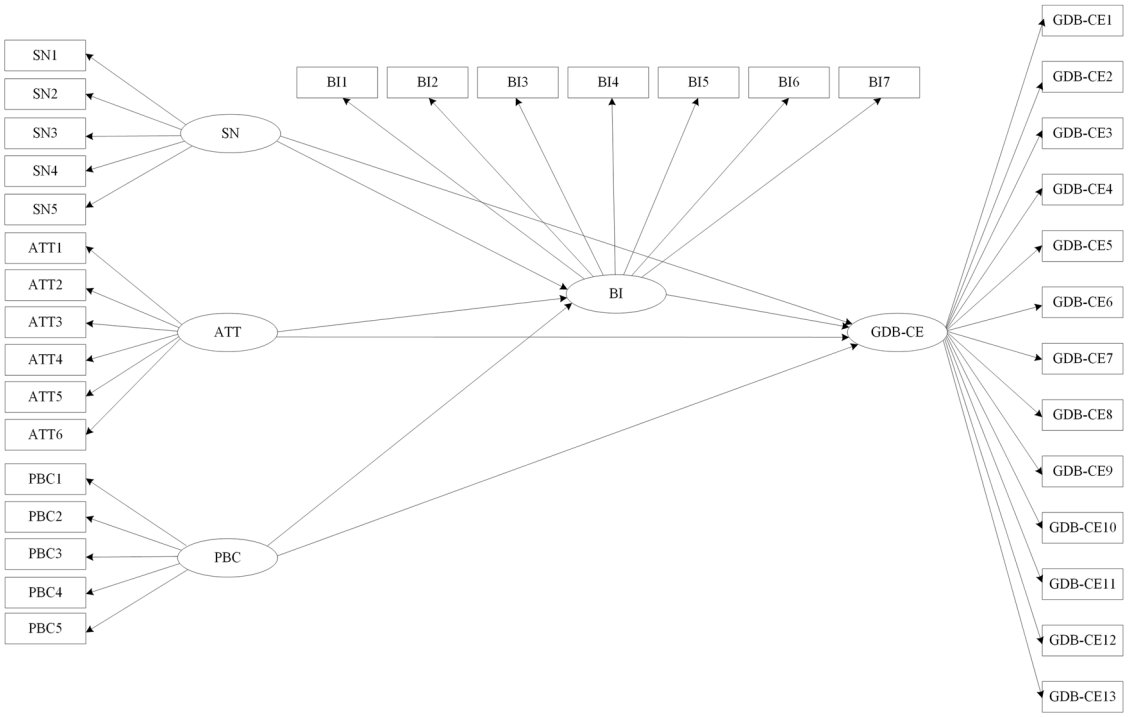

Fig. 3 A multigroup structural equation model of the green development behavior of construction enterprises. It shows the measurement and structure model. In the measurement model, attitude is measured by 6 indicators, subjective norms are measured by 5 indicators, and perceived behavioral control is measured by 5 indicators. Intention is measured by 7 indicators and behavior by 13 indicators. The structure model consists of cognition, intention, and behavior.

variance (CMV). Factor analysis of all questions was conducted by SPSS v26. The analysis result shows that the variance percentage of the first extracted unrotated common factor is 35.503%, which is <40%. This indicates that CMV is not a serious problem in this study.

Reliability and validity. In terms of reliability, the study questionnaire is tested at both the overall and each latent variable level using SPSS 26.0 and SmartPLS 3.0, and the results are shown in Table 3. The results show that the overall Cronbach's α is 0.945, and the latent variable Cronbach's α is in the range of 0.779−0.921, all >0.7. The composite reliability (CR) is in the range of 0.850−0.932 and is >0.7. In conclusion, the study questionnaire had high reliability.

This study mainly examined content validity and structural validity terms of validity. The questionnaire is modified based on a mature questionnaire, which is reviewed and preresearched by experts. This ensures the content validity of the questionnaire. In addition, the structural validity of this study was tested by SPSS 26.0 and SmartPLS 3.0 software (Table 4). The results showed that the overall KMO of the questionnaire was 0.928, and the latent variable KMO ranged from 0.823 to 0.926, all >0.7. The average variance extracted (AVE) ranged from 0.514 to 0.543, all >0.5. The HTMT index measured differential validity of 0.495−0.834 (Table 5), all <0.85 (Henseler et al., 2015). This indicates that the discriminant validity of this study met the requirements. This shows that the study questionnaire passed the validity test.

