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Understanding consumer responses to carbon footprint product labels: A multi-group analysis of online and offline shopping engagement in retail contexts

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ABSTRACT

As carbon footprint product labels (CFPL) gain prominence as tools for encouraging environmentally responsible consumption, it becomes increasingly important to explore how consumers interpret and respond to such information. This study applies the Value-Belief-Norm (VBN) framework to investigate the relationships among Sustainability-Oriented Values (SOV), Carbon Label Awareness (CLA), Eco-Conscious Norms (ECN), and Sustainable Purchase Behavior (SPB), while also examining the moderating influence of Shopping Engagement Modes and Cognitive Processing Styles. A multi-group structural equation modeling (SEM) analysis was conducted using a sample of 662 consumers, segmented into Online-Dominant Shoppers ($n = 340$) and Offline-Dominant Shoppers ($n = 322$), as well as Systematic Processors ($n = 345$) and Heuristic Processors ($n = 317$). The findings reveal differentiated decision-making patterns across these consumer groups. Online-focused consumers exhibited a greater reliance on CLA for immediate decisions, whereas offline consumers were more likely to follow a sequence involving both CLA and ECN, indicating the heightened role of social influence in physical shopping contexts. Systematic Processors demonstrated more deliberate integration of eco-labels and norms into their decisions, while Heuristic Processors were more influenced by surface-level label recognition. The study underscores that consumer responses to sustainability labels are not homogenous, and that both contextual and cognitive factors shape purchasing behavior. Strategic implications include enhancing digital label visibility for online shoppers and strengthening normative messaging in physical retail to encourage sustainable consumption.

1. Introduction

Addressing climate change and environmental decline remains one of the most pressing global challenges, with extensive consequences for ecological systems, economic structures, and human well-being. As the demand for emissions reduction intensifies, the choices made by individual consumers are increasingly seen as key contributors to sustainability transitions. One market-driven approach to influence these choices is the use of Carbon Footprint Product Labels (CFPLs), which inform buyers about the environmental consequences associated with the production and distribution of goods, thus enabling more responsible consumption decisions. Several countries have trialed or implemented CFPL systems to facilitate this behavioral shift. For instance, the United Kingdom led early efforts through the Carbon Trust in 2006, which played a pivotal role in elevating public engagement and shaping

corporate sustainability efforts (Zhao & Geng, 2021). Japan and Taiwan later launched government-endorsed CFPL schemes incorporating lifecycle emissions data, highlighting institutional backing for such initiatives (Wong et al., 2022). In recent years, countries like China, South Korea, and Thailand have introduced or expanded CFPL applications, illustrating a growing international consensus around the use of carbon labels to influence consumption patterns. These efforts represent growing global alignment on the role of CFPLs in transforming consumption patterns. Below, Table 1 summarizes various carbon labels worldwide.

Despite their increasing prevalence, the impact of CFPLs appears to differ across retail settings, as consumer engagement with sustainability information varies by shopping mode and cognitive style. Although prior studies have examined how eco-labels affect consumer behavior, insufficient attention has been paid to how individual cognitive

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processing tendencies influence the interpretation and effectiveness of CFPLs within various shopping environments (Hwang & Hwang, 2024). Additionally, new hybrid formats such as live-stream commerce and community-driven group buying are beginning to blur the lines between digital and traditional retail models. With global e-commerce reaching \$5.8 trillion in 2023, the accelerating shift toward digital retail has altered the way sustainability information is encountered and processed, prompting further investigation into how CFPLs operate across different consumer interfaces (Hwang & Hwang, 2024). The emergence of omnichannel retailing—where consumers fluidly combine online and offline shopping experiences—adds further complexity to how purchasing decisions are formed (Hu & Hu, 2024; Khan & Mahmood, 2024). Those identified as Online-Dominant Shoppers typically engage with CFPLs through detailed product listings and digitally embedded sustainability cues, whereas Offline-Dominant Shoppers rely more on tangible interactions with packaging, shelf labels, and in-store stimuli such as employee recommendations or peer behaviors. These variations imply that CFPL effectiveness is not uniform and that the underlying psychological and contextual mechanisms driving sustainable purchasing may differ significantly between digital and physical environments.

Consumer choices are shaped in part by how individuals cognitively process sustainability-related information, a function commonly understood through cognitive processing styles (Brotja Nee Oliver et al., 2024). Dual-process decision-making frameworks explain that Systematic Processors tend to engage in careful, reflective evaluations of eco-labels, assessing environmental claims before making a purchase, while Heuristic Processors often depend on simplified cues such as visuals, brand familiarity, or promotional tags to guide their decisions (Duan et al., 2023). This contrast is particularly relevant when examining CFPL efficacy, since digital environments typically support detailed, analytical processing, while in-person shopping settings often prompt more intuitive or time-limited decisions (Elmor et al., 2024). Although many studies have investigated the influence of eco-labels, limited attention has been paid to the combined effects of Shopping Engagement Modes and Cognitive Processing Styles in driving sustainable choices. As a result, a gap remains in understanding how these factors jointly determine the behavioral outcomes of sustainability labeling efforts across diverse retail formats.

To address this gap, the present research employs the Value-Belief-Norm (VBN) theory (Stern et al., 1999) to analyze the influence of these moderating variables on the relationships among Sustainability-Oriented Values (SOV), Carbon Label Awareness (CLA), Eco-Conscious Norms (ECN), and Sustainable Purchase Behavior (SPB). VBN, grounded in environmental psychology, describes a sequential pathway where personal values inspire belief in environmental consequences, activate moral norms, and ultimately lead to pro-environmental behavior. By incorporating both psychological (processing style) and contextual (shopping mode) moderators, this research enhances the explanatory power of the VBN framework in modern retail contexts. However, these

behavioral pathways are expected to diverge based on differences in how consumers shop and think. For instance, those who primarily shop online may engage more deeply with numerical or comparative carbon data, while those in offline environments might base their decisions on signage, social interactions, or product packaging. These distinctions suggest the importance of developing carbon labeling strategies that are aligned with specific consumer traits and contexts.

This study seeks to achieve two main objectives:

- To explore the direct and indirect relationships between SOV and SPB, emphasizing the mediating roles of CLA and ECN.
- To assess the moderating effects of Shopping Engagement Modes (Online-Dominant vs. Offline-Dominant Shoppers) and Cognitive Processing Styles (Systematic vs. Heuristic Processors).

Through these objectives, the study argues that CFPLs do not influence all consumers equally but are instead filtered through a combination of context and cognition. Insights from this investigation are intended to assist marketers and policymakers in crafting more targeted and effective carbon labeling systems that cater to both online and offline consumption environments (Tiwari, 2023). Ultimately, the research seeks to inform evidence-based approaches for strengthening the behavioral impact of sustainability labels in varied retail settings.

2. Literature review and hypothesis development

This study expands the current sustainability literature by bringing together conceptual and behavioral perspectives to evaluate the effectiveness of CFPLs. While earlier studies have focused on the role of personal values and social norms in sustainable consumer actions (Hwang & Hwang, 2024; Stern et al., 1999), this research advances the VBN framework by integrating two pivotal constructs—CLA and ECN—to better understand how SOV affects SPB. A multi-group structural equation modeling (SEM) technique is used to analyze how consumer differences, in terms of Shopping Engagement Modes and Cognitive Processing Styles, influence these relationships (Gao et al., 2022; Muthaffar et al., 2024; Xiao et al., 2019). The dual-moderator approach allows for a nuanced view, showing that CFPLs exert varying levels of influence depending on consumer profiles and the retail context. This approach addresses a previously underexplored area in sustainability marketing, aligning with recent calls for more differentiated and situational analyses of eco-label effectiveness (Overton & Yang, 2021; Rese & Baier, 2025).

2.1. Value-belief-norm (VBN) theory and sustainable consumer behavior

Originally developed by Stern et al. (1999), the VBN Theory is widely recognized for explaining environmentally responsible behavior by tracing a path from internal values to specific actions through belief

Table 1
Global carbon footprint product labels overview.

Country/Region	Administering Organization	Key Features	Example Products/Brands	Consumer Utilization
United Kingdom	Carbon Trust	Lifecycle CO ₂ e disclosure; reduction commitments; third-party verification	Walkers Crisps, Nestlé, Unilever	Displayed on packaging and marketing materials
Japan	SuMPO (formerly JEMAI)	Lifecycle CO ₂ e data; integrated into broader environmental labeling	Citizen Watches, Nippon Meat Packers	Labels on products; online information
South Korea	Korea Environmental Industry & Technology Institute	Two-step certification: emission disclosure and low-carbon certification	Various consumer goods	Labels on packaging; certification marks
China	China Electronic Energy Saving Technology Association (CEESTA)	Lifecycle CO ₂ e disclosure; expanding across sectors; third-party verification	Electronics, textiles, daily consumer goods	Labels on products; online databases
United States	Private companies (e.g., Carbon Trust, Carbonfund.org)	No federal standard; third-party certifications	Allbirds, Oatly, Unilever	Labels on packaging; brand websites
Thailand	Thailand Greenhouse Gas Management Organization (TGO)	CO ₂ e disclosure; reduction label for emissions cut	Various consumer goods	Labels on packaging; TGO website

Sources: Data collection by Authors (2025).

formation and moral norms. Its relevance to consumer behavior in sustainability contexts, especially concerning CFPLs, has been emphasized in recent environmental psychology literature (Hwang & Hwang, 2024). The VBN model builds on foundational concepts like Schwartz's Norm-Activation Theory and the New Environmental Paradigm, outlining a sequential flow from personal values to pro-environmental actions.

