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Navigating Climate Change in Green Marketing: Consumer Response to Carbon-Neutral Claims and Carbon-Washing

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ABSTRACT

The escalating climate crisis has driven increased CSR and decarbonization efforts. However, ambiguous or unsubstantiated carbon claims—known as *carbon-washing*—pose significant barriers to the adoption of low-carbon products. This study examines the effects of disclosing emissions transparency along the value chain and substantiating explicit *carbon-neutral* claims, as outlined in forthcoming European directives. Across three experimental studies with 1593 Italian consumers (aged 18–70), we find that both interventions reduce perceived greenwashing (PGW) and enhance purchase intentions (PIs), but only when claims are understood. Poor comprehension reverses or nullifies these benefits, as consumers often rely on heuristic reasoning, leading to superficial judgments. Preliminary explanations (PEs) improve the ability to identify carbon-washing practices but remain insufficient to drive behavioral change. These findings emphasize the urgent need for clear, standardized and lifecycle-based communication and ongoing educational initiatives to empower consumers' decisions and foster a low-carbon economy.

1 | Introduction

Climate change represents a paramount challenge of our era, unequivocally attributed to human activities (Masson-Delmotte et al. 2021). This period has seen excessive natural resource consumption and escalating greenhouse gas emissions, peaking during globalization and profoundly altering the planetary climate system (Lewis and Maslin 2015).

Organizations perpetuate climate change through their operational processes, supply chains, and product lifecycles, yet they also hold significant potential to mitigate its effects (Boiral et al. 2012). They face growing pressures to adopt and communicate sustainable practices, driven by global environmental agreements and consumer demand for green and low-carbon products (Sprengel and Busch 2011; Zhang et al. 2023). However, companies may integrate these practices symbolically rather than substantively due to the diversity of stakeholder expectations (Testa, Boiral, and Iraldo 2018). The pursuit of maintaining market legitimacy and competitive advantage (Suchman 1995) may easily result in greenwashing practices (Coen et al. 2022; Testa, Miroshnychenko, et al. 2018).

Decarbonization and other mitigation strategies are relatively recent topics, rarely discussed in everyday conversations, and often difficult for individuals to understand when presented in corporate communications (Birkenberg et al. 2021). Although green marketing aims to make such technical information more accessible, the proliferation of unstandardized declarations significantly contributes to a confusing landscape of non-comparable carbon footprint labels (Rondoni and Grasso 2021). For instance, while consumers can recognize that beef has a higher carbon footprint than apples, they often struggle to quantify the extent of this difference (Camilleri et al. 2019). In such contexts, persuasive marketing strategies find fertile ground and can easily trigger emotional

responses, which are less cognitively demanding yet highly effective (Schmuck et al. 2018). *Net-zero* commitments and *carbon-neutral* claims, for instance, are inherently precarious and ambiguous concepts that can lead to misconceptions (Christiansen et al. 2023; Hale et al. 2022).

In summary, carbon mitigation practices are primarily internal and not easily observable by external stakeholders. This information asymmetry is exacerbated by consumers' limited understanding, inconsistent labeling, and misleading practices. Compromised communications leave consumers puzzled about the sincerity and effectiveness of mitigation initiatives, leading to skewed competition and suboptimal purchasing decisions that hinder the diffusion of low-carbon products. Building on these practical challenges, we analyzed the theoretical state-of-the-art and identified several gaps:

1. Initial results highlight consumer confusion regarding carbon-related information and labelling (Camilleri et al. 2019; Feucht and Zander 2018; Li et al. 2017; Thøgersen and Nielsen 2016). However, there is scant empirical evidence on how consumers navigate different decarbonization strategies and discern true carbon neutrality.
2. Some studies conflict with traditional assumptions from the theory of planned behavior (Ajzen 1991), revealing a complex relationship between the provision of environmental information and the impact on purchase intention (PI) (Cerri et al. 2018; Kahan et al. 2012; Taufique et al. 2017). We aim to explore this dynamic in the context of carbon neutrality, examining how consumers elaborate on such information, aligning their cognitive and behavioral responses.
3. Green marketing messages are often processed through intuitive thinking (i.e., heuristics), which often override rational analysis (Hoek et al. 2013; Santa and Drews 2023). However, the role of heuristics in interpreting *carbon-neutral* claims and affecting behavior remains underexplored.
4. *Carbon-neutral* declarations may deceive consumers if not properly supported, leading them into the greenwashing trap. Academic discussions on greenwashing have predominantly focused on theory rather than on empirical research (Hartmann et al. 2023). Specifically, consumer sensitivity to the issue of carbon-washing has received very little attention due to its recent emergence.

To address the above-mentioned literature gaps, we propose the following research question:

RQ1. *Are consumers able to understand carbon claims in green marketing messages, adjusting their perception of greenwashing and purchase intention accordingly?*

By enhancing accessibility to key information, companies can foster consumer trust, support the recognition of meaningful decarbonization efforts, and ultimately guide more responsible purchasing (Feucht and Zander 2018; Michaud and Llerena 2011). However, overloading consumers with excessively detailed or complex information can lead to cognitive burden (Sweller 2010), impairing their ability to process and retain information effectively, and hence deterring effective decision-making (Eng et al. 2021). To date, little research has focused specifically on the provision of carbon neutrality explanations during purchasing decisions. These considerations lead us to our second exploratory research question:

RQ2. *How does providing additional information on carbon neutrality affect consumer response to carbon claims in green marketing messages?*

To address these overarching questions, we conducted three studies, employing a combination of experimental manipulation and survey methods. Two online surveys were used to collect a total of 1593 valid responses from a representative sample of the Italian population aged 18–70. Our studies revealed five key insights:

1. By emphasizing both direct and indirect emissions, lifecycle information addresses a broader scope of climate responsibility. Compared to firm-level data, providing detailed lifecycle information is more effective in fostering positive cognitive and behavioral responses.
2. Comprehension plays a pivotal role in shaping such responses. When consumers fully understand lifecycle-based information, it reduces perceived greenwashing (PGW) and increases PIs. Conversely, limited understanding can reverse these effects.
3. Consumers often rely on heuristic reasoning, triggered by terms like *carbon-neutral*, especially when comprehension is limited. This can lead to superficial assessments and potential susceptibility to carbon-washing. Analytical processing, driven by a proper understanding, enables more deliberate and informed decision-making.
4. There is a consistent negative relationship between PGW and PI: as skepticism increases, the likelihood of purchasing decreases.
5. Educating consumers with preliminary explanations (PE) about carbon neutrality enhances their ability to detect carbon-washing. Literacy interventions bridge the knowledge gap, enabling consumers to differentiate between substantiated and unsubstantiated claims.

The following sections detail the theoretical background and explain the design of the three experimental studies. We then discuss the major results and highlight how they contribute to the debate on consumers' cognitive and behavioral responses to carbon claims, addressing a research priority that has previously received limited attention.

2 | Theoretical Background

2.1 | Theoretical Foundations of Environmental Communication and Greenwashing

The investigation into why organizations communicate their environmental efforts is informed by various theoretical frameworks. Stakeholder Theory posits that companies are increasingly facing external pressure to adopt environmental practices,

reduce carbon footprints, and transition to cleaner energy sources (Sprengel and Busch 2011). According to legitimacy theory (Suchman 1995), the need to maintain operational license and competitive advantage prompts companies to disclose environmental performance and climate pledges—in line with the growing trend of organizations disseminating extensive environmental information.

However, the nature of stakeholder demands and pressures may lead to the symbolic rather than substantive adoption of pro-environmental measures (Testa, Boiral, and Iraldo 2018). When stakeholders are distant and unable to verify these measures, companies can exploit information asymmetry to their advantage. They legitimate their operations and boost their reputation through marketing strategies while avoiding substantial investments (Testa, Miroshnychenko, et al. 2018).