Table 3 Results of reliability and validity tests.

Variable	Cronbach' α	CR	KMO	AVE
ATT	0.826	0.873	0.840	0.534
SN	0.790	0.856	0.823	0.543
PBC	0.779	0.850	0.828	0.532
BI	0.857	0.891	0.878	0.539
BEH	0.921	0.932	0.926	0.514
Total	0.945	-	0.928	-

Table 4 Discriminant validity (HTMT).

	ATT	BEH	BI	PBC	SN
ATT					
BEH	0.568				
BI	0.834	0.781			
PBC	0.693	0.495	0.760		
SN	0.674	0.539	0.740	0.671	

Results and discussion

This study tests the theoretical model of the green development behavior of construction enterprises using partial least-squares structural equation modeling (PLS-SEM). In this study, SmartPLS 3.0 is used to calculate the path coefficients of each variable and the inter-variate effects. Then, PLS-MGA analysis is used to obtain the differences between two multiple groups of enterprise size and the level of regional green development where the enterprise is located.

Model test results. The value of R^2 ranges from 0 to 1, and the higher the value is, the better the fit of the model to the data (Hair et al., 2019). The explanatory structural model index R^2 is 0.614 and 0.522. Thus, the model in the study has a good fit. The model estimation results show that the normalization coefficients of H1, H2, H3, and H5 are positive and significant (Fig. 4). Specifically, attitude, subjective norms, and perceived behavioral control all have a significant positive impact on GDB-CE. H4 not only is the standardized coefficient negative but also does not reach the significance level of 0.05. Therefore, the result rejects H4. Correspondingly, H6d and H7d are not supported.

Testing intermediation effect. According to the results of the direct effect test, attitude, subjective norms, and perceived behavioral control of the green development behavior of construction enterprises have significant positive effects on intention. Additionally, the intention of green development behavior of construction enterprises has significant positive effects on behavior. Therefore, this paper tests the intermediation effect of intention on attitude, subjective norms, and perceived behavioral control on the green development behavior of construction enterprises. After 5000 iterations using the bootstrapping algorithm, this paper obtains the direct effect, indirect effect, and total effect of the three paths in the structural model, as shown in Table 5. Hair et al. (2014) noted that variance accounted for (VAF) is used to calculate the intensity of intermediation. VAF > 80% indicates complete intermediation, 20% ≤ VAF ≤ 80% indicates partial intermediation and VAF < 20% indicates no intermediation effect. As shown in Table 6, the green development behavioral intention of construction enterprises has a VAF value of 99.34% in the path between green development behavior attitude and behavior of construction enterprises. This means that the green development behavioral intention of construction enterprises fully intermediates the relationship between the green development behavior attitude and the behavior of construction enterprises. The green development behavioral intention of construction enterprises has a VAF value of 71.81% in the path between subjective norms and the green development behavior of construction enterprises. This means that the green development behavioral intention of construction enterprises partially intermediates the relationship between subjective norms and the behavior of green development behavior of construction

Table 5 Results of intermediating effect test.

Variable relation	Path	Effect	Effect value	VAF	Hypothesis	Total effect
ATT→BI→GDB-CE	ATT→GDB-CE	Total effect	0.305***	99.34%	H5a	Supported
		Direct effect	0.002			
		Indirect effect	0.303***			
SN→BI→GDB-CE	SN→GDB-CE	Total effect	0.227***	71.81%	H5b	Supported
		Direct effect	0.064			
		Indirect effect	0.163***			
PBC→BI→GDB-CE	PBC→GDB-CE	Total effect	0.155***	116.13%	H5c	Supported
		Direct Effect	-0.025			
		Indirect effect	0.180***			