The first stage consists of fundamental values, including biospheric (concern for nature), altruistic (concern for others), and egoistic (concern for self) orientations (Davis et al., 2023). The second stage involves beliefs about environmental consequences, where individuals recognize the impact of their consumption choices on the environment (Setiawan et al., 2021). Recent work has shown that online green communities can strengthen this belief structure by reinforcing social responsibility and subjective norms through repeated exposure to group-shared sustainability content (Shihab et al., 2025). The final stage activates personal norms, creating a moral obligation to act sustainably, which is influenced by ascription of responsibility—the belief that one's actions can mitigate environmental harm (Stern et al., 1999).

This study applies VBN Theory to examine how SOV drives CLA as a cognitive response, ECN as an internalized moral obligation, and ultimately SPB. In doing so, the study aligns CLA with the VBN's "belief" component—representing an individual's understanding of environmental consequences informed by values—while ECN captures the "personal norm" stage, reflecting moral obligation and responsibility (Stern et al., 1999; Wongsachia et al., 2025). In this study, ECN represent the operationalization of personal norms within the VBN framework. While personal norms traditionally refer to an individual's internalized moral obligation, ECN extends this by incorporating normative influences shaped by social awareness, environmental identity, and behavioral expectations relevant to modern sustainable consumption (Wongsachia et al., 2025). For instance, clustered retail environments, supported by digital technology, have also been shown to foster stronger consumer awareness and responsibility toward sustainability, reinforcing these value-driven pathways (Sun et al., 2024). Additionally, corporate social responsibility (CSR) messaging embedded in retail and hospitality settings can activate ECN more effectively when anthropomorphic appeals and positively framed consequences are used in tandem, which supports the VBN mechanism by strengthening emotional and moral engagement with environmental behavior (Surira et al., 2025). This conceptual alignment strengthens the theoretical basis for Hypotheses H1 and H2, which follow directly from the sequential structure of the VBN model (i.e., values influence beliefs, and beliefs influence norms).

H1. Higher Sustainability-Oriented Values (SOV) will positively influence Carbon Label Awareness (CLA).

H2. Higher Sustainability-Oriented Values (SOV) will positively influence Eco-Conscious Norms (ECN).

2.2. Sustainability-oriented values (SOV) and consumer decision-making

SOVs reflect ethical beliefs that drive pro-environmental behavior, shaping consumer preferences for sustainable products. Research highlights that biospheric values, emphasizing environmental well-being, are strong predictors of sustainable purchasing patterns (Caniëls et al., 2021). However, the extent to which these values influence purchasing behavior varies, as different consumers engage with sustainability information to varying degrees (Truc, 2024). In the context of online retail and food delivery services, recent studies show that value-driven purchasing decisions are shaped not only by environmental concern but also by perceived convenience, price sensitivity, and cultural alignment with sustainability claims (Nivornusit et al., 2024; Phonthanukitithaworn et al., 2022). Individuals with strong low-carbon awareness, influenced by SOVs, exhibit higher willingness to pay for carbon-labeled agricultural products, reinforcing the link between personal values and

sustainable behavior (Xu et al., 2024). Moreover, research suggests that emotional engagement with sustainability issues, such as an individual's affinity toward nature, further strengthens their commitment to sustainable consumption (Taufique, 2022). Recent evidence from high-tech retail enterprises in China shows that when external resources—such as policy mandates, green technologies, and consumer demand—are aligned with sustainability-oriented values, they significantly enhance green productivity and environmentally responsible behavior (Wang et al., 2025). This confirms that values alone may be insufficient unless supported by external structural and institutional stimuli, highlighting the importance of synergy between internal motivations and systemic support mechanisms. Given these insights, it is necessary to examine how carbon label awareness translates into eco-conscious norms.

In line with the VBN framework, CLA is conceptualized in this study as a belief-level construct—reflecting the individual's cognitive recognition of how consumption choices, such as carbon-labeled products, relate to environmental consequences. When consumers become more aware of the ecological impact conveyed by carbon labels, this belief fosters a stronger sense of moral responsibility to act. ECN, in turn, represent the personal norm component of the VBN sequence—internalized expectations to engage in environmentally responsible purchasing behavior. Thus, a higher level of CLA can serve as the cognitive trigger that activates ECN, reinforcing the belief-to-norm pathway at the heart of the VBN model (Stern et al., 1999; Wongsachia et al., 2025).

H3. Higher Carbon Label Awareness (CLA) will positively influence Eco-Conscious Norms (ECN).

2.3. Carbon label awareness (CLA) and its role in sustainable purchases

ECN are internalized moral standards that motivate consumers to make environmentally responsible choices. Research indicates that ECN help bridge the gap between awareness and action, reinforcing sustainable purchasing behavior (Lavuri, 2022; Rusyani et al., 2021). Consumers who internalize ECNs tend to prioritize sustainability, even in the absence of external incentives (Kumar & Yadav, 2021). In line with the VBN model, a necessary precursor to such behavioral outcomes is the formation of specific beliefs about environmental consequences—captured here by CLA (Hwang & Hwang, 2024; Stern et al., 1999).

CLA reflects consumers' understanding of the environmental impact of their purchasing choices, based on the information provided by CFPLs (Ang et al., 2024). This belief component is central to the VBN theory, as it connects value-based concerns to action by making environmental outcomes more cognitively salient and concrete. The perceived believability of CFPLs influences how consumers interpret environmental sustainability, particularly for carbon-intensive food products, reinforcing the cognitive role of CLA (Ang et al., 2024). Supporting this, Zhao et al. (2025) found that in-app appraisal factors—such as product information quality, price evaluations, and coping mechanisms—have strong mediating effects on sustainable purchase intentions in digital platforms. When sustainability cues are clearly integrated within mobile shopping environments, their influence on CLA and purchase intention is significantly amplified.

H4. Higher Carbon Label Awareness (CLA) will positively influence Sustainable Purchase Behavior (SPB).

2.4. Eco-conscious norms and sustainable purchase behavior

ECN are internalized moral standards that motivate consumers to make environmentally responsible choices. Research indicates that ECN help bridge the gap between awareness and action, reinforcing sustainable purchasing behavior (Lavuri, 2022; Rusyani et al., 2021). Consumers who internalize ECN tend to prioritize sustainability, even in the absence of external incentives (Kumar & Yadav, 2021). As suggested by the VBN theory, ECN reflects the final stage in the psychological

pathway from values to behavior, where individuals translate their environmental values and beliefs into a sense of moral duty to act sustainably (Stern et al., 1999). These norms are shaped not only by personal feelings of responsibility but also by shared environmental concerns in society, highlighting their dual nature as both individual motivations and socially influenced standards (Wongsaichia et al., 2025). In this framework, ECN serves as the key normative link that connects internal beliefs with actual sustainable behavior.

However, Shopping Engagement Mode and Cognitive Processing Style influence how eco-conscious norms translate into sustainable purchasing decisions. Systematic Processors may critically assess carbon labels in online settings, whereas Heuristic Processors rely on familiarity and visual cues in physical stores. Additionally, social influences play a role, as peer recommendations and promotional campaigns reinforce normative behaviors (Ebrahimi et al., 2021). Further, Tan, Casidy, and Arli (2025) demonstrated that SME owner-managers who possess strong biospheric values often establish firm-wide strategic green marketing orientations, which are perceived by customers and translated into eco-conscious behaviors. This confirms the indirect influence of managerial norms on consumer behavioral alignment.

H5. Higher Eco-Conscious Norms (ECN) will positively influence Sustainable Purchase Behavior (SPB).

2.5. Mediation effects of carbon label awareness and eco-conscious norms

While SOVs influence SPB, these effects may be indirect, mediated by CLA and ECN. Prior research suggests that CFPLs act as an intermediary between values and purchasing decisions, helping consumers translate pro-environmental attitudes into concrete actions (Feucht & Zander, 2018). Additionally, ECN further strengthens this relationship, reinforcing the idea that sustainable purchasing is a moral duty (Kumar & Yadav, 2021). Research on matched green advertising appeals also shows that when egoistic or altruistic message types align with product types, perceived credibility and purchase intentions increase, suggesting that mediating effects can be amplified when labels are embedded in the right context (Zhang et al., 2025). Within the VBN framework, CLA and ECN serve as mechanisms that channel abstract values into sustainable actions. CLA captures consumers' awareness of environmental consequences, while ECN reflects their internalized sense of moral responsibility (Stern et al., 1999; Wongsaichia et al., 2025). This sequence—SOV → CLA → ECN → SPB—illustrates how values shape beliefs, which in turn activate behavioral norms and sustainable behaviors.

H6. Carbon Label Awareness (CLA) will mediate the relationship between Sustainability-Oriented Values (SOV) and Sustainable Purchase Behavior (SPB).

H7. Eco-Conscious Norms (ECN) will mediate the relationship between Sustainability-Oriented Values (SOV) and Sustainable Purchase Behavior (SPB).

H8. Carbon Label Awareness (CLA) and Eco-Conscious Norms (ECN) will sequentially mediate the relationship between Sustainability-Oriented Values (SOV) and Sustainable Purchase Behavior (SPB).

2.6. Moderation effects of shopping engagement mode and cognitive processing style

The influence of SOV, CLA, and ECN on SPB is not uniform across consumers. Differences in Shopping Engagement Mode (Online-Dominant vs. Offline-Dominant) and Cognitive Processing Style (Systematic vs. Heuristic) shape how individuals process CFPLs and incorporate sustainability information into their purchasing decisions (Xiao et al., 2019). These variables act as boundary conditions that may strengthen or weaken the pathways established in the VBN framework, affecting how values are translated into beliefs, norms, and ultimately, behavior.

Online-Dominant Shoppers rely primarily on e-commerce platforms and digital content to guide purchasing decisions. Studies indicate that mobile commerce and digital interfaces enhance consumer interaction with sustainability labels, as online shopping provides structured and detailed product information (Gao et al., 2022). In contrast, Offline-Dominant Shoppers engage more with physical stores, making purchasing decisions based on in-person product attributes, shelf labeling, and verbal communication from store staff (Muthaffar et al., 2024). These differing engagement environments may moderate how CLA and ECN are activated, thereby influencing the overall strength of the value-to-behavior link proposed by VBN. The way CFPLs are presented across shopping modes influences how sustainability messages are processed and acted upon. In a similar vein, Reese and Baier (2025) found that the presence of sustainable fashion labels in subscription-based models increased consumers' willingness to pay, particularly in curated or self-selected packages, showing how interface design and consumer expectations mediate the influence of sustainability cues.