As a result, organizations exaggerate or fabricate their environmental stewardship to gain legitimacy from stakeholders (de Freitas Netto et al. 2020; Lyon and Montgomery 2015), giving rise to greenwashing. Deceptive communications may also occur unintentionally when other actors in the value chain fail to guarantee adequate information or verified performance (Szabo and Webster 2021).

2.2 | Complexities Associated With Carbon-Related Communication

Global institutions urge companies to align with the Paris Agreement and meet the EU emissions neutrality targets for 2050, while consumers demand climate-friendly products (Zhang et al. 2023). Therefore, companies increasingly disclose their carbon performance. At the organizational level, companies usually rely on standards such as the GHG Protocol (WRI and WBCSD) categorizing emissions into Scope 1 (direct emissions), Scope 2 (energy supply), and Scope 3 (indirect emissions). Thus, organizations aiming for greater climate responsibility seek to demonstrate decarbonization commitments that extend beyond firm-level operations. Similarly, product-level carbon footprints measure emissions from raw material extraction to disposal. The lifecycle approach is particularly relevant for labeling a product as *carbon-neutral*, which requires addressing both direct and indirect emissions. However, collecting transparent and reliable data across supply chains poses significant challenges, especially when Scope 3 emissions span multinational boundaries due to the complexity of business strategies (Zhang et al. 2023).

Intentional or unintentional, misleading communications reflect the discrepancy between carbon claims and actual corporate carbon performance (Delmas and Burbano 2011), ultimately leading to *carbon-washing*. The widespread use of terms such as *net-zero* and *carbon-neutral* is often criticized for lacking substance and standardization. While approximately 20% of organizations have adopted net-zero targets, only one-fifth are considered robust and adhere to established protocols (Hale et al. 2022). Standards like ISO 14068 or PAS 2060 can help reduce information asymmetry by verifying corporate communications at the organizational level, but are more rarely applied to products, hindering consumer evaluations.

2.3 | The Role of Carbon Claims in Shaping Consumer Understanding and Behavior

Existing research reveals that consumers often lack the specific knowledge needed to understand how their purchasing decisions can help reduce carbon emissions (Brunner et al. 2018; Li et al. 2017). Many are unable to distinguish between climate change and broader environmental or ethical issues (Feucht and Zander 2018), highlighting the importance of carbon claims in enabling informed consumer choices.

Properly informing consumers to facilitate sustainable purchasing is a key tenet of green marketing studies. Inadequate information at the point of sale can impede responsible decisions (Bray et al. 2011), whereas well-designed green marketing and eco-labelling positively impact behavior (Pickett-Baker and Ozaki 2008). Expanding the theory of planned behavior (Ajzen 1991), context-specific information serves a dual purpose: It acts as a catalyst for enhancing environmental awareness and shapes predictors like attitude and perceived behavioral control (Dihr et al. 2021; Michaud and Llerena 2011).

However, the relationship between information and consumer response is complex. Psychological mechanisms, such as cultural biases and cognitive dissonance, influence how consumers interpret carbon claims (Kahan et al. 2012). For instance, consumers may avoid information that contradicts their beliefs, rejecting the climate impact of food products they are willing to buy (Edenbrandt et al. 2021). Confusion about sustainability terminology further complicates decision-making (Smith and Brower 2012). Consumers struggle to distinguish legitimate advertising from greenwashing (Fernandes et al. 2020; Schmuck et al. 2018), often attributing insincere motives to companies' environmental disclosures (Nyilasy et al. 2014). Ultimately, misconceptions fail to influence purchasing decisions or can even backfire, deterring consumers (Thøgersen et al. 2010).

Among these factors, rational comprehension of messages emerges as pivotal. Possessing broad environmental knowledge alone is insufficient. Instead, the ability to critically evaluate product characteristics is more likely to lead consumers to prefer truly low-carbon products (Testa et al. 2015). However, studies show that consumers in Europe and Asia are unfamiliar with or mistrustful of carbon footprints (Li et al. 2017). Therefore, even if some individuals appreciate such labels, they often find it difficult to fully understand or compare them (Thøgersen and Nielsen 2016).

2.3.1 | Hypotheses Development

Misconceptions surrounding carbon-related communications are well-documented, with many consumers struggling to compare the climate impact of different products. At the same time, misleading claims and inconsistent labels exacerbate confusion and skepticism. To address these issues, clear information explaining how companies manage emissions along the entire product lifecycle could offer a more transparent view of a product's climate impact (Testa et al. 2015). This approach aligns with the principles required by carbon neutrality, helping minimize information asymmetry. Reliable lifecycle-based information—as long as critically assessed—empowers

consumers to distinguish between legitimate and misleading claims (Chen and Chang 2013; Leonidou and Skarmeas 2015), leading to the recognition of truly low-carbon products (Ertz et al. 2017). We developed our hypotheses drawing on these considerations:

H1a. *If the claim is understood, a higher level of information (lifecycle vs. firm-level) decreases perceived greenwashing.*

H1b. *If the claim is not understood, a higher level of information (lifecycle vs. firm-level) increases perceived greenwashing.*

H2a. *If the claim is understood, a higher level of information (lifecycle vs. firm-level) increases purchase intention.*

H2b. *If the claim is not understood, a higher level of information (lifecycle vs. firm-level) decreases purchase* intentions.

H3. *Higher levels of perceived greenwashing result in lower purchase intention.*

2.4 | Rational Versus Heuristic Information Processing

Considering major theories on decision-making (e.g., Kahneman 2011; Shiv and Fedorikhin 1999), individuals can process information through a dual lens: either by relying on automatic judgments, cognitive shortcuts and gut reactions or by engaging in conscious reflection and calculation, adopting a more analytical and effortful approach. Although the classical belief posits that minimizing rational processing compromises precision, heuristics can actually enhance accuracy by using less information, demanding fewer computational skills, and requiring less time (Gigerenzer and Brighton 2009). Heuristics often prevail over rational analysis as individuals have limited resources and try to reduce cognitive load, simplifying decision-making.

This tendency is especially evident in green marketing, where consumers encounter an overwhelming number of messages, labels and certifications (Segev et al. 2016). Heuristic responses may be triggered by cues such as the color green, symbols, images of nature, or specific terminology (Lim et al. 2020; Matthes et al. 2014; Parguel et al. 2015). Words like "green," "eco-friendly," and "climate-friendly" evoke positive associations and reassure consumers about the sustainability of products (Smith and Brower 2012). However, such terms are ambiguously worded and can easily cause consumers to underestimate the actual environmental impact of products if not clearly supported (Naderer et al. 2017).

This ambiguity is particularly pronounced for carbon-related terminology, where terms like *carbon-neutral* and *net-zero* are often perceived as interchangeable, with a stronger association to emission reductions than to compensation efforts (ASA and Jigsaw Research 2022). Initial studies reveal that many consumers fail to differentiate between short-term offsetting and long-term emissions reduction—a key distinction in understanding carbon neutrality (Iovino et al. 2023). Additionally, a product marked as *carbon neutral* might give the impression that it is not contributing to climate change, while *offsetting* projects may falsely suggest a restoration of climate balance (Birkenberg et al. 2021; Warburg et al. 2021).

2.4.1 | Hypotheses Development

Although international agreements and corporate commitments have driven the proliferation of *carbon-neutral* claims, research has scarcely explored consumer response to it. Consumers may respond positively to such resonant terms without fully understanding their technical meanings (Santa and Drews 2023). If they prefer to trust such claims rather than scrutinize each product's credentials, the likelihood of being deceived increases (Feucht and Zander 2018).