***Indicates $p < 0.001$, **indicates $p < 0.01$.

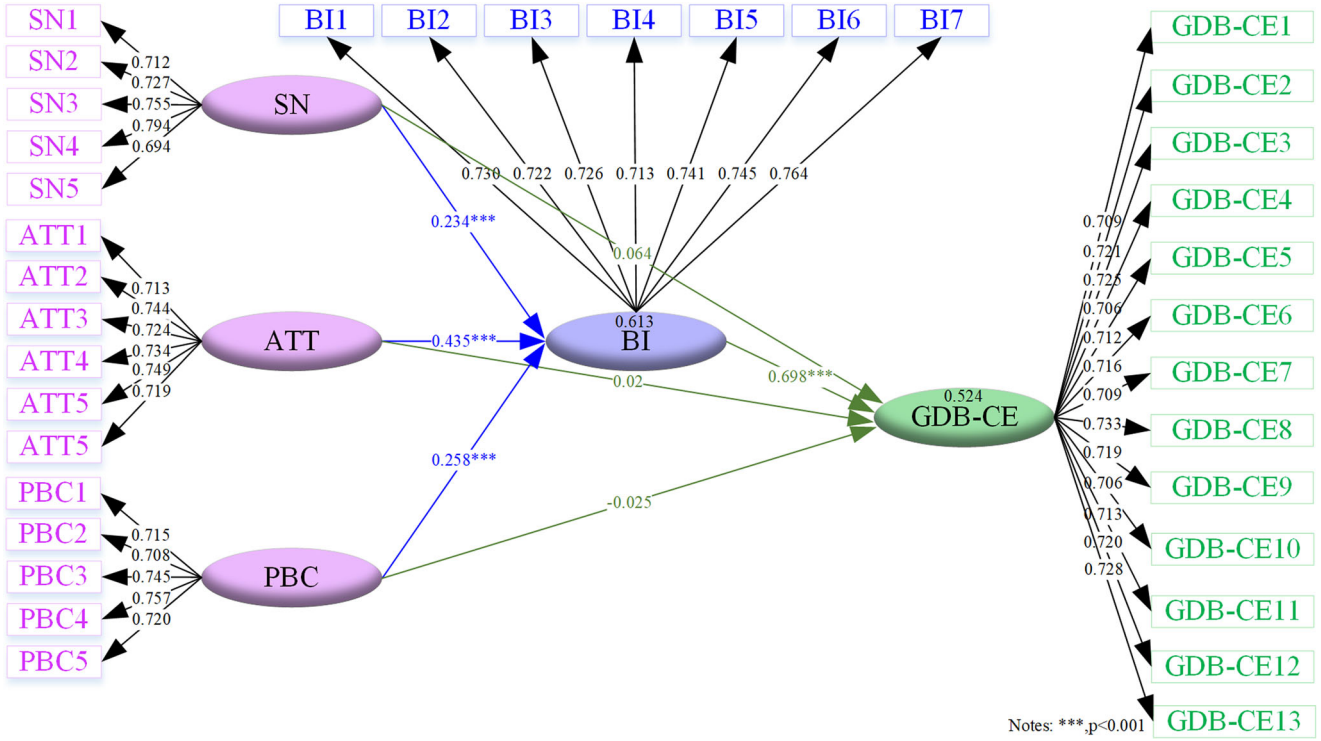

Fig. 4 Model standardization coefficient estimation results. It shows the path coefficient results of the multi-group structure model of green development behavior of construction enterprises. The path coefficient of attitude dimension is in the range of 0.713–0.749, the path coefficient of subjective norms dimension is in the range of 0.694–0.794, the path coefficient of perceived behavior control dimension is in the range of 0.708–0.749, and the path coefficient of intention is in the range of 0.713–0.764. The behavior path coefficient is in the range of 0.709–0.733.

Table 6 Multi-group results.

Path	Enterprise size (H7a, H7b, H7c, H7e)			Level of regional green development (H6a, H6b, H6c, H6e)	
	Small	Medium	Large	Low	High
H1	0.445***	0.506***	0.360***	0.429***	0.429***
H2	0.135	0.176*	0.385***	0.197**	0.266***
H3	0.391***	0.159	0.260***	0.361***	0.204**
H5	0.802***	0.668***	0.769***	0.648***	0.752***

***Indicates $p < 0.001$, **indicates $p < 0.010$, *indicates $p < 0.050$.

enterprises. The green development behavioral intention of construction enterprises has a VAF value of 116.13% in the path between perceived behavioral control and the behavior of green development behavior of construction enterprises. This means that the green development behavioral intention of construction enterprises fully intermediates the relationship between perceived behavioral control and the behavior of green development behavior of construction enterprises.