HA: Shopping Engagement Mode (Online-Dominant vs. Offline-Dominant) will moderate the structural relationships between key constructs in the model.

Consumers also process sustainability information differently depending on their Cognitive Processing Style. Systematic Processors engage in detailed evaluations of sustainability labels, carefully assessing carbon impact data before making a decision. They are more likely to rely on comparative product rankings and structured sustainability claims (Overton & Yang, 2021). Heuristic Processors, on the other hand, use simplified cues such as eco-labels and visual indicators, relying on intuitive judgments rather than analytical assessments (Muthaffar et al., 2024). Research suggests that information presentation influences consumer engagement with sustainability claims. While systematic processors prefer structured data, heuristic processors respond more to clear and visually distinct sustainability indicators (Overton & Yang, 2021). By accounting for differences in cognitive processing style, this study examines whether the internal mechanisms proposed by the VBN model operate uniformly across consumer segments or whether distinct communication strategies are needed to sustain their influence.

HB: Cognitive Processing Style (Systematic vs. Heuristic) will moderate the structural relationships between key constructs in the model.

3. Methodology

3.1. Proposed research framework and mathematical specification

Based on the VBN theoretical framework, this study proposes several hypothesized relationships that reflect the theory's causal chain. The model is extended by incorporating two segmentation variables—Shopping Engagement Mode (Online-Dominant vs. Offline-Dominant) and Cognitive Processing Style (Systematic vs. Heuristic)—to examine how consumers' contextual environments and psychological orientations influence the strength of value-driven behavioral mechanisms. Fig. 1 illustrates the proposed research framework, identifying both direct and indirect pathways, as well as the multigroup structure for moderation analysis. To enhance accessibility, Table 2 provides a summary of all hypotheses categorized by type (direct, mediation, and moderation). This study adopts a quantitative design using SEM, which is appropriate for testing complex relationships, examining latent constructs, and simultaneously evaluating direct and indirect effects (Byrne, 2004).

The following equations represent the mathematical specification of hypothesized relationships in the model, corresponding to the hypotheses listed in Table 1.

Direct Effects:

$$H1: CLA = \beta1 \times SOV + \epsilon1.$$

$$H2: ECN = \beta2 \times SOV + \epsilon2.$$

$$H3: ECN = \beta3 \times CLA + \epsilon3.$$

$$H4: SPB = \beta4 \times CLA + \epsilon4.$$

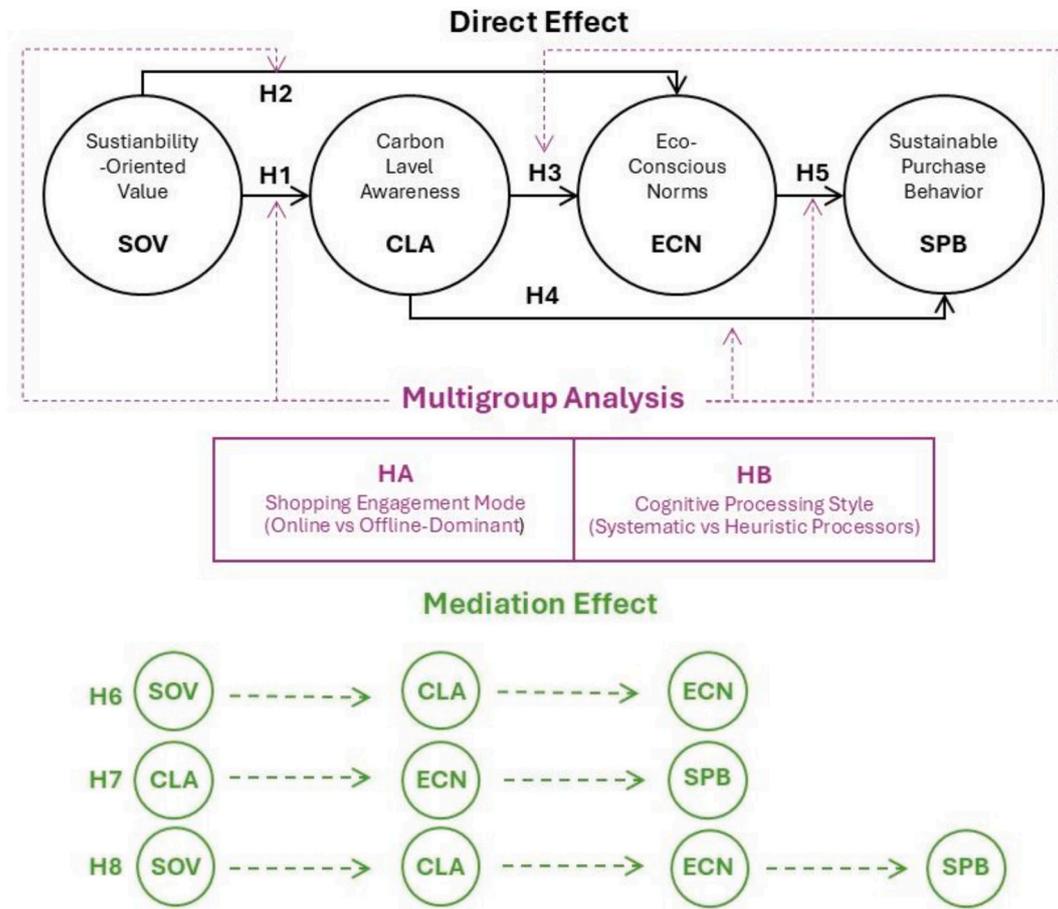


Fig. 1. Proposed research framework and hypothesis.

Table 2
Summary of hypotheses by type.

Type	Hypothesis	Path	Description
Direct Effects	H1	SOV → CLA	Sustianbility-oriented values positively influence carbon label awareness.
	H2	SOV → ECN	Sustianbility-oriented values positively influence eco-conscious norms.
	H3	CLA → ECN	Carbon label awareness positively influences eco-conscious norms.
	H4	CLA → SPB	Carbon label awareness positively influences sustainable purchase behavior.
	H5	ECN → SPB	Eco-conscious norms positively influence sustainable purchase behavior.
Mediation Effects	H6	SOV → CLA → SPB	CLA mediates the effect of SOV on SPB.
	H7	SOV → ECN → SPB	ECN mediates the effect of SOV on SPB.
	H8	SOV → CLA → ECN → SPB	CLA and ECN sequentially mediate the relationship between SOV and SPB.
Moderation Effects	HA	Multigroup (Online vs. Offline)	Shopping Engagement Mode moderates structural relationships in the model.
	HB	Multigroup (Systematic vs. Heuristic)	Cognitive Processing Style moderates structural relationships in the model.

H5: $SPB = \beta_5 \times ECN + e_5$.

Where β_1 to β_5 are standardized path coefficients and ϵ_1 to ϵ_5 represent error terms. A positive β implies that an increase in the independent variable leads to an increase in the dependent variable.

Mediation Effects:

H6 (Indirect through CLA): $SOV \rightarrow CLA \rightarrow SPB = \beta_1 \times \beta_4$.

H7 (Indirect through ECN): $SOV \rightarrow ECN \rightarrow SPB = \beta_2 \times \beta_5$.

H8 (Sequential mediation): $SOV \rightarrow CLA \rightarrow ECN \rightarrow SPB = \beta_1 \times \beta_3 \times \beta_5$.

Total Effect:

Total = $(\beta_1 \times \beta_4) + (\beta_2 \times \beta_5) + (\beta_1 \times \beta_3 \times \beta_5)$.

Multigroup SEM Testing:

HA: If β coefficients differ significantly between Online-Dominant and Offline-Dominant shopper groups, Shopping Engagement Mode moderates the structural relationships.

HB: If β coefficients differ significantly between Systematic and Heuristic processors, Cognitive Processing Style moderates the structural relationships.

3.2. Data collection and measurement

To achieve regionally representative insights, this study applied a stratified sampling technique that captured consumer diversity across Thailand’s five primary regions. Drawing on guidance from Wolf et al. (2013), the required sample size for SEM was set at no fewer than 200 respondents, but to facilitate robust subgroup analysis, the research team increased the target to 650 participants.

Data collection was conducted across Bangkok (Central, $n = 150$), Chiang Mai (North, $n = 100$), Khon Kaen (Northeast, $n = 150$), Chonburi (East, $n = 100$), and Phuket (South, $n = 162$) to ensure geographic

diversity. These locations reflect varying retail environments and consumer behaviors. To address potential contextual bias, all locations were selected from urban and peri-urban zones with similar access to carbon-labeled products, ensuring relatively consistent consumer exposure to sustainability messaging across regions. In-store shoppers were recruited from shopping malls, supermarkets, and sustainability events, while online shoppers were reached through e-commerce platforms and targeted digital recruitment. In addition, all respondents were required to be fluent in Central Thai—the national language used in education, media, and product labeling—which helped ensure uniform comprehension of terminology related to CFPLs. This approach ensured a balanced representation of Shopping Engagement Mode (Online-Dominant vs. Offline-Dominant shoppers) and Cognitive Processing Style (Systematic vs. Heuristic Processors). By combining stratified sampling with behavioral segmentation, the study design strengthens generalizability while enabling nuanced comparisons between consumer types. The final sample comprised 662 respondents, aligning closely with the planned distribution.