To address this potential risk, we draw on the principles of carbon neutrality. Substantiating a *carbon-neutral* claim by explaining how the company has addressed emissions across the entire product lifecycle can positively influence cognitive and behavioral responses (Ertz et al. 2017). Nonetheless, consumers with limited comprehension of the message may find it challenging to analytically process this type of information and may instead bypass it (Hoek et al. 2013). Based on this, we have formulated the following hypotheses:

H4a. *If the claim is understood, a substantiated (legitimate) carbon-neutral claim decreases perceived greenwashing compared to an unsubstantiated (illegitimate) claim.*

H4b. *If the claim is not understood, a substantiated (legitimate) carbon-neutral claim does not affect perceived greenwashing compared to an unsubstantiated (illegitimate) claim.*

H5a. *If the claim is understood, a substantiated (legitimate) carbon-neutral claim increases purchase intention compared to an unsubstantiated (illegitimate) claim.*

H5b. *If the claim is not understood, a substantiated (legitimate) carbon-neutral claim does not affect purchase intention compared to an unsubstantiated (illegitimate) claim.*

2.5 | The Impact of Education on Consumer Behavior

Consumer misunderstanding often stems from inconsistencies in carbon labels, prompting several scholars to underscore the need for standardized, reliable, and accessible information, as outlined in Rondoni and Grasso's (2021) literature review. For these reasons, consumers are reluctant to consider carbon footprint labeling when shopping unless they receive prior guidance or education about it (Emberger-Klein and Menrad 2018; Upham et al. 2011). Research further indicates that, once people understand the purpose and mechanics of climate-related practices, such as carbon offsetting, their attitudes become favorable toward these initiatives (Babakhani et al. 2017; Kim et al. 2016). These findings confirm that disseminating comprehensive information about climate change and products' carbon performance plays a pivotal role in bolstering consumer understanding and influencing their decision-making (Brunner et al. 2018).

On the other hand, the volume of information provided is also a critical factor. Excessive details can overwhelm consumers, leading to cognitive overload due to limited human capacity for information absorption. According to Cognitive Load Theory (Sweller 2010), fatigue may arise from: (i) *intrinsic load* (inherent and fixed complexity of the content); (ii) *extraneous load* (how information is presented); (iii) *germane load* (effort dedicated to understanding and assimilating). Consequently, inherently sophisticated carbon labels may be hard to comprehend, complicating decision-making (Feucht and Zander 2018).

2.5.1 | Hypotheses Development

In light of these mixed findings, we support the hypothesis that educating consumers with PEs can foster a positive response to carbon claims, on the condition that the information is presented effectively. Hence, we assume that reducing intrinsic load by managing extraneous load Sweller (2010)—through clear yet comprehensive explanations of carbon neutrality—can facilitate understanding and retention, strengthening the effect of a substantiated *carbon-neutral* claim:

H6. *Preliminary explanations enhance the effect of claim substantiation on decreasing perceived greenwashing.*

H7. *Preliminary explanations enhance the effect of claim substantiation on increasing purchase intention.*

3 | Methodology

3.1 | Overall Design

We conducted three studies (Study A, Study B, and Study C) to test our hypotheses using an experimental design. Participants were exposed to different advertisements outlining a product's carbon performance, in which we varied the level of information (LOI) provided, the legitimacy of the claim, and the presence of PEs to assess their reactions. The three studies were conducted sequentially, following a progressive design in which each experiment built upon the previous one. Study A explored how different levels of information disclosure affect PGW and PI within a context of legitimate communication. Study B extended this design by comparing legitimate and illegitimate (carbon-washing) communication contexts. This was achieved by introducing an explicit *carbon-neutral* claim and manipulating the LOI provided to substantiate it. Study C further investigated whether providing PEs on carbon neutrality—used as a proxy for induced knowledge—modifies these effects.

We chose to advertise a wooden chair as a representative item in the timber supply chain, as this research is part of a broader European project, LIFE CO2PES&PEF, focused on land use, land-use change, and forestry (LULUCF) activities. The project aims to support European climate mitigation initiatives in alignment with the Paris Agreement's goals and emission reduction targets. Specifically, it focuses on balancing emissions and absorption in LULUCF activities, with an emphasis on conserving and enhancing carbon stocks in forestry and wooden materials/products. The extensive involvement of companies in this project provided valuable feedback during the design phase of our three experimental studies.

To design the carbon-related messages used in the experiments, we relied on claims inspired by real green marketing advertisements present in the Italian market. We identified carbon-related claims used in the market through a collaboration with *GS1 Italy*, a non-profit organization and community of 40,000 companies active in the consumer goods sector that promotes the use of GS1 standards such as the barcode (EAN). Thanks to GS1 Italy's observatory on the information reported on the packaging of approximately 133,000 consumer products, we identified about 25 examples of market-used carbon-related claims. This process allowed us to identify two main messages commonly conveyed by market actors: companies' commitment to reducing CO_2 emissions across various phases of the product lifecycle and the implementation of offsetting practices, often associated with the concept of carbon neutrality.

Subsequently, we assessed the conformity of these messages with international standards, such as ISO 14021, ISO 14068, and PAS 2060, identifying potential misleading practices, including the improper use of *carbon-neutral* claims. These insights informed the design of the carbon-related messages tested in our experiments.

To simulate a real-life purchasing scenario in the experiments, we displayed an image of a wooden chair named "Lorena" alongside each message to enhance participant immersion. The same image was shown to all participants to ensure visual consistency across the three studies, while the written content of the message varied in each condition.

3.2 | Measurements

After viewing a randomly assigned advertisement, each participant was asked to complete a questionnaire designed to measure three key outcome variables: *claim understanding* (CU), *perceived greenwashing* and *purchase intention*.

Given that objective knowledge on the topic is more reliable than self-reported knowledge due to the subjective nature of the latter (Parguel et al. 2015), we chose to directly measure participants' understanding of the claim. To achieve this, we presented participants with specific statements based on the content of the observed communication. Participants were asked to judge these statements as true or false:

1. The company has reduced and offset CO_2 emissions along the entire value chain, not just those from its facilities.
2. The company communicates that the Lorena chair has achieved carbon neutrality.

To measure PGW and PI, we asked participants to rate some statements on a scale from 1 (*strongly disagree*) to 7 (*strongly agree*). The measures for these constructs were adapted from validated scales used in existing literature and further refined to better suit

TABLE 1 | Measurements.

Construct	Items	Response scale	Adapted from	Cronbach's α
Purchase intention	If I were to buy a chair with a reduced environmental impact, I would like to purchase *Lorena*	7-point Likert agreement scale	Dodds et al. (1991)	0.95
	If I were to buy a chair with a reduced environmental impact, I would want to buy *Lorena*			
	If I were to buy a chair with a reduced environmental impact, I would definitely choose *Lorena*			
	If I were to buy a chair with a reduced environmental impact, I would make sure to purchase *Lorena*			
Perceived greenwashing	*Lorena* cannot be defined as a "green" or "eco-friendly" chair	7-point Likert agreement scale	Chen and Chang (2013), Testa et al. (2022)	0.89
	Communication about *Lorena* omits or masks important information, making its environmental features seem better than they are			
	Communication about *Lorena* overestimates/exaggerates its actual ecological quality			

our research context and objectives (see Table 1). For example, to measure PI we used four items inspired by the scale developed by Dodds et al. (1991), originally applied to a generic product (e.g., "If I were going to buy this product, I would consider buying this model"). We adapted these items to focus on our specific product type ("If I were to buy a chair with a reduced environmental impact, I would like to purchase Lorena"). Likewise, to measure PGW and evaluate mistrust regarding the environmental characteristics presented in the advertisements, we adapted three items from Chen and Chang (2013) (e.g., "This product overestimates/exaggerates its actual ecological quality").

In addition to the main constructs, we included in the questionnaire socio-demographic variables (e.g., age, gender, education, and income) and a measure of perceived knowledge (PK) (see Appendix A). These variables were included as control measures to test whether the main effects hold when accounting for individual differences. In particular, PK was included to control for the possibility that PGW and PI may vary depending on how competent or informed consumers feel about climate change–related issues. The measure was adapted from the multidimensional model of environmental knowledge proposed by Frick et al. (2004), which distinguishes system, action-related, and effectiveness knowledge. In our case, the construct refers to perceived rather than objective knowledge, since objective comprehension is already captured by the CU variable.