Multigroup results. In order to test H6 (H6a, H6b, H6c, H6d, H6e) and H7 (H7a, H7b, H7c, H7d, H7e), this paper uses the PLS-MGA algorithm to perform a multigroup analysis. The algorithm was iterated 5000 times, and the results are shown in Table 6. In path H1 of positive attitude-behavioral intention impact, small enterprises (0.445, $p < 0.001$), medium enterprises (0.506, $p < 0.001$) and large enterprises (0.360, $p < 0.001$) had slightly higher values than the other two sizes. It supports H7a. The impacts with a low level of regional green development (0.429, $p < 0.001$) and a high level (0.429, $p < 0.001$) are positive and significant. It supports H6a. In path H2 of the positive influence of subjective norm-behavioral intention, small enterprises (0.135) are not significant, and medium enterprises (0.176, $p < 0.050$) and large enterprises (0.385, $p < 0.001$) have a significant positive influence. It supports H7b. The impact of a low level of regional green development (0.197, $p < 0.050$) is lower than that of high levels (0.266, $p < 0.001$). It supports H6b. Path H3 of perceived behavioral control—behavioral intention has a positive influence. Medium enterprises (0.159) are insignificant, while small enterprises (0.391, $p < 0.001$) and large enterprises (0.260, $p < 0.001$) have a significant positive influence. It supports H7c. The impact of a low level of regional green development (0.361, $p < 0.001$) is higher than that of a high level (0.204, $p < 0.010$). It supports H6c. In path H5 of behavioral intention-behavior, small enterprises (0.802, $p < 0.001$) have a higher influence than medium-sized enterprises (0.668, $p < 0.001$) and large enterprises (0.769, $p < 0.001$). It supports H7e. The impact of a low level of regional green development (0.648, $p < 0.001$) is lower than that of a high level (0.752, $p < 0.001$). It supports H6e.

Discussion

Test path discussion. The results show that H1, H2, and H3 are supported. This indicates that behavioral intention is positively and significantly influenced by attitude, subjective norms, and perceived behavioral control. In terms of individual environmental behavior, Kumar and Nayak (2022) used a meta-analysis method based on the TPB model to examine how attitude, subjective norms, and perceived behavioral control influence green energy behavior. In terms of organizational environmental behavior, Long et al. (2017) verified that environmental behavior attitude, subjective norms, and perceived behavioral control positively affect environmental behavioral intention from the perspective of industrial enterprises. The difference is that this

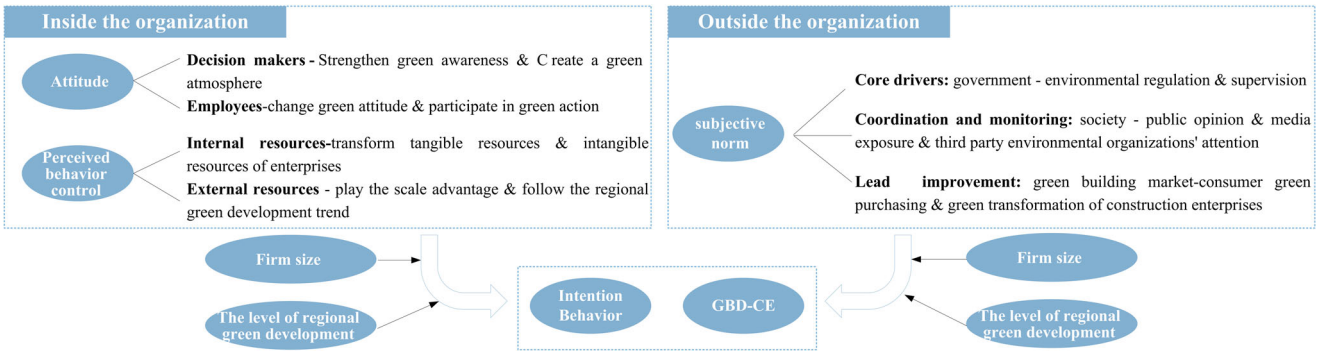

Fig. 5 Management implication framework. It presents management implications from the perspective of internal and external organizations based on the research results of model verification.

paper further discusses the organizational behavior of the green development of construction enterprises. There are significant differences in the degree of effect of each factor. In response, this study analyzed from an organizational perspective that both attitude and perceived behavioral control within the organization play a greater role than subjective norms. The results of Li et al. (2022d) mentioned that the degree of influence is greater within the organization than outside the organization. A more voluntary approach is exhibited within the organization. Attitude reflects the intangible resources of the enterprise, and perceived behavioral control reflects the tangible resources of the enterprise. Both are internal resources that the enterprise can deploy on its own. In contrast, subjective norms come from outside the organization and act on the construction firm in the form of pressure. Driven by external pressures, construction enterprises involuntarily take reactive measures without using degrees. This results in different levels of action.