The survey instrument (Appendix 1) contained three sections. [Section 1](#) collected demographic data, including gender, age, income, and education. [Section 2](#) measured Shopping Engagement Mode and Cognitive Processing Style to classify respondents into behavioral groups. To determine Shopping Engagement Mode, participants were asked to select one of two descriptions that best reflected their shopping behavior: (1) Online-Dominant Shopper, defined as individuals who primarily shop online and rely on digital information such as product descriptions, reviews, and online sustainability labels to make purchasing decisions; or (2) Offline-Dominant Shopper, defined as individuals who primarily shop in physical stores and rely on in-person factors such as packaging, store displays, or interaction with sales staff to validate their decisions ([Kim et al., 2024](#)). To assess Cognitive Processing Style, respondents were asked to choose between two evaluation styles: (1) Systematic Processor, describing individuals who carefully analyze product details, compare options based on factual sustainability information, and rely on structured data such as carbon footprint scores or ranking systems before making a purchase; and (2) Heuristic Processor, referring to individuals who rely on simple cues such as eco-labels, brand reputation, and visual indicators (e.g., green packaging) rather than conducting in-depth evaluations of sustainability claims ([Tan, Fauzi, & Harun, 2025](#)). [Section 3](#) used 7-point Likert scales (1 = Strongly Disagree to 7 = Strongly Agree) to assess key constructs: SOV ([Kim et al., 2024](#)), CLA ([Taufique, 2022](#)), ECN ([Tan, Casidy, & Arli, 2025](#)), and SPB ([Malhotra & Srivastava, 2024](#)). To enhance reliability, data triangulation techniques ([Kumar et al., 2023](#)) were employed by incorporating responses from diverse geographic and demographic subgroups, ensuring that findings are representative of Thailand's consumer landscape.

3.3. Data analysis

The analytical approach followed a systematic process to ensure robust and reliable results. Prior to primary analysis, preliminary assessments were conducted to verify data quality and suitability for SEM. Common Method Variance (CMV) was evaluated to address potential bias arising from the use of similar measurement methods and sources, particularly with Likert scales ([Podsakoff et al., 2003](#)). The analysis yielded a cumulative variation of 45.22 %, below the critical threshold of 50 %, indicating CMV was not a significant concern. Data normality was confirmed through examination of skewness (−0.069 to 0.371) and kurtosis (−0.640 to −0.367) values, both within acceptable ranges (−1 to 1), signifying appropriate distribution without substantial asymmetry or outliers.

SEM was conducted using AMOS version 26. This multivariate statistical technique is commonly used in sustainable consumer and business research to examine complex relationships among observed and latent variables ([Ketkaew et al., 2021](#); [Naruetharadhol et al., 2021](#);

[Wongsachia et al., 2025](#)). Covariance-based SEM (CB-SEM) was selected over Partial Least Squares SEM (PLS-SEM) due to its superior accuracy in parameter estimation with large datasets and its suitability for validating complex theoretical models ([Byrne, 2004](#); [Reinartz et al., 2009](#)). The measurement model was assessed using Confirmatory Factor Analysis (CFA). Model fit was evaluated using key fit indices, including the Comparative Fit Index (CFI), Goodness of Fit Index (GFI), Tucker-Lewis Index (TLI), Incremental Fit Index (IFI), and Root Mean Square Error of Approximation (RMSEA) ([Cheung & Rensvold, 2002](#)). Cutoff criteria followed established benchmarks: values of CFI, GFI, TLI, and IFI above 0.90, and RMSEA values below 0.08, were interpreted as indicating good model fit ([Hu & Bentler, 1999](#)). Construct reliability and validity were verified through standardized factor loadings, Composite Reliability (CR), and Cronbach's alpha to ensure internal consistency ([Raykov, 2009](#)). Convergent validity was calculated to confirm adequate variance explained among indicators ([Ab Hamid et al., 2017](#)). Discriminant validity was assessed using both the Fornell and Larcker criterion and the Heterotrait-Monotrait (HTMT) ratio to ensure that constructs were empirically distinct ([Cheung et al., 2024](#)).

To explore group-specific effects, multigroup SEM analysis was applied, contrasting Online-Dominant vs. Offline-Dominant shoppers and Systematic vs. Heuristic processors. Bootstrapping with 5000 resamples was used to test differences with 95 % confidence intervals, confirming whether moderation effects were statistically robust ([Koufteros & Marcoulides, 2006](#)). Mediation pathways were analyzed using bias-corrected bootstrapping, which allows for accurate testing without requiring normally distributed indirect effects ([Preacher & Hayes, 2008](#)). To complement the bootstrap results, the Sobel test was also conducted to assess the statistical significance of indirect effects. A z-value greater than 1.96 indicates statistical significance at the 0.05 level ([MacKinnon et al., 2004](#)). This additional test reinforces the robustness of the mediation findings. Together, these techniques enabled the research to reveal both general and segment-specific patterns in how carbon labeling influences purchasing behavior in the Thai retail context. Prior to multigroup comparisons, configural, metric, and scalar invariance were established. Changes in comparative fit indices across invariance levels remained within recommended thresholds, supporting meaningful cross-group path comparisons in the subsequent multigroup analysis.

4. Results

4.1. Demographic profiles

[Table 3](#) presents the demographic characteristics of respondents categorized by Shopping Engagement Mode (Online-Dominant vs. Offline-Dominant) and Cognitive Processing Style (Systematic vs. Heuristic). These classifications are essential for the multigroup SEM analysis, where moderation effects are tested by examining whether β coefficients differ significantly between these groups.

The sample comprises a nearly balanced gender distribution, with males constituting 48.64 % and females 51.36 %. This suggests that neither Shopping Engagement Mode nor Cognitive Processing Style is inherently gender-driven. Income distribution analysis highlights a distinction in spending power between groups. Respondents with lower monthly income (<10,000 THB) represent the largest segment across both Shopping Engagement Modes but are more prevalent among Offline-Dominant Shoppers (47.83 %) than Online-Dominant Shoppers (41.18 %). Conversely, the highest income group (20,001–30,000 THB) is more concentrated among Online-Dominant Shoppers (25.88 %), suggesting that higher-income consumers may prefer structured online shopping experiences over in-store purchasing.

Age segmentation reveals a strong skew toward younger consumers, with the 18–25 group forming the majority across all categories (76.44 %). The slightly higher representation of younger consumers in Offline-Dominant Shoppers (77.33 %) suggests that a blend of in-person

Table 3
Demographic profiles by shopping engagement mode and cognitive processing style.

Demographics	Category	A1	%A1	A2	%A2	B1	%B1	B2	%B2	Total	%Total
Gender	Male	165	48.53	157	48.76	168	48.7	154	48.58	322	48.64
	Female	175	51.47	165	51.24	177	51.3	163	51.42	340	51.36
Income (THB)	<10,000	140	41.18	154	47.83	143	41.45	151	47.63	294	44.41
	10,001–20,000	113	33.24	113	35.09	115	33.33	111	35.02	226	34.15
	20,001–30,000	87	25.88	55	17.08	87	25.22	55	17.35	142	21.45
	18–25	260	76.47	249	77.33	264	76.52	245	77.29	509	76.84
	26–30	60	17.65	48	14.91	62	17.97	46	14.51	108	16.32
Age	31–40	13	3.82	12	3.73	11	3.19	14	4.42	25	3.78
	41–50	7	2.06	13	4.04	8	2.32	12	3.79	20	3.02
	High School	42	12.35	39	12.11	43	12.46	38	11.99	81	12.24
Education	Diploma	226	66.47	214	66.46	229	66.38	211	66.56	440	66.47
	Undergraduate	72	21.18	69	21.43	73	21.16	68	21.45	141	21.6
Group Size		340	51.36	322	48.64	345	52.12	317	47.88	662	100

Note: A1 = Online-Dominant, A2 = Offline-Dominant, B1 = Systematic, B2 = Heuristic.

interaction and online research remains relevant for this demographic. Educational attainment follows a uniform pattern, with diploma holders constituting the largest proportion (66.47 %), followed by undergraduate degree holders (21.60 %). This distribution remains consistent across Shopping Engagement Mode and Cognitive Processing Style, suggesting that educational background does not significantly impact these groupings.

4.2. Measurement model: confirmatory factor analysis and measurement invariance

The measurement model demonstrated adequate fit based on several goodness-of-fit indices. The CFI (0.990), GFI (0.929), TLI (0.981), and IFI (0.990) all exceeded the recommended threshold of 0.90, indicating good model fit. The RMSEA (0.054) was well below the 0.08 threshold, suggesting an acceptable level of error approximation. The chi-square/df ratio (2.912) was within the recommended range of less than 3, further supporting the model's adequacy.

Table 4 presents the convergent validity assessment of the four constructs. All Cronbach's alpha values exceeded the recommended threshold of 0.70 (SOV = 0.837, SPB = 0.947, CLA = 0.935, ECN = 0.885), demonstrating high internal consistency. The Average Variance Extracted (AVE) for all constructs was above the 0.50 threshold (SOV = 0.607, SPB = 0.831, CLA = 0.804, ECN = 0.677), confirming that each construct explained more than half of the variance in its indicators. Composite Reliability (CR) values were all above 0.70 (SOV = 0.860, SPB = 0.951, CLA = 0.942, ECN = 0.888), further supporting the reliability of the constructs. Most standardized factor loadings (β) exceeded the recommended threshold of 0.70, with values ranging from 0.698 to 0.927, and all were statistically significant ($p < 0.001$).

Table 4
Convergent validity.

Construct	Indicator	β (>0.70)	p-Value	Cronbach's Alpha (>0.70)	AVE (>0.50)	CR (>0.70)
Sustainability-Oriented Values (SOV)	SOV1	0.893	***	0.837	0.607	0.86
	SOV2	0.698	***			
	SOV3	0.705	***			
	SOV4	0.744	***			
Sustainable Purchase Behavior (SPB)	SPB1	0.909	***	0.947	0.831	0.951
	SPB2	0.918	***			
	SPB3	0.913	***			
	SPB4	0.901	***			
Carbon Label Awareness (CLA)	CLA1	0.811	***	0.935	0.804	0.942
	CLA2	0.922	***			
	CLA3	0.916	***			
	CLA4	0.925	***			
Eco-Conscious Norms (ECN)	ECN1	0.927	***	0.885	0.677	0.888
	ECN2	0.91	***			
	ECN3	0.859	***			
	ECN4	0.486	***			

Note: *** denotes significance p-value <0.001.