3.3 | Pre-Tests and Revisions

To enhance the survey's reliability and accuracy, we conducted a pre-test with non-expert volunteers from the authors' private network, representing diverse backgrounds to capture a range of perspectives. Based on the feedback received, we refined the questionnaire further. We also incorporated suggestions from the professional survey provider responsible for data collection, who recommended improvements in clarity and structure, as well as insights from company representatives involved in the European project, adding valuable industry perspectives. These revisions led to minor adjustments and refinements. The professional survey provider then conducted a final pre-test with a smaller sample to check for potential biases, and no significant concerns emerged.

3.4 | Data Collection

The experiments were conducted through online surveys administered in the first half of December 2022 (Studies A and B) and the first half of January 2023 (Study C), targeting samples representative of the Italian population aged 18–70. We collected a total of 523 valid questionnaires for Study A, 523 for Study B, and 547 for Study C. All three studies included questionnaires designed to measure the outcome variables and various control factors, including sociodemographic and cognitive-behavioral variables.

To reduce sampling biases and ensure external validity, we engaged an external provider for randomized sample selection based on Italian sociodemographic quotas. This provider also managed survey administration and data collection. Online responses were checked for quality and consistency, and

TABLE 2 | Sample demographics.

		Study A		Study B		Study C		Population 18–70	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%
Sample	*N*	523	100%	523	100%	547	100%	39,912,847	100%
Gender	Male	268	51.2%	267	51.1%	274	50.1%	19,844,122	49.7%
	Female	255	48.8%	256	48.9%	273	49.9%	20,068,725	50.3%
Age group	18–24	54	10.3%	54	10.3%	56	10.2%	4,100,475	10.3%
	25–34	83	15.9%	82	15.7%	85	15.5%	6,244,627	15.6%
	35–44	96	18.4%	97	18.5%	100	18.3%	7,272,205	18.2%
	45–54	122	23.3%	122	23.3%	129	23.6%	9,378,257	23.5%
	55–70	168	32.1%	168	32.1%	177	32.4%	12,917,283	32.4%
Geographical area	Northwest	150	28.7%	144	27.5%	146	26.7%	10,636,542	26.6%
	Northeast	95	18.2%	99	18.9%	104	19.0%	7,788,226	19.5%
	Center	122	23.3%	121	23.1%	124	22.7%	9,010,124	22.6%
	South and islands	156	29.8%	159	30.4%	173	31.6%	12,477,955	31.3%
Education	None or primary school	0	0%	2	0.4%	4	0.7%		
	Middle school diploma	38	7.3%	36	6.9%	29	5.3%		
	High school (incomplete)	20	3.8%	39	7.5%	23	4.2%		
	High school diploma	209	40.0%	211	40.3%	220	40.2%		
	University (incomplete)	62	11.9%	54	10.3%	55	10.1%		
	University degree or higher	194	37.1%	181	34.6%	216	39.5%		
Income class	Very low	14	2.7%	12	2.3%	14	2.6%		
	Low	43	8.2%	38	7.3%	35	6.4%		
	Lower–middle	128	24.5%	120	22.9%	122	22.3%		
	Middle	252	48.2%	275	52.6%	285	52.1%		
	Upper–middle	64	12.2%	53	10.1%	58	10.6%		
	High	7	1.3%	13	2.5%	13	2.4%		
	Very high	9	1.7%	4	0.8%	10	1.8%		
	Don't know or prefer not to say	6	1.1%	8	1.5%	10	1.8%		

participants were incentivized through a points-based system for digital rewards. The sample met all pre-set representativeness criteria (gender, age, geographic distribution) and provided a 95% confidence interval with a 3.5% margin of error (see Table 2).

To reduce respondents bias during data collection several precautions were taken. The above-mentioned pre-tests (see Section 3.3) helped us to ensure that all questions were clearly worded and not leading or ambiguous, reducing interpretation bias and improving questionnaire reliability. All questions were formulated in a neutral style, avoiding any wording that might suggest socially desirable or "preferred" answers. Procedurally, we guarantee respondents' anonymity to mitigate social desirability bias. The online self-administered format of the questionnaire allowed respondents to complete it autonomously and privately, minimizing interviewer bias and social pressure. After data collection, we checked for common method bias (CMB) using Harman's single-factor test that did not indicate any substantial bias.

The specific design, methods, and results of Studies A, B, and C are described in the following sections.

4 | Study A

4.1 | Design and Procedures

The primary objective of this study was to test H1a/H1b–H3 by employing a between-subjects experimental design with two conditions (Figure 1). We manipulated the level of carbon-related information provided about the wooden chair to observe its impact on greenwashing perception and PI. Specifically, the *Firm-level*

information condition illustrates how the company has addressed direct emissions by incorporating renewable energy in its facilities and supporting reforestation projects as an offsetting measure. In contrast, the *Lifecycle information* condition describes how the company has managed both direct and indirect emissions throughout the supply chain, considering the product's overall climate impact and thus aligning with carbon neutrality requirements.

Participants were randomly assigned to one of these two conditions, ensuring homogeneous groups in terms of sociodemographic characteristics. After reading the message, they completed the questionnaire intended to measure the experiment's outcomes: CU, PGW, and PI.

For CU, the expected correct answer for both statements was "false" in the *Firm-level* condition and "true" in the *Lifecycle* condition. These questions assess whether participants can accurately interpret carbon claims based on prior knowledge. We created a three-level categorical variable for CU, assigning a value of 2 if both statements were answered correctly, 1 if one was answered correctly, and 0 if neither was correct—corresponding to high, moderate, and low levels of understanding, respectively.

4.2 | Analyses and Results

We applied structural equation modeling (SEM) to examine relationships between the LOI, CU, PGW, and PI, leveraging SEM's strengths in analyzing latent constructs and interrelated variables.

SEM was chosen because it allows for the simultaneous estimation of multiple relationships among latent and measured variables, which aligns with the multidimensional nature of our conceptual framework. Specifically, SEM enables us to test both the measurement and the structural components of the model within a single analytical framework, providing a more comprehensive assessment of construct validity and the hypothesized causal relationships.

The study considers two polarized understanding conditions (i.e., claim understood and claim not understood) based on questionnaire responses. We employed multiple-group SEM analysis (Jöreskog 1971) to evaluate the effects of LOI on PGW and PI within different CU conditions as well as the effect of PGW on PI (see Figure 2).

Prior to estimation, the assumptions underlying covariance-based SEM (CB-SEM) were verified (Kline 2023). The data satisfied the requirement of multivariate normality, and no convergence or identification issues were detected, confirming the adequacy of the model specification.