Second, relative to the remaining two factors, attitude plays a greater role in behavioral intention to a greater extent. Paul et al. (2016) mentioned that the driving effect of attitude is higher than the other two factors when studying the consumption behavior of green products because the positive attitude of green consumers in the Indian market encourages them to buy more green products. Kumar and Nayak (2022) also tested attitude as the most crucial antecedent of behavioral intention. Different from the individual green behaviors of green consumers, this study studies corporate behaviors, and companies often guide corporate behaviors by formulating strategic layouts. The strategic layout of construction enterprises is carried out with management as the core and with the assistance of employees. Thus, it is clear that attitude is a joint reflection of the green attitude of enterprise employees and management decision-makers. In summary, behavioral intention combines voluntary behavioral attitude, subjective norms, and perceived behavioral control. Therefore, construction enterprises can adopt a means to improve their intention to develop green behaviors by focusing on the internal organization and monitoring the external organization.

This study has analyzed the direct paths of GDB-CE. The results show that behavioral intention directly affects behavior (H5). However, the path perceived behavioral control-behavior does not pass the test (H4). Perceived behavioral control does not directly drive construction enterprises to adopt green development behaviors, which is contrary to the findings of Li et al. (2022d). Although construction enterprises have sufficient resources for adopting green development behavior, this does not drive construction enterprises to adopt the behavior. The profit-seeking nature of business is the key to this phenomenon. In contrast, the results of the study confirm a higher indirect positive effect of perceived behavioral control on GDB-CE. Tashakor et al. (2019) verified that perceived behavioral control significantly and indirectly affects the adoption of environmental management accounting practices by Australian cotton farmers. In contrast, the paper reveals significant indirect effects of perceived behavioral control on GDB-CE, resulting in evidence from the construction industry.

Multi-group results in discussion. The results show that behavioral intention is constrained by enterprise size (H6). Similarly, Li et al. (2022d) found that firm size moderates firms' green behavior. This study complements their research by focusing on construction enterprises from various angles. A possible reason for this phenomenon is that firm size determines both resource allocation and external pressure levels. Larger enterprises have more accumulated resources and can afford to adopt green behaviors more easily than smaller ones. Furthermore, large enterprises also receive preferential treatment due to their size (Chien et al., 2021). In the construction industry, large construction enterprises' strategies attract more attention from the government, society, and the market. Therefore, there are differences between small, medium, and large construction enterprises. Additionally, there was a significant difference in the degree of contribution to the path at different levels in the grouping of the regional green development level where the enterprise is located (H7). Different from the existing research that only considers the measurement and evaluation of regional green development behavior, this paper applies this concept to the empirical research of the construction industry and examines its moderating effect on construction enterprises. A high level of regional green development indicates financial investment, a regional government governance system, a regional enterprise technology innovation level, and industrial structure upgrading. Regions with different green development levels vary significantly in terms of green market maturity, green consumer preference, government governance methods, social attention degree, and so on. A high level of regional green development facilitates construction enterprises to adopt green development behavior.

Management implications. This study investigated how construction enterprises' green development behavioral intention is influenced by attitude, subjective norms, and perceived behavior control. It also examined how this intention translates into green development behavior, both internally and externally. Therefore, this study proposes a framework for managing the green development behavior of construction enterprises based on these findings (see Fig. 5). The framework suggests that within the organization, managers and employees should foster a positive attitude towards green development and leverage organizational resources to facilitate it. Outside the organization, government leadership and social participation are crucial for promoting green development. This study also acknowledges that enterprise size and regional green

development level may moderate these effects. Thus, future research should explore how different contexts affect the green development behavior of construction enterprises.

Inside the organization, construction enterprises need to start from two aspects: attitude and perceived behavioral control. Managers should prioritize environmental protection over profit in their production and operation activities. They need to strengthen their green awareness, create a green culture within the organization, and change the attitudes of staff at all levels toward green innovation. This will encourage grassroots employees to participate more actively in the green innovation process. Grassroots employees should not only adopt green values but also take part in green innovation themselves. The enterprise strategy should be based on intangible resources with tangible resources as a supplement. Enterprises should focus on organizational structure, brand reputation, corporate culture, and technological innovation to develop relevant green behaviors for construction enterprises. This will improve the intention and ability of employees at different levels to act greenly. In addition, construction enterprises should adapt to the local green development trend, leverage their scale advantages, and achieve green transformation.