Table 5
Discriminant validity – fornell and larcker criterion and HTMT ratios.

Constructs	SOV	SPB	CLA	ECN
<i>Fornell-Larcker Criterion</i>				
SOV	0.902	–	–	–
SPB	0.525	0.867	–	–
CLA	0.459	0.542	0.871	–
ECN	0.526	0.525	0.606	0.875
<i>HTMT Ratios</i>				
SOV	–	–	–	–
SPB	0.801	–	–	–
CLA	0.686	0.849	–	–
ECN	0.649	0.754	0.834	–

Note: Upper section = Fornell-Larcker Criterion (bold diagonal = $\sqrt{\text{AVE}}$). Lower section = HTMT ratios (all values <0.85).

constructs SPB and CLA (0.849). Despite these correlations, the discriminant validity is maintained as the AVE values for each construct are sufficiently high. The Fornell-Larcker Criterion results confirm that the constructs in this study exhibit good discriminant validity, ensuring that each construct is distinct and measures a unique aspect of the theoretical framework. In addition, the HTMT ratios of correlations were computed to provide a more stringent assessment of discriminant validity, as recommended by Hair Jr et al. (2021). All HTMT values ranged between 0.649 and 0.849, remaining below the conservative threshold of 0.85, which confirms that the constructs are empirically distinct. The combined evidence from both the Fornell-Larcker and HTMT assessments demonstrates robust discriminant validity across all latent constructs, supporting the reliability and accuracy of the subsequent structural equation modeling analysis.

Table 6 presents the results of the measurement invariance tests for Shopping Engagement Mode (A1 vs. A2: Online-Dominant vs. Offline-Dominant) and Cognitive Processing Style (B1 vs. B2: Systematic vs. Heuristic Processors). The fit indices for configural, metric, and scalar invariance indicate a strong model fit across groups. Specifically, CFI values for Online-Dominant vs. Offline-Dominant range from 0.980 to 0.987, and for Systematic vs. Heuristic Processors from 0.980 to 0.985, all exceeding the threshold of 0.900, supporting measurement consistency. GFI values (0.932 to 0.949) also meet the acceptable threshold of 0.900, reinforcing model adequacy. Additionally, TLI values (0.962 to 0.977) and IFI values (0.980 to 0.987) further validate model performance. RMSEA values remain within the acceptable range (0.042 to 0.054, below the 0.100 threshold), suggesting a good model fit. The Chi-square/df ratios (2.191 to 2.941) are below the critical threshold of 3.000, indicating no overfitting. Furthermore, the changes in CFI ($\Delta\text{CFI} \leq 0.01$) and RMSEA ($\Delta\text{RMSEA} \leq 0.015$) between configural, metric, and scalar models suggest that the model maintains invariance across both Shopping Engagement Modes and Cognitive Processing Styles. These results confirm measurement equivalence across groups, allowing for valid comparisons of structural relationships in the subsequent multi-group SEM analysis.

Table 6
Measurement invariance testing.

Fit Index	Shopping Engagement Mode (A1 vs. A2)			Cognitive Processing Style (B1 vs. B2)			Threshold
	Configural	Metric	Scalar	Configural	Metric	Scalar	
CFI	0.986	0.98	0.987	0.985	0.98	0.98	>0.900
GFI	0.949	0.937	0.948	0.94	0.935	0.932	>0.900
TLI	0.974	0.962	0.977	0.974	0.966	0.967	>0.900
IFI	0.986	0.98	0.987	0.984	0.98	0.98	>0.900
RMSEA	0.045	0.054	0.042	0.045	0.052	0.051	<0.100
Chi-square/df	2.347	2.941	2.191	2.358	2.751	2.691	<3.000
ΔCFI	–	0.006	0.007	–	0.005	0.005	≤ 0.010
ΔRMSEA	–	0.009	0.012	–	0.007	0.006	≤ 0.015

4.3. Full structural model

The full structural model showed excellent fit (CFI = 0.990, GFI = 0.966, TLI = 0.981, IFI = 0.990, RMSEA = 0.054, $\chi^2/\text{df} = 2.949$). As summarized in Table 7, all hypothesized direct effects were statistically significant ($p < 0.01$), confirming the conceptual robustness of the VBN model.

4.3.1. Value-to-cognition pathway

The path from SOV to CLA was strongly supported (H1: $\beta = 0.810$, $p < 0.001$), indicating that individuals with pro-environmental values are more likely to develop cognitive awareness of carbon labels. This result aligns with the belief formation stage of the VBN framework, where internalized values stimulate awareness of environmental consequences (Stern et al., 1999). It is also supported by findings that biospheric values drive sustainability cognition and label engagement in contemporary consumer settings (Xu et al., 2024).

4.3.2. Cognition-to-norms pathway

The results also support H3, showing that CLA significantly predicts ECN ($\beta = 0.632$, $p < 0.001$). This supports the VBN proposition that cognitive awareness of environmental consequences leads to personal moral norms (Stern et al., 1999). In addition, SOV directly influences ECN (H2: $\beta = 0.307$, $p < 0.001$), suggesting a dual pathway in which values shape norms both directly and through beliefs. This layered influence is consistent with empirical work demonstrating how value-based environmental concern can manifest as a moral obligation to act (Wongsaichia et al., 2025).

4.3.3. Norms-to-behavior pathway

Both CLA and ECN significantly influenced SPB, supporting the behavioral endpoint of the VBN model. CLA exerted a robust effect (H4: $\beta = 0.587$, $p < 0.001$), suggesting that consumers use carbon labels as a meaningful cue for action when cognitively engaged (Ang et al., 2024). ECN also showed a significant positive effect (H5: $\beta = 0.368$, $p < 0.001$), affirming the role of internal moral standards in motivating sustainable consumption (Kumar & Yadav, 2021). Together, these findings support the full VBN chain (SOV → CLA → ECN → SPB), offering empirical evidence that sustainable behavior is shaped by a progression of values, beliefs, and norms (Stern et al., 1999).

Table 7
Full structural model - hypothesis test results.

Hypothesis	Path	β	p-value	Decision
H1	SOV → CLA (β_1)	0.810	<0.001**	Passed
H2	SOV → ECN (β_2)	0.307	<0.001**	Passed
H3	CLA → ECN (β_3)	0.632	<0.001**	Passed
H4	CLA → SPB (β_4)	0.587	<0.001**	Passed
H5	ECN → SPB (β_5)	0.368	<0.001**	Passed

Note: ** denotes significance p-value <0.010.

4.4. Multigroup analysis

This section provides a concise summary of the multigroup analysis results, while detailed interpretations of direct, indirect, total, and multigroup effects are presented in Section 5. Statistical outcomes and path comparisons are reported in Tables 8 and 9.

Path contrasts indicate distinct behavioral mechanisms across shopping modes. In online contexts, the process is primarily cognition led, whereas in offline contexts it is norm led. The Value → Awareness (SOV → CLA) and Awareness → Behavior (CLA → SPB) paths are significantly stronger among online shoppers, reflecting the influence of digital information and visible carbon-label cues in activating cognitive responses that lead to sustainable purchase behavior. Offline shoppers show stronger Awareness → Norms (CLA → ECN) and Norms → Behavior (ECN → SPB) links, suggesting that physical retail environments more effectively translate awareness into normative commitment and subsequent action. Indirect effects follow the same pattern. The Value → Awareness → Behavior mediation is more pronounced online, while the Value → Norms → Behavior pathway is stronger offline. All indirect effects have confidence intervals excluding zero, confirming their robustness.

Cognitive style also shapes the pathways. Heuristic processors display a stronger Value → Norms (SOV → ECN) relationship, indicating faster internalization of values when cues are simple and aligned with beliefs. Systematic processors, conversely, exhibit a stronger Awareness → Norms (CLA → ECN) path, reflecting deeper engagement with label information. Behavioral pathways (CLA → SPB; ECN → SPB) are comparable across styles once cognition or norms are activated. Mediation tests confirm significance in both groups, the Value → Awareness → Behavior chain is relatively larger for heuristic processors, while the full sequential chain (Value → Awareness → Norms → Behavior) is more pronounced among systematic processors.

5. Discussion

This section presents the results from the multigroup SEM analysis using two moderation criteria: (1) Shopping Engagement Modes (Online-Dominant vs. Offline-Dominant Shoppers) and (2) Cognitive Processing Styles (Systematic vs. Heuristic Processors). For each criterion, the Direct Effects, Indirect Effects, and Total Effects are interpreted and discussed separately.

5.1. Shopping engagement modes

The multigroup SEM comparing Online-Dominant and Offline-

Dominant shoppers demonstrated good model fit ($\chi^2/df = 2.412$, CFI = 0.986, TLI = 0.973, GFI = 0.947, RMSEA = 0.046), supporting the robustness of group comparisons.