Both PGW and PI are latent constructs measured by multiple observed items. SEM effectively integrates the items of each construct, as evidenced by high standardized loadings. This

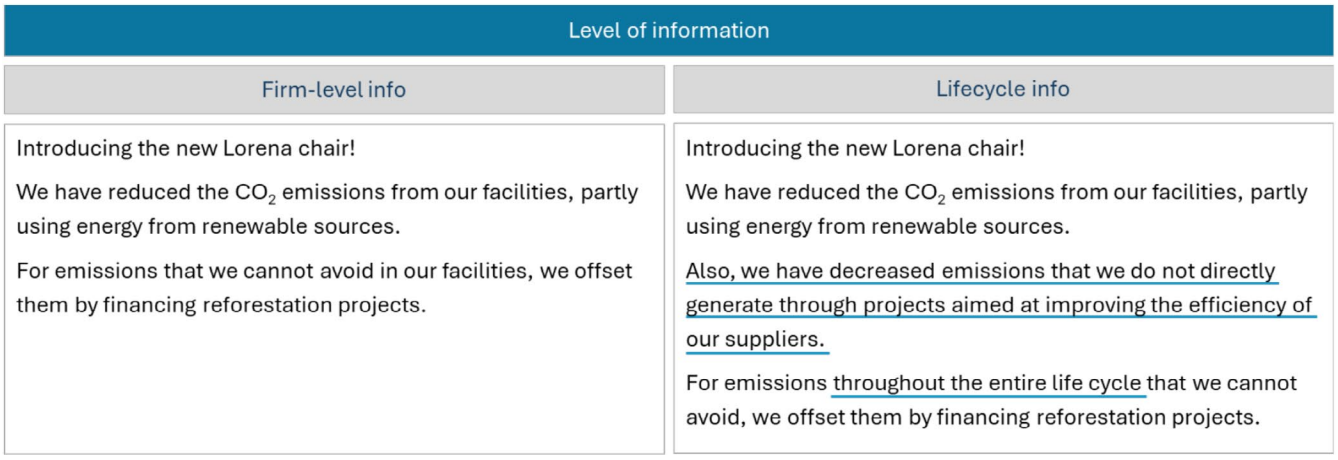

FIGURE 1 | Carbon claims presented in the between-subjects experiment—Study A.

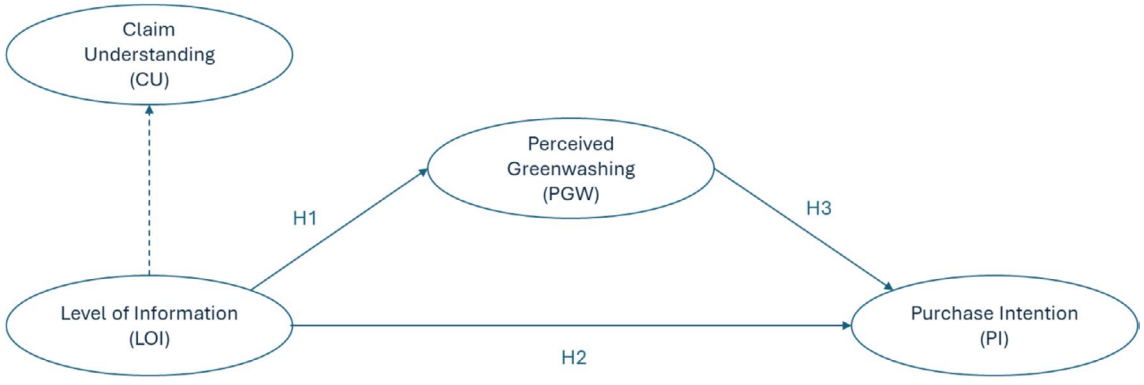

FIGURE 2 | Tested model (Study A).

TABLE 3 | Multiple-group SEM results (Study A).

Sample	Path	Coef.	SE	z	$p>z$	95% CI (lower)	95% CI (upper)
Total sample ($N=523$)	PGW ← LOI	−0.018	0.046	−0.39	0.693	−0.108	0.072
	PI ← LOI	0.006	0.044	0.13	0.895	−0.080	0.091
	PI ← PGW	−0.231	0.045	−5.19	0.001	−0.318	−0.144
Low CU ($N=121$)	PGW ← LOI	0.199	0.089	2.24	0.025	0.025	0.373
	PI ← LOI	−0.446	0.069	−6.43	0.001	−0.583	−0.310
	PI ← PGW	−0.25	0.081	−3.09	0.002	−0.409	−0.092
High CU ($N=161$)	PGW ← LOI	−0.148	0.08	−1.85	0.064	−0.303	0.008
	PI ← LOI	0.414	0.064	6.45	0.001	0.289	0.540
	PI ← PGW	−0.073	0.076	−0.97	0.334	−0.222	0.075

Abbreviations: CU, claim understanding; LOI, level of information; PGW, perceived greenwashing; PI, purchase intention.

confirms the constructs' internal consistency, initially indicated by Cronbach's alpha (see Table 1).

The average variance extracted (AVE) values for PGW (0.746) and PI (0.837) exceed the threshold of 0.5, indicating robust construct reliability and supporting convergent validity. Additionally, discriminant validity is confirmed, as the AVE values are higher than the squared correlation between the constructs (0.053).

Considering the adequacy of SEM in representing the hypothesized relationships among LOI, CU, PGW and PI, key fit statistics demonstrate a strong overall model fit: log-likelihood = −4766.50, chi-squared = 15.62, degrees of freedom = 13, $p=0.2701$, CFI = 1.000, RMSEA = 0.000, and SRMR = 0.014.

Supported by validity and fit tests, this SEM model provides a structured approach to test our hypotheses. Considering the full sample, the direct effects of LOI on PGW and PI are not significant, suggesting no change when shifting from firm-level to lifecycle information. However, to test H1a/H1b and H2a/H2b we need to differentiate between who has understood and who has not. Therefore, applying a multiple-group SEM analysis, we divided the initial model into two groups representing distinct levels of understanding: low understanding (CU = 0) and high understanding (CU = 2). This approach focuses on participants with polarized levels of CU, excluding the non-significant intermediate group with moderate understanding (CU = 1).

Among participants who understood the claim, lifecycle information reduces the perception of greenwashing (coef. = −0.148; $p=0.064$) and increases the intention to buy (coef. = 0.414, $p=0.000$), supporting H1a and H2a. In contrast, when the claim is not understood, the effects are reversed: More detailed information leads to an increased perception of being deceived (coef. = 0.199, $p=0.025$) and a lowered PI (coef. = −0.446, $p=0.000$), confirming H1b and H2b. Finally, we tested H3 across the full sample. As expected, PGW is negatively associated with intention to buy, confirming H3 (coef. = −0.2309, $p=0.000$). The results of the SEM analysis are summarized in Table 3.

To test hypotheses, we first estimated the models without control variables, as the primary goal was to assess the direct and indirect effects of LOI and PGW. To evaluate the robustness of these findings, we also estimated an extended model—including demographic and knowledge-related controls (age, gender, education, income, and PK)—reported in Appendix B.

The main effects remain directionally consistent, and some coefficients even increase in significance, further supporting the robustness of the models. Additional patterns emerge. Younger consumers appear more skeptical toward carbon claims ($\beta=-0.170$, $p<0.01$), particularly among those who do not understand the claim ($\beta=-0.348$, $p<0.01$). In contrast, among participants with higher comprehension, income and PK positively predicted PGW ($\beta=0.154$, $p<0.10$; $\beta=0.253$, $p<0.01$). In the full sample, education and income slightly predict PI ($\beta=-0.134$, $p<0.01$; $\beta=0.064$, $p<0.10$). PK consistently shows a strong positive effect on PI ($\beta=0.550$, $\beta=0.481$, $\beta=0.529$; $ps<0.01$) across all groups. Other tested relationships are not statistically significant.

5 | Study B

5.1 | Design and Procedures

The second study addresses H4a/H4b and H5a/H5b while replicating H3 to validate and expand upon our initial findings. We employed a between-subjects design with two conditions to capture differences in greenwashing perception and PI between groups exposed to substantiated versus unsubstantiated *carbon-neutral* claims (Figure 3).

We maintained the core design from Study A, advertising the "Lorena" wooden chair with manipulated levels of information. This time, we added an explicit *carbon-neutral* claim in both conditions, focusing on its substantiation and legitimacy. Specifically, the *unsubstantiated* condition features a carbon-washing example, where the carbon-neutral claim is improperly used due to insufficient supporting evidence, as the company addresses only direct (firm-level) emissions. By contrast, the *substantiated* condition presents a legitimate *carbon-neutral*

claim, backed by detailed information on how the company has reduced and offset both direct and indirect emissions throughout the entire product lifecycle, as prescribed by European directives.