Outside the organization, the government, society, and the green market in the construction industry actively promote the adoption of green development behaviors by construction enterprises from outside the organization and accelerate the green transformation of the construction industry. As the core driving force for the green development and transformation of the whole industry, the government encourages construction enterprises to adopt green development behaviors by introducing policies and monitoring means to improve the green market of the construction industry. The government provides subsidies to construction companies that make the transition through environmental regulations and penalizes those that do the opposite. Residents, media, and third-party environmental organizations should increase supervision. Governments should also consider regional heterogeneity and develop environmental regulations for the development of each region, as well as increase the intensity and frequency of environmental regulation. The public can use their opinion to pressure construction companies to reduce pollution, encourage them to build green brands, and publish their Environmental-Social- Governance (ESG) reports so that their green development becomes transparent. The public can also learn more about green knowledge through various channels so that they can participate more actively in the process of green development. Incentives and penalties should be dynamically adjusted to encourage enterprises and the public to participate in green development actions and achieve local adaptation. In addition, construction enterprises and green consumers in the construction industry green market should also create a good environment for green development and avoid this phenomenon. In addition, in regions with high levels of green development, the government can focus on green technology innovation. Governments can use the subsidy mechanism of environmental regulation to encourage construction companies and the public to participate in the innovation process. In less developed areas, the government can increase the frequency of publicity campaigns on the theme of green development to raise public awareness of the environment.

Conclusion

To reveal the role mechanism of the green development behavior of construction enterprises, this study is based on TPB and 306 questionnaire research data points related to the green development of construction enterprises in 28 provinces (cities) in China. This study uses PLS-SEM to conduct an empirical study on the mechanism of the green development behavior of construction enterprises. This paper verifies the intermediating effect of intention on the mechanism of the green development behavior of construction enterprises. In addition, this study establishes multiple clusters to analyze the moderating role of regional green development level and enterprise size. This study found the following:

(1) Attitudes, subjective norms, and perceived behavioral control have significant positive effects on the green development behavioral intention of construction enterprises, with attitudes being the strongest predictor.
(2) Intention intermediates the relationships between attitude, subjective norms, perceived behavioral control, and the green development behavior of construction enterprises to varying degrees.
(3) Regional green development level and enterprise size positively moderate the four groups of the relationship between attitude, subjective norms, perceived behavioral control, intention, and green development behavior of construction enterprises.

This study contributes to the theory of planned behavior (TPB), a classic framework for understanding individual behavior, by developing and testing a TPB-based model to explain the green development behavior of construction enterprises as a specific type of organization. By applying partial least squares structural equation modeling (PLS-SEM), this study offers novel empirical support for the TPB and reveals how different factors influence the green development behavior of construction enterprises. Moreover, this study recognizes that green development behavior is an organizational phenomenon that involves multiple actors within and outside the firm, with managers playing a pivotal role in shaping and implementing it. Thus, this study advances our knowledge of green development behavior and organizational behavior in the context of construction firms. The findings also have implications for other industries that face similar challenges and opportunities for pursuing green development.

This study has some limitations that may affect the validity and generalizability of the findings. First, due to the limitation of article length, this paper did not explore in depth the intermediating role of behavioral intention between behavior and its antecedents (behavioral attitude, subjective norms, and perceived behavioral control). This may lead to an incomplete understanding of the factors that influence the green development behavior of construction enterprises. Future research should examine this intermediating mechanism more thoroughly using longitudinal data and structural equation modeling. Second, this paper focused only on construction enterprises in one country and did not compare them with other industries or regions. This may limit the applicability of the results to other contexts and settings. Future research should expand the scope of the investigation and conduct cross-industry and cross-national comparisons to test the robustness and universality of the proposed model.

Data availability

The data are available from the corresponding author on reasonable request.

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Author contributions

Xingwei L: Conceptualization, methodology, writing—original draft, supervision, project administration; JD: Methodology, validation, formal analysis, investigation, resources, data curation, writing—original draft, writing— review & editing, visualization; SQ: conceptualization, supervision; writing—review & editing; XZ, JL, JH, YH, Xiang L: Review & Editing.

Ethical approval

Our study was not medical research nor employed any experiments on humans, and we used a survey to collect data. Hence, according to the Declaration of Helsinki, the ethical issue should not be a problem in our study. Furthermore, the gathered information is strictly confidential and anonymous and is only used for research purposes.

Informed consent

We obtained informed consent from the participants by enclosing a confirmation question for the consent statement in the research questionnaire.

Competing interests

The authors declare no competing interests.

Additional information

Supplementary information The online version contains supplementary material available at https://doi.org/10.1057/s41599-023-01724-9.

Correspondence and requests for materials should be addressed to Qiong Shen.

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