5.1.1. Direct effects

According to Table 8, results reveal that SOV significantly influenced CLA in both groups, with a stronger effect among Online-Dominant shoppers ($\beta = 0.902$) than Offline-Dominant shoppers ($\beta = 0.727$). The group difference was statistically significant (CRD = 2.03), highlighting that consumers who primarily shop online are more responsive to sustainability values when forming carbon label awareness. The difference in effects was 0.175 (95 % CI = [0.584, 1.028]), indicating a significantly larger SOV → CLA path for the online group. This aligns with prior findings that digital environments facilitate cognitive engagement with structured sustainability information (Gao et al., 2022). Similarly, SOV had a significantly stronger impact on ECN among Online-Dominant shoppers ($\beta = 0.686$) than Offline-Dominant ones ($\beta = 0.163$; CRD = 3.47). The difference in effects was 0.523 (95 % CI = [0.266, 3.858]), confirming that the value-to-norm pathway was markedly stronger online. This may reflect the influence of personalized and algorithm-driven sustainability content in digital platforms, which fosters internalized environmental norms (Xiao et al., 2019). In contrast, CLA exerted a significantly stronger influence on ECN in Offline-Dominant shoppers ($\beta = 0.785$ vs. 0.248; CRD = 4.29). The difference in effects was -0.537 (95 % CI = [0.545, 0.937]), indicating a significantly larger CLA → ECN path offline. This finding supports the notion that in physical store environments, consumers rely more on visible eco-label cues and contextual reinforcements (Manju & Latha, 2024). Both groups showed significant effects of CLA on SPB, with a stronger path for Online-Dominant shoppers ($\beta = 0.737$ vs. 0.520; CRD = 2.15). The difference in effects was 0.217 (95 % CI = [0.498, 1.067]), indicating that cognitive engagement through carbon-label information exerts a stronger behavioral impact online. ECN significantly predicted SPB in the Offline-Dominant group ($\beta = 0.452$), while the effect was weaker in Online-Dominant shoppers ($\beta = 0.220$; CRD = 2.05). The difference in effects was -0.232 (95 % CI = [0.291, 0.630]), confirming that internalized norms play a stronger role offline. These results reflect the stronger role of internalized norms in traditional or hybrid retail contexts where social cues and in-store experiences may amplify normative influences (Ebrahimi et al., 2021).

5.1.2. Indirect and total effects

The indirect effect of SOV on SPB via CLA was significant in both groups, and it was stronger for Offline-Dominant shoppers than Online-Dominant shoppers ($\beta = 0.571$ vs. 0.224). The difference in indirect

Table 8
Multigroup structural model – shopping engagement modes (A1 = Offline-Dominant, A2 = Online-Dominant).

Effect Type	Hypothesis	Path	β_{A1} (LB, UB)	β_{A2} (LB, UB)	β_{Diff}	CRD	Sobel z-A1	Sobel z-A2
Direct Effect	H1A1, H1A2	SOV → CLA	0.727** (0.584, 0.893)	0.902** (0.795, 1.028)	0.175	2.03*	-	-
	H2A1, H2A2	SOV → ECN	0.163** (0.043, 0.439)	0.686* (0.266, 3.858)	0.523	3.47*	-	-
	H3A1, H3A2	CLA → ECN	0.785** (0.545, 0.937)	0.248* (-0.948, 0.695)	-0.537	4.29*	-	-
	H4A1, H4A2	CLA → SPB	0.520** (0.341, 0.693)	0.737** (0.498, 1.067)	0.217	2.15*	-	-
	H5A1, H5A2	ECN → SPB	0.452** (0.291, 0.630)	0.220* (-0.110, 0.450)	-0.232	2.05*	-	-
Indirect Effect	H6A1, H6A2	SOV → CLA → SPB	0.571** (0.318, 0.837)	0.224** (-0.343, 0.714)	0.347	-	3.52*	2.14*
	H7A1, H7A2	SOV → ECN → SPB	0.074** (0.013, 0.277)	0.151* (-0.029, 1.736)	-0.077	-	2.08*	2.00*
Total Effect	H8A1, H8A2	SOV → CLA → ECN → SPB	0.171** (0.058, 0.390)	0.146** (0, 0.493)	0.025	-	-	-

Note: ** denotes significance p-value <0.010, * denotes significance p-value <0.050 (absolute value of critical ratio diff >1.96), Lower denotes Lower Bound, UB denotes Upper Bound, and CRD denotes Critical Ratio for Path Differences.

Table 9
Multigroup structural model – cognitive processing styles (B1 = Systematic, B2 = Heuristic Processors).

Effect Type	Hypothesis	Path	βB1 (LB, UB)	βB2 (LB, UB)	βDiff	CRD	Sobel z-B1	Sobel z-B2
Direct Effect	H1B1, H1B2	SOV → CLA	0.750** (0.623, 0.891)	0.881** (0.764, 1.015)	0.131	1.56	–	–
	H2B1, H2B2	SOV → ECN	0.205** (0.079, 0.468)	0.512* (0.211, 2.418)	0.307	2.59*	–	–
	H3B1, H3B2	CLA → ECN	0.791** (0.544, 0.968)	0.390* (–0.535, 0.706)	–0.401	3.11*	–	–
	H4B1, H4B2	CLA → SPB	0.543** (0.357, 0.727)	0.638** (0.448, 0.921)	0.095	0.90	–	–
	H5B1, H5B2	ECN → SPB	0.408** (0.234, 0.596)	0.316* (–0.038, 0.511)	–0.092	0.84	–	–
Indirect Effect	H6B1, H6B2	SOV → CLA → SPB	0.407** (0.222, 0.648)	0.562** (0.342, 0.935)	0.155	–	3.07*	3.41*
	H7B1, H7B2	SOV → ECN → SPB	0.084** (0.018, 0.279)	0.162* (0.008, 1.236)	0.078	–	2.10*	2.00*
Total Effect	H8B1, H8B2	SOV → CLA → ECN → SPB	0.242** (0.079, 0.514)	0.109* (0, 0.365)	–0.133	–	–	–

Note: ** denotes significance p -value <0.010 , * denotes significance p -value <0.050 (absolute value of critical ratio diff >1.96), Lower denotes Lower Bound, UB denotes Upper Bound, and CRD denotes Critical Ratio for Path Differences.

effects was 0.347 (95 % CI = [0.318, 0.837]), confirming a stronger mediation through CLA offline. This indicates that CLA functions as a more central mediating mechanism in physical retail contexts where consumers interact with multiple, concurrent cues (e.g., shelf displays, package textures, certification logos, signage, and social signals from peers or staff). In this study, “intuitive engagement” denotes rapid, affective, and experience-based processing of these in-store sustainability signals that heighten moral salience without requiring extensive analytical reasoning, consistent with dual-process perspectives on heuristic or experiential processing in stimulus-rich environments (Duan et al., 2023; Manju & Latha, 2024). This interpretation aligns with evidence that carbon footprint labels help translate sustainability values into concrete purchase behavior by making environmental impacts cognitively salient at the point of decision (Feucht & Zander, 2018), and the robustness of this pathway is supported by significant Sobel statistics for both groups ($z = 3.52$ for A1; $z = 2.14$ for A2). The indirect path through ECN was also significant in both groups—larger for Online-Dominant shoppers ($\beta = 0.151$; $z = 2.00$) than Offline-Dominant shoppers ($\beta = 0.074$; $z = 2.08$). The difference in indirect effects was -0.077 (95 % CI = [0.013, 0.277]), showing that the SOV → ECN → SPB pathway is stronger online. This supports the VBN account that internalized eco-conscious norms mediate the value-behavior linkage via moral obligation (Kumar & Yadav, 2021; Stern et al., 1999). The comparatively stronger ECN pathway online is consistent with the growing moral salience of sustainability messaging in digital contexts, where structured information and repeated cues can aid internalization even outside physical social settings.

Furthermore, the total sequential mediation (SOV → CLA → ECN → SPB) was significant in both groups ($\beta = 0.171$ vs. 0.146). The difference in total effects was 0.025 (95 % CI = [0.058, 0.390]), confirming that both groups follow the full VBN chain with only minor differences in overall magnitude. Bootstrapped confidence intervals excluding zero confirm the integrity of the model, in which abstract values guide behavior through cognitive engagement and moral internalization (Wongsaichia et al., 2025). Overall, the moderating role of shopping engagement mode reflects not only differences in access to information but also deeper social-sensory processing differences: offline contexts foreground ambient social validation and embodied cues that intensify CLA’s mediating role, whereas online contexts privilege deliberate evaluation and value-consistent internalization that bolster the ECN pathway.

5.2. Cognitive processing styles

The multigroup SEM comparing Systematic and Heuristic Processors

also exhibited good model fit ($\chi^2/df = 2.990$, CFI = 0.979, TLI = 0.961, GFI = 0.935, RMSEA = 0.055), indicating reliable comparisons.

5.2.1. Direct effects

According to Table 9, SOV significantly influenced CLA in both groups, with a stronger effect among Heuristic Processors ($\beta = 0.881$ vs. 0.750), but the difference was not statistically significant (CRD = 1.56). The difference in effects was 0.131 (95 % CI = [0.623, 1.015]), and the confidence interval included zero, confirming that this difference was not statistically significant. Interestingly, SOV had a significantly stronger effect on ECN among Heuristic Processors ($\beta = 0.512$ vs. 0.205; CRD = 2.59), suggesting that intuitive consumers may more readily internalize sustainability values into moral norms when exposed to simplified messaging (Muthaffar et al., 2024). The difference in effects was 0.307 (95 % CI = [0.211, 2.418]), indicating a statistically significant group difference favoring heuristic processors. Conversely, CLA exerted a significantly stronger influence on ECN among Systematic Processors ($\beta = 0.791$ vs. 0.390; CRD = 3.11), reflecting the rational elaboration of label information into ECN consistent with their deeper cognitive processing style (Overton & Yang, 2021). The difference in effects was -0.401 (95 % CI = [0.544, 0.968]), confirming a significantly larger CLA → ECN path for systematic processors. Both groups showed significant effects of CLA on SPB, with a slightly stronger path for Heuristic Processors ($\beta = 0.638$ vs. 0.543), though the difference was not significant (CRD = 0.90). The difference in effects was 0.095 (95 % CI = [0.357, 0.921]), and the overlapping interval indicates no statistically significant difference between groups. The ECN → SPB relationship was also significant in both groups, but the difference was not significant (CRD = 0.84). The difference in effects was -0.092 (95 % CI = [0.234, 0.596]), confirming that this path is comparable across processing styles.