Participants were randomly divided into two groups to ensure sociodemographic similarity across conditions. Each group read the assigned advertisement and then responded to questions assessing the outcome variables. For claim comprehension, the expected correct answers in the *unsubstantiated* condition were "false" for the first statement and "true" for the second. In the *substantiated* condition, both statements had "true" as the correct response. Following the same criteria used in Study A, we created a three-level categorical variable to measure CU.

5.2 | Analyses and Results

Similar to Study A, we employed SEM to examine the latent constructs and relationships between legitimate substantiation (LS), CU, PGW, and PI. To account for the two polarized levels of understanding, we applied a multiple-group SEM analysis (Jöreskog 1971) (Figure 4).

Prior to estimation, the assumptions underlying CB-SEM were verified, confirming the adequacy of the model specification (Kline 2023). The data met the assumption of multivariate normality, and no convergence or identification issues were detected.

Both PGW and PI were validated as reliable latent constructs, measured through multiple observed items. The high standardized loadings for each item confirm internal consistency, with Cronbach's alpha as initial evidence (refer to Table 1). The AVE values for PGW (0.714) and PI (0.831) exceed the threshold of 0.5, demonstrating strong convergent validity. Additionally, the squared correlation between PGW and PI (0.080) is notably lower than the AVE values, which indicates discriminant validity without overlap.

The SEM analysis produced fit statistics indicating a robust model fit: log-likelihood = −5233.292, chi-squared = 43.91, degrees of freedom = 18, $p = 0.0006$, CFI = 1.000, RMSEA = 0.000, and SRMR = 0.014. These metrics suggest that the SEM model accurately represents the hypothesized relationships among LS, CU, PGW, and PI.

To test H4a/H4b and H5a/H5b, we conducted a multiple-group SEM analysis based on levels of claim comprehension, considering low (CU = 0) and high (CU = 2) understanding groups. In the high understanding group, providing a legitimate and substantiated *carbon-neutral* claim reduces the perception

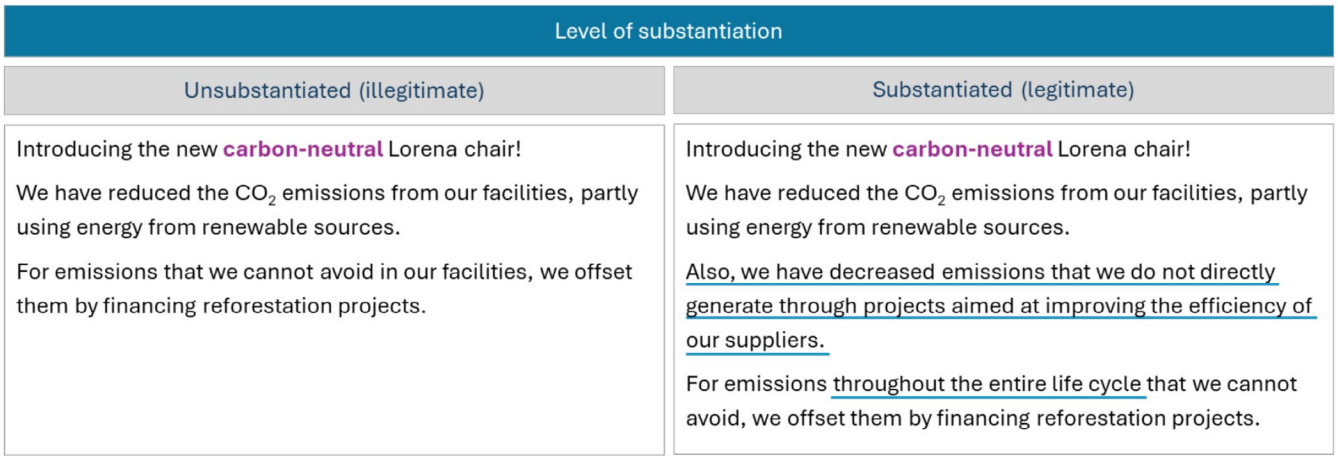

FIGURE 3 | Carbon claims presented in the between-subjects experiment—Study B.

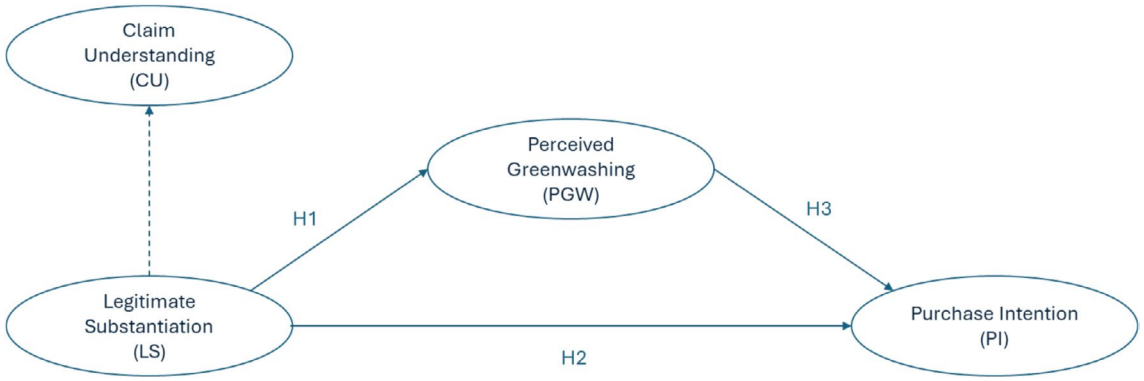

FIGURE 4 | Tested model (Study B).

TABLE 4 | Multiple-group SEM results (Study B).

Sample	Path	Coef.	SE	z	$p>z$	95% CI (lower)	95% CI (upper)
Total sample ($N=523$)	PGW ← LS	−0.029	0.046	−0.63	0.526	−0.12	0.061
	PI ← LS	0.06	0.043	1.38	0.166	−0.025	0.144
	PI ← PGW	−0.281	0.044	−6.39	0.001	−0.367	−0.195
Low claim understanding ($N=22$)	PGW ← LS	0.34	0.218	1.56	0.119	−0.088	0.767
	PI ← LS	−0.14	0.231	−0.61	0.543	−0.592	0.312
	PI ← PGW	0.029	0.272	0.11	0.915	−0.504	0.562
High claim understanding ($N=275$)	PGW ← LS	−0.139	0.062	−2.24	0.025	−0.261	−0.017
	PI ← LS	0.205	0.058	3.57	0.001	0.093	0.318
	PI ← PGW	−0.237	0.061	−3.89	0.001	−0.356	−0.118

Abbreviations: CU, claim understanding; LS, level of substantiation; PGW, perceived greenwashing; PI, purchase intention.

Did you know that...

Carbon neutrality – the European goal for 2050 – refers to a state of balance between the CO_2 emitted into the atmosphere and that removed.

According to ISO 14021 and PAS 2060 standards, a product is **carbon neutral** if the emissions generated throughout all phases of its life cycle – from the extraction/production of raw materials, transport, manufacturing in company plants, distribution, to product use and end of life – are equal to or less than those removed.

To achieve **carbon neutrality**, companies should take three consecutive actions: first, measure emissions throughout the entire life cycle of their products; then, take action to reduce those emissions; and finally, they can offset unavoidable CO_2 emissions through carbon absorption or sequestration projects, such as reforestation.

FIGURE 5 | Preliminary explanation about carbon neutrality.

of greenwashing (coef. = −0.139; $p=0.025$) and increases PI (coef. = 0.205; $p=0.000$), confirming H4a and H5a. In contrast, when the message is not understood (CU = 0), substantiating the *carbon-neutral* claim does not yield significant effects on greenwashing perception (coef. = 0.340; $p=0.119$) or PI (coef. = −0.140; $p=0.543$), thereby confirming H4b and H5b.

Lastly, we tested H3 across the entire sample. The results demonstrated that PGW negatively affects PI (coefficient = −0.2806, $p=0.000$), mirroring the relationship found in Study A, thus corroborating its robustness across different experimental contexts. The results of the SEM analysis are summarized in Table 4.

As in Study A, we assessed the robustness of the structural models by including socio-demographic and cognitive control variables (see Appendix B). The main relationships remain stable, whereas additional patterns emerge. Among participants with full claim understanding, men and younger consumers appear more skeptical toward carbon-related claims ($\beta=-0.101$, $\beta=-0.114$, $ps<0.10$). In the full sample, age and PK show a negative effect on PGW ($\beta=-0.104$; $\beta=-0.106$, $ps<0.05$). Age also has a positive effect on PI ($\beta=0.108$, $p<0.01$), while education exerts a small negative influence ($\beta=-0.062$, $p<0.10$)—an effect that reverses and becomes strongly positive among participants with low comprehension ($\beta=0.313$, $p<0.01$). Among consumers with high comprehension, income slightly increases PI ($\beta=0.080$, $p<0.10$). As in study A, PK strongly predicts PI across all groups ($\beta=0.584$, $\beta=0.871$, $\beta=0.562$; $ps<0.01$). Other tested relationships are not statistically significant.

6 | Study C

6.1 | Design and Procedures

The third study aims to test H6 and H7. The findings from Study A and B informed the design of our third and final study. Our previous experiments demonstrated that comprehension is a pivotal factor in recognizing carbon-washing and influencing PI toward low-carbon products. Therefore, Study C intends to provide participants with additional knowledge to assess whether it alters the effect of providing substantiated and legitimate *carbon-neutral* claims.

In Study C, we replicated the experimental design developed in Study B (see Figure 3) by introducing an additional layer. Participants were randomly divided into two groups. Only one group read PEs clarifying the concept of carbon neutrality (Figure 5) before being exposed to the advertisements. This approach allows us to assess the moderating role of PE as a proxy of induced knowledge.

To develop the text used as preliminary information we carefully considered the definitions and requirements contained in ISO 14021 and PAS 2060 standards to ensure that the text accurately reflects the latest guidance on CO_2 accounting and carbon neutrality. Then, we conducted a test with a group of 14 non-experts in the field (recruited from the authors' acquaintances) to ensure that the language is clear, concise, and easy to understand by individuals from different backgrounds. This diversity of perspectives helped us identify potential areas of confusion or ambiguity in the text and refine it accordingly.

All participants, regardless of whether they received PEs, were randomly assigned to one of the two messages used in Study B (see Figure 3). Indeed, we maintained the key focus on substantiating *carbon-neutral* claims. As in the previous experiment, we manipulated substantiation to reflect the extent of lifecycle information provided to legitimize the *carbon-neutral* claim. The unsubstantiated condition highlights only the company's direct CO_2 mitigation practices, exemplifying carbon-washing. In contrast, the substantiated condition provides a comprehensive explanation, also addressing indirect emissions across the product lifecycle to ensure regulatory compliance.

Fundamentally, we employed a between-subjects design with four conditions, manipulating the presence of both a LS and PEs. This approach divided the participants into four homogeneous groups in terms of sociodemographic characteristics. As in Studies A and B, participants answered survey questions, including claim comprehension, which allowed us to construct a three-level categorical variable.

6.2 | Analyses and Results

In Study C, we considered only participants who demonstrated full claim comprehension (CU = 2), which reduced the sample size from 547 to 294. We conducted ANOVA (Analysis of Variance) to compare the means of PGW and PI across groups defined by the presence or absence of LS, both with and without the provision of PEs on carbon neutrality (Figure 6).

We evaluated the effects on PGW to test H6. Participants who do not receive PEs show no significant difference ($p = 0.22$) in PGW between the unsubstantiated (I = 3.34, SD = 1.20) and substantiated ($M = 3.04$, SD = 1.28) conditions (Figure 7). This suggests that, without PEs, participants are unable to discern between legitimate and illegitimate *carbon-neutral* claims. In contrast, a marginally significant difference ($p = 0.06$) in PGW emerges between the two LS conditions when participants are exposed to additional explanations. Specifically, the results show a decrease in PGW from $M = 3.54$ (SD = 1.28) in the unsubstantiated condition to $M = 3.08$ (SD = 1.26) in the substantiated condition (Figure 7). These findings support H6, suggesting that PEs can enhance the effect of LS on reducing PGW.

Proceeding with the analysis, we observe that LS produces a significant increase in PI across both PE conditions (i.e., with/without PEs). Without PEs, PI rises from $M = 4.04$ (SD = 1.33) in the unsubstantiated condition to $M = 4.51$ (SD = 1.05) in the substantiated condition, with $p = 0.03$ (Figure 8). Similarly, with PEs, PI increases from $M = 3.97$ (SD = 1.06) to $M = 4.41$ (SD = 1.14) in the substantiated condition, with $p = 0.04$ (Figure 8). However, contrary to our expectations, PEs do not amplify the effect of LS on increasing PI. Instead, the effect is slightly lower in the condition with PE (+0.44) than in the one without PE (+0.47). Thus, H7 is rejected.

Table 5 provides an overview of the hypotheses supported and rejected in Studies A, B, and C.

7 | Discussion

As companies commit to addressing CO_2 emissions either within its own boundaries or across the entire supply chain, Study A aims to assess if consumers can recognize and reward companies that adopt more comprehensive approaches in climate disclosure. Our results demonstrate that positive cognitive and behavioral responses are significantly influenced by the LOI provided. Lifecycle information—covering the reduction and offsetting of both direct and indirect emissions—generates a stronger positive effect compared to firm-level information. Specifically, lifecycle information reduces the likelihood of consumers perceiving carbon-washing (H1a) and increases the intention to buy the advertised product (H2a). Moreover, consumers develop a perception of carbon-washing that inversely impacts PI: As this perception rises, their willingness to buy diminishes, and vice versa (H3). These findings build upon the theory of planned behavior, which suggests environmental communication can effectively minimize information asymmetry,

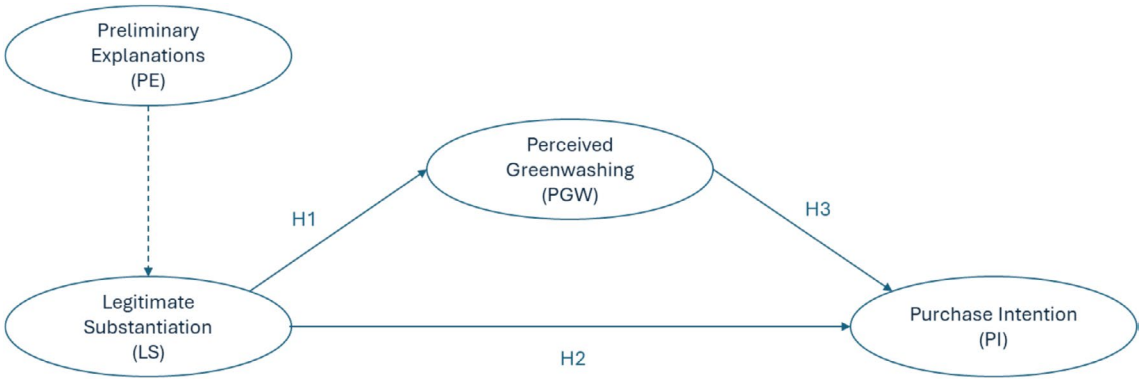

FIGURE 6 | Tested model (Study C).