5.2.2. Indirect and total effects

The indirect effect of SOV on SPB via CLA was also significant across processing styles and was stronger for Heuristic Processors ($\beta = 0.562$ vs. 0.407). Sobel test values were above the significance threshold in both groups ($z = 3.41$ for Heuristic, $z = 3.07$ for Systematic), affirming the mediating role of CLA as a cognitive conduit between internal values and sustainable behavior (Feucht & Zander, 2018). The difference in indirect effects was 0.155 (95 % CI = [0.342, 0.935]), confirming that the CLA-mediated pathway was significantly stronger among heuristic processors. The stronger pathway among heuristic processors suggests that intuitive decision-makers are particularly responsive to the presence of simplified, easily interpretable carbon cues. The indirect path through ECN was likewise significant in both groups ($\beta = 0.084$ for

Systematic, $\beta = 0.162$ for Heuristic), supported by Sobel z-values ($z = 2.10$ and 2.00 , respectively). The difference in indirect effects was 0.078 (95 % CI = $[0.008, 1.236]$), indicating a significant difference favoring heuristic processors on the SOV \rightarrow ECN \rightarrow SPB path. These findings reinforce prior claims that eco-conscious norms act as internal moral drivers of sustainable behavior, even among consumers who process information differently (Kumar & Yadav, 2021; Stern et al., 1999). While heuristic processors may rely more on affective or visual cues to activate these norms, systematic processors may arrive at moral conclusions through more analytical elaboration.

Lastly, the full sequential mediation (SOV \rightarrow CLA \rightarrow ECN \rightarrow SPB) remained significant in both groups, with a stronger total effect among Systematic Processors ($\beta = 0.242$ vs. 0.109). The difference in total effects was -0.133 (95 % CI = $[0.079, 0.514]$), indicating a significantly stronger sequential mediation effect for systematic processors. However, overlapping confidence intervals suggest that the underlying mechanism—values translating into beliefs, then norms, and finally behavior—holds true across both cognitive styles. This echoes insights from recent work on value-congruent messaging, where sustainability cues are most effective when matched to the processing tendencies of the consumer (Zhang et al., 2025). In short, the dual mediation structure remains stable, but its strength is shaped by how consumers engage with sustainability information.

Although several structural relationships, such as the path from Sustainability-Oriented Values (SOV) to Carbon Label Awareness (CLA), did not differ significantly between Systematic and Heuristic Processors, these non-significant differences remain theoretically meaningful. They suggest that value-based cognitive activation operates as a stable psychological mechanism that transcends individual processing tendencies. In other words, whether consumers engage in analytical reasoning or rely on intuitive shortcuts, sustainability-oriented values consistently translate into awareness of carbon labels. This finding reflects a form of channel invariance in the value-cognition mechanism, indicating that the activation of sustainability awareness from underlying values remains stable across distinct information-processing styles (Muthaffar et al., 2024; Overton & Yang, 2021). Theoretically, this invariance highlights that core environmental values serve as universal cognitive anchors within the VBN framework, even when consumers process information through different cognitive routes. Practically, this suggests that activating consumers' sustainability values should remain a central strategy for marketers and policymakers, regardless of the channel or message format—whether analytical and data-driven for systematic processors (Overton & Yang, 2021) or visually intuitive and emotionally engaging for heuristic ones (Muthaffar et al., 2024). Overall, the absence of significant group differences reinforces that cognitive style primarily affects how sustainability information is interpreted, rather than whether values initiate awareness. Consequently, while certain moderating effects emerge further along the behavioral chain (e.g., CLA \rightarrow ECN), the value-to-awareness link stands as a foundational and resilient component of sustainable decision-making across processing styles.

In summary, these results extend the VBN framework by incorporating moderating effects of Shopping Engagement Mode and Cognitive Processing Style. The findings suggest that the cognitive and normative pathways linking values to sustainable behavior differ meaningfully across consumer types. These insights provide actionable direction for marketers and policymakers seeking to tailor sustainability messaging and label strategies to specific shopper profiles.

5.3. Practical implications for marketing strategy and policy design

This study makes a distinctive contribution by applying the VBN framework within a segmentation-based context, exploring how consumer heterogeneity—specifically in shopping behavior and information processing—shapes sustainable purchase decisions. The moderating effects identified in this research illustrate how different psychological and situational factors influence the pathway from SOV to SPB, with

CLA and ECN acting as key mediators. These insights not only reinforce the theoretical structure of the VBN model but also offer globally relevant practical direction for promoting sustainable purchasing across multiple consumer segments and shopping contexts. In particular, the results highlight both differentiated pathways across channels and a degree of channel invariance in the value-cognition mechanism, suggesting that activating consumers' core sustainability values remains essential across digital and physical settings. From both marketing and policy perspectives, the findings offer strategic direction on optimizing the deployment of CFPLs to match consumer characteristics and channel-specific conditions.

5.3.1. Marketing and retail strategy implications

For businesses, the findings suggest that sustainability-oriented strategies must adapt to both the shopping environment and the cognitive profile of their target consumers. Marketers should recognize that although consumers process sustainability information differently, the activation of underlying values consistently drives awareness and behavioral intention across segments.

5.3.1.1. Engaging online-dominant shoppers. Consumers in digital environments demonstrate a stronger cognitive response to SOVs, particularly through heightened awareness of carbon labels that directly influence purchase behavior. As supported by findings on structured digital decision-making (Gao et al., 2022), online retail platforms should adopt transparency tools like interactive carbon ratings, filtering options based on sustainability, or visible CFPL indicators. Embedding QR codes that provide access to detailed product carbon profiles can support systematic decision-making and enhance credibility. Digital retailers might also enhance the consumer experience by delivering personalized eco-messages that align with browsing preferences or purchase trends, using AI-driven nudges to foster environmentally conscious behavior. For example, live-stream shopping platforms such as Lazada, TikTok Shop, or global e-commerce sites like Amazon, Flipkart, and Alibaba could overlay real-time CFPL graphics to reinforce sustainability claims and facilitate in-the-moment decision-making.

5.3.1.2. Targeting offline-dominant shoppers. Among consumers in physical retail spaces, the data suggest a stronger influence of CLA on the formation of internal eco-conscious norms, indicating that physical cues and sensory stimuli play a larger role in reinforcing moral responsibility (Manju & Latha, 2024). Retailers could therefore amplify the visibility of sustainability messaging through high-impact label placement, ambient signage, or staff-led green storytelling. Tactile elements such as labeled packaging, shelf talkers, or interactive displays can also support experiential engagement with sustainability claims. In-store layout designs may include designated low-carbon sections or display peer influence messages (e.g., "Customers here prefer eco-certified options") to nudge behavioral shifts in subtle, non-intrusive ways. Retailers across different regions—such as Tesco Lotus (Thailand), Carrefour (EU), Walmart (US), and Aeon (Japan)—could leverage digital shelf tags that highlight carbon scores, modeled after best practices from international schemes like the UK's Carbon Trust or Germany's Blue Angel. Such hybrid visual-informational labeling formats may help reinforce both normative and cognitive engagement, bridging online and offline consumer responses.

5.3.1.3. Accommodating diverse cognitive processing styles. The study reaffirms that not all consumers interpret sustainability cues the same way. Heuristic Processors respond more favorably to visually intuitive markers such as green labels, traffic light systems, or recognizable eco-branding (Muthaffar et al., 2024), while Systematic Processors require access to comprehensive data that support analytical evaluation and product comparison (Overton & Yang, 2021). Despite these differences, the invariance observed in the value-awareness relationship suggests that strategies should always begin by activating consumers' core values

before tailoring message complexity and visual emphasis to fit each processing style. To meet these divergent needs, businesses should use layered communication strategies—simple eco-symbols for quick decision-making and deeper information access for data-driven consumers. Multi-format label presentations, including clickable icons in mobile apps or scannable in-store labels, can accommodate both heuristic and systematic cognition. In fast-paced, mobile-first platforms like Shopee or JD Central, or their global counterparts such as Target, Instacart, or Zalando, such dual-format labeling improves engagement across diverse consumer profiles and enhances clarity for users with different literacy or cultural backgrounds.

5.3.2. Policy implications for enhancing CFPL effectiveness

Policy stakeholders can also draw several actionable insights to strengthen the role of CFPLs in shaping pro-environmental consumer behavior in Thailand:

5.3.2.1. Establishing a national standard for carbon labeling. Unlike countries such as Germany and the UK that have long implemented nationally recognized eco-labeling systems (e.g., Blue Angel, Carbon Trust), Thailand currently lacks a standardized and certified CFPL framework. Establishing such a system—aligned with international standards and adapted for both online and offline retail—could increase consumer trust and reduce confusion (Hartikainen et al., 2014). The Thailand Greenhouse Gas Management Organization (TGO) could serve as the certifying body, expanding its existing label scope and partnering with major supermarkets and digital commerce platforms to ensure label consistency. Globally, countries may follow a similar model by building institutional capacity around trusted environmental authorities and aligning national CFPL efforts with ISO 14067 or regional eco-labeling standards.

5.3.2.2. Promoting carbon label literacy through public education. While countries like Japan and South Korea actively invest in public sustainability education, Thailand remains behind in this regard. This gap can be narrowed through multimedia campaigns that use infographics, animated videos, and interactive online modules to improve consumers' interpretation of CFPLs. Embedding sustainability and carbon literacy in school curricula can also cultivate long-term behavioral shifts (Feucht & Zander, 2018; Taufique, 2022). Government bodies such as the Ministry of Education and Ministry of Natural Resources and Environment could collaborate on educational and awareness-raising initiatives to institutionalize carbon literacy at both formal and informal levels. In addition, government agencies such as the Ministry of Education could integrate carbon literacy into vocational training and consumer protection education programs. Similar approaches could be adopted internationally, where ministries or NGOs coordinate with retailers and digital platforms to launch culturally adapted carbon literacy programs in schools, consumer advisories, and retail spaces.

5.3.2.3. Supporting digital integration and consumer incentives. E-commerce platforms in Thailand have not yet integrated CFPLs into product listings as systematically as in some European or East Asian markets. Government agencies could partner with major e-retailers to pilot voluntary carbon label integration, supported by incentives or recognition schemes. Public-private partnerships may also encourage startups to develop technologies that track, verify, and display carbon data across platforms. Programs that reward CFPL purchases with “green points,” discounts, or digital badges may drive wider adoption, particularly among younger, mobile-first consumers. Globally, companies like Rakuten, Shopify, or Mercado Libre could experiment with green loyalty tiers, sustainability dashboards, or blockchain-traceable carbon badges. Digital reward systems—such as cashback offers or “green points” tied to CFPL purchases—can further motivate eco-conscious choices, especially among younger consumers. Initiatives like GreenerPoint, currently in

early-stage rollout, could serve as a model for combining blockchain traceability with consumer-facing reward systems.

5.4. Theoretical contributions

This study offers several significant theoretical contributions to the fields of sustainability behavior research and environmental psychology. It extends the Value-Belief-Norm (VBN) Theory (Stern et al., 1999) by demonstrating that the value-belief-norm chain is moderated by both contextual factors (shopping engagement mode) and cognitive variables (processing style). This integration suggests that the VBN mechanism operates not as a fixed linear pathway, but as a context-sensitive psychological system whose strength varies according to the consumer's environment and mode of information engagement. At the same time, the consistent significance of the SOV → CLA pathway across all groups indicates a form of channel invariance, suggesting that core sustainability values reliably activate awareness regardless of shopping mode or cognitive style. In doing so, the study advances a situational extension of VBN theory, aligning it with the realities of hybrid online-offline retail contexts.

Furthermore, the findings reveal that cognitive processing style serves as a boundary condition influencing how sustainability values translate into awareness and normative obligations. This insight contributes to dual-process and bounded rationality theories by showing that both heuristic and systematic processors can arrive at similar behavioral outcomes via distinct cognitive routes—one through analytical elaboration, the other through affective intuition. This coexistence of differentiation and invariance suggests that cognitive style functions not only as a moderator but also as a stabilizing mechanism that preserves the integrity of the VBN chain across diverse consumer cognition profiles.

The study thereby enriches the dialogue between cognitive psychology and sustainability communication, illustrating that environmental values can manifest through parallel cognitive mechanisms. The identification of intuitive engagement with environmental cues among offline consumers also provides a conceptual bridge between embodied cognition and pro-environmental behavior theories, suggesting that sustainability behavior may arise not only from reflective moral reasoning but also from sensory and affective experiences in real-world shopping environments. Together, these findings show that the VBN framework is both adaptable to different shopping contexts and consistent across cognitive styles, offering a clearer understanding of how values, beliefs, and norms work together to shape sustainable behavior. Finally, the study offers a theoretical foundation for future research in label design and message framing, proposing that sustainability information should be understood as both a cognitive stimulus and a moral cue.

6. Conclusion

This study advances understanding of sustainable consumer behavior by extending the VBN framework to include CLA and ECN as mediators between SOV and SPB. The findings reveal that these pathways differ significantly across Shopping Engagement Modes (Online-Dominant vs. Offline-Dominant) and Cognitive Processing Styles (Systematic vs. Heuristic), emphasizing that consumers do not uniformly respond to sustainability cues. The practical impact lies in demonstrating that Online-Dominant shoppers are more influenced by structured carbon label information, while Offline-Dominant shoppers rely more on eco-conscious norms formed through in-store experiences. Similarly, heuristic processors respond better to intuitive cues, whereas systematic processors require more detailed data. These insights call for tailored sustainability strategies—ranging from user-friendly carbon label design to retail-based normative reinforcement. For Thailand, where CFPL usage and standardization remain limited, the study highlights an urgent need for integrated policy frameworks and public

awareness efforts. Enhancing carbon label visibility across platforms could foster greater behavioral impact. By identifying context-specific mechanisms that translate values into action, this research offers a foundation for more targeted interventions—supporting both national sustainability goals and global climate commitments through informed consumer engagement.

7. Limitations and future research

This study contributes novel insights into the cognitive and contextual mechanisms underlying sustainable purchasing behavior, particularly through the lens of the Value-Belief-Norm (VBN) framework. Nonetheless, several considerations offer valuable directions for future research. First, the use of cross-sectional survey data limits causal inference, making the proposed sequential pathways provisional. Longitudinal or experimental designs are recommended to assess the temporal stability and responsiveness of cognitive–normative processes to repeated sustainability messaging. In particular, the interpretation of the stronger effect of social cues (Eco-Conscious Norms) observed in the offline group should be treated with caution, as these effects may partly reflect Common Method Variance (CMV), such as social desirability bias in self-reported responses. Future studies could mitigate this potential bias by employing multi-method approaches, such as field experiments or time-series panel designs, to better isolate the causal influence of normative cues from measurement artifacts. Second, while self-reported measures effectively captured cognitive and moral constructs, they may not fully represent actual consumer behavior. Incorporating behavioral or digital-tracking data, such as eye-tracking, clickstream patterns, or verified purchase records, would enhance ecological validity and confirm whether the mediating roles of Carbon Label Awareness and Eco-Conscious Norms persist in real-world contexts. Third, as the sample was drawn from Thai consumers, interpretations should consider Thailand’s evolving sustainability infrastructure. Comparative studies across markets with varying levels of carbon-labeling maturity and normative climates could strengthen the model’s cross-cultural generalizability. Addressing these considerations will enable future research to refine theoretical pathways and expand practical understanding of how values, awareness, and norms shape sustainable consumption across diverse sociotechnical environments.

CRedit authorship contribution statement

Aye Chan Soe: Writing – original draft, Formal analysis, Data curation. **Chavis Ketkaew:** Writing – review & editing, Writing – original draft, Supervision, Resources, Investigation, Conceptualization.

Ethical statement

The Ethics Committee for Human Research at Khon Kaen University reviewed our research protocols. The protocols were approved as an exemption, given the number HE683025.

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Declaration of competing interest

The authors of this research study declare that there are no conflicts of interest.

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Appendix A. Appendix 1: Survey questionnaire

Section 1: Nominal Questions (Demographics and Shopping Experiences).

1) Gender:

Male.

Female.

2) Age:

18–25.

26–30.

31–40.

41–50.

51–60.

61 and older.

3) Income (Monthly in Thai Baht):

Below 10,000.

10,001-20,000.

20,001-30,000.

30,001-40,000.

40,001-50,000.

Above 50,000.

4) Occupation:

Student.

Employee.

Self-employed.

Homemaker.

Retired.

Other (please specify) _____.

5) Educational Level:

High School or equivalent.

Diploma.

Undergraduate Degree.

Graduate Degree (Master’s).

Doctorate (PhD).

Other (please specify) _____.

6) Please read the description carefully and select the option that best represents your shopping behavior.

Online-Dominant Shopper: I primarily shop through online platforms and rely on digital information such as product descriptions, customer reviews, and online sustainability labels when making purchasing decisions.

Offline-Dominant Shopper: I primarily shop in physical stores and make purchasing decisions based on in-store experiences such as product packaging, shelf labels, staff recommendations, and physical interaction with products.

7) Please read the description carefully and select the option that best represents how you evaluate product information.

Systematic Processor: I carefully analyze product details, compare options based on factual sustainability information, and rely on structured data such as carbon footprint scores or ranking systems before making a purchase.

Heuristic Processor: I rely on simple cues such as eco-labels, brand reputation, and visual indicators (e.g., green packaging) rather than conducting in-depth evaluations of sustainability claims.

Section 2: Ordinal Questions (Constructs with 7-point Likert Scale).

Please indicate your level of agreement with the following statements using a 7-point Likert scale, where 1 = Strongly Disagree and 7 = Strongly Agree.

1) Sustainability-Oriented Values (SOV).

SOV1. I believe that protecting the environment is important for the future of our planet.

1 2 3 4 5 6 7.

SOV2. I am willing to make sacrifices to reduce my personal

environmental impact.

1 2 3 4 5 6 7.

SOV3. Sustainability should be prioritized over convenience when it comes to purchasing products.

1 2 3 4 5 6 7.

SOV4. I often consider the long-term environmental consequences of my actions.

1 2 3 4 5 6 7.

2) Carbon Label Awareness (CLA).

CLA1. I am aware of the carbon footprint labels on products.

1 2 3 4 5 6 7.

CLA2. I actively look for carbon footprint labels when purchasing products.

1 2 3 4 5 6 7.

CLA3. Carbon footprint labels influence my purchasing decisions.

1 2 3 4 5 6 7.

CLA4. I am willing to pay more for products that have a lower carbon footprint.

1 2 3 4 5 6 7.

3) Eco-Conscious Norms (ECN).

ECN1. My family and friends encourage me to buy environmentally friendly products.

1 2 3 4 5 6 7.

ECN2. I feel a personal obligation to choose sustainable products.

1 2 3 4 5 6 7.

ECN3. I try to set an example for others by choosing eco-friendly products.

1 2 3 4 5 6 7.

ECN4. I believe that society should promote the consumption of eco-friendly products.

1 2 3 4 5 6 7.

4) Sustainable Purchase Behavior (SPB).

SPB1. I regularly buy products that are environmentally sustainable.

1 2 3 4 5 6 7.

SPB2. I prefer buying products with a lower carbon footprint, even if they cost more.

1 2 3 4 5 6 7.

SPB3. I switch to more sustainable brands if I know they have a better environmental impact.

1 2 3 4 5 6 7.

SPB4. I am willing to reduce my consumption of non-sustainable products.

1 2 3 4 5 6 7.

Data availability

Data will be made available on request.

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