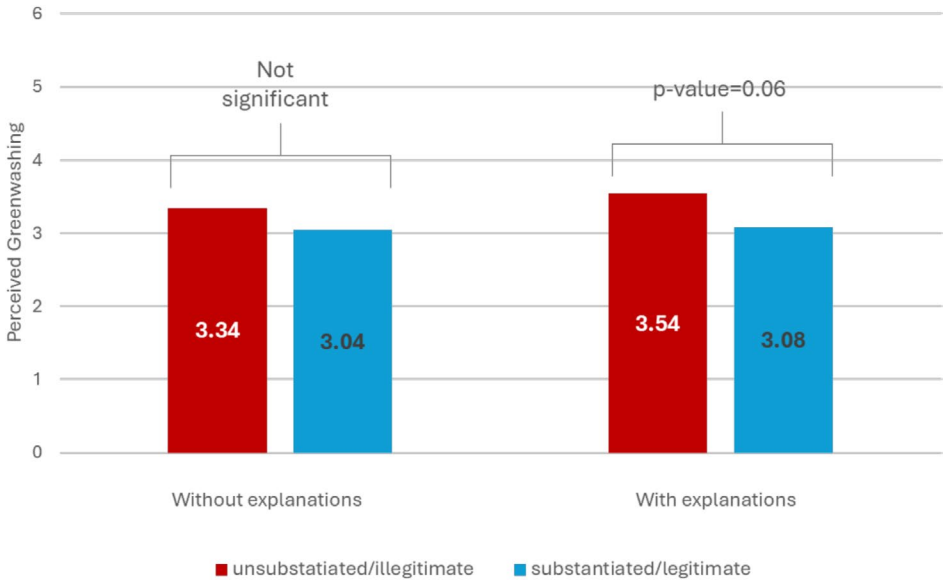

FIGURE 7 | Effect of legitimate substantiation and preliminary explanations on perceived greenwashing.

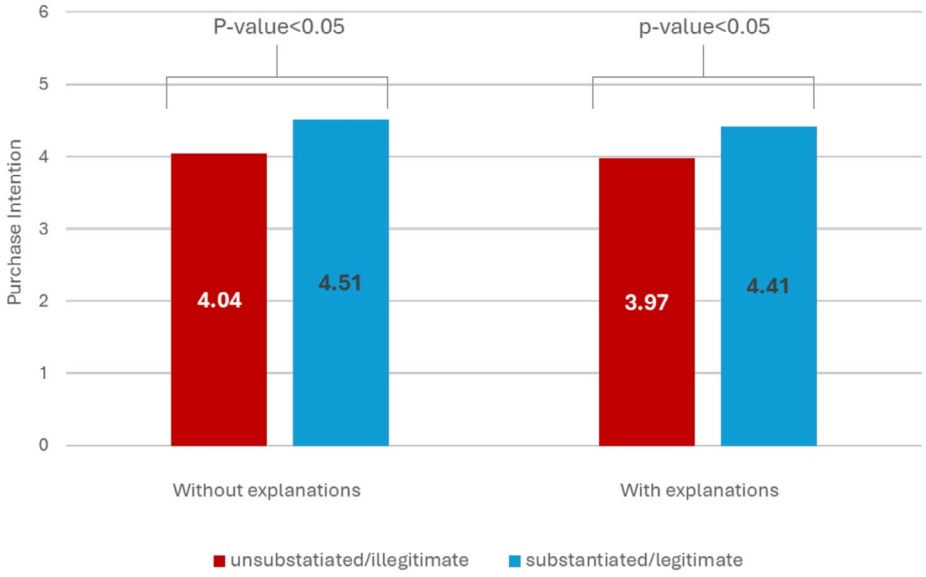

FIGURE 8 | Effect of legitimate substantiation and preliminary explanations on purchase intention.

thereby guiding consumers toward green and low-carbon products (Brunner et al. 2018; Dihr et al. 2021).

However, our results show that positive effects only manifest when consumers can critically evaluate carbon claims. Conversely, when comprehension is limited, we find that negative behavioral responses are more likely to develop. These findings expand previous research indicating that consumers struggle to navigate carbon labelling effectively (Li et al. 2017; Thøgersen and Nielsen 2016). Some authors suggest that consumers may experience fatigue and cognitive overload when striving to interpret overwhelming and unintelligible information (e.g., Eng et al. 2021). Others argue that individuals avoid engaging deeply with unfamiliar claims or messages that contradict their beliefs (e.g., Edenbrandt et al. 2021; Kahan et al. 2012). As a common result, confusion or skepticism counteracts the intended positive impact of carbon disclosure. We add that consumer misunderstanding—that may stem from cognitive limitations or psychological resistance—undermines the functioning of advertisements communicating lifecycle emissions information, hindering the recognition of truly low-carbon products. In fact, when the carbon claim is not understood, conveying comprehensive information backfires, increasing the suspicion of carbon-washing (H1b) and reducing PI (H2b).

Study B specifically examines whether consumers are sensitive to information that supports and legitimates *carbon-neutral* labels and whether they are able to identify instances of carbon-washing. Improper use of the term *carbon-neutral* often occurs when only direct emissions (e.g., from the production phase) are addressed. This distinction is particularly relevant, as green marketing frequently abuses explicit *carbon-neutral* labels, exploiting them in ways that can be misleading or even illegitimate (de Jong et al. 2020). Our findings indicate that for consumers with

TABLE 5 | Summary of hypotheses supported and rejected—Study A, B and C.

Study A		
H1a	If the claim is understood, a higher level of information (lifecycle vs. firm-level) decreases perceived greenwashing	Supported
H1b	If the claim is not understood, a higher level of information (lifecycle vs. firm-level) increases perceived greenwashing	Supported
H2a	If the claim is understood, a higher level of information (lifecycle vs. firm-level) increases purchase intention	Supported
H2b	If the claim is not understood, a higher level of information (lifecycle vs. firm-level) decreases purchase intention	Supported
H3	Higher levels of perceived greenwashing result in lower purchase intention	Supported
Study B		
H4a	If the claim is understood, a substantiated (legitimate) carbon-neutral claim decreases perceived greenwashing compared to an unsubstantiated (illegitimate) claim	Supported
H4b	If the claim is *not* understood, a substantiated (legitimate) carbon-neutral claim does not affect perceived greenwashing compared to an unsubstantiated (illegitimate) claim	Supported
H5a	If the claim is understood, a substantiated (legitimate) carbon-neutral claim increases purchase intention compared to an unsubstantiated (illegitimate) claim	Supported
H5b	If the claim is *not* understood, a substantiated (legitimate) carbon-neutral claim does not affect purchase intention compared to an unsubstantiated (illegitimate) claim	Supported
Study C		
H6	Preliminary explanations enhance the effect of claim substantiation on decreasing perceived greenwashing	Supported
H7	Preliminary explanations enhance the effect of claim substantiation on increasing purchase intention	Rejected

a high understanding of the message, substantiated and legitimate *carbon-neutral* claims significantly reduce perceptions of greenwashing (H4a) and notably increase PI (H5a). Conversely, when the message is not understood, substantiation does not produce statistically significant effects either on cognitive (H4b) or behavioral response (H5b). In such cases, consumers are not able to discern between companies that focus solely on direct emissions and those that also tackle indirect emissions.

Appling major decision-making theories (Ajzen 1991; Kahneman 2011; Shiv and Fedorikhin 1999) in the context of green marketing, our study demonstrates that consumers who fully comprehend carbon claims are more likely to engage in a rational and deliberative analysis, valuing legitimate and substantiated declarations. Conversely, those who lack understanding fail to differentiate between substantiated and unsubstantiated claims. In such cases, intuitive and emotion-driven responses—triggered by the label itself—prevail over a deeper investigation into how companies manage indirect emissions. Our findings also enrich the work of Matthes et al. (2014) and Lim et al. (2020), who explore how heuristic and emotional responses are elicited by visual cues such as the color green, symbols, or images of nature. We extend this literature by highlighting that specific terminology, like the *carbon-neutral* declaration, serves as a cognitive shortcut that activates heuristic reasoning.

Our conclusive comments across Study A and Study B underscore the critical role of consumers' comprehension in shaping their reactions. Specifically, claim understanding reverses (Study A) or nullifies (Study B) the positive effects of lifecycle information. Hence, in Study C, we equipped half of the sample with PEs to improve their comprehension of unfamiliar concepts like carbon neutrality.

We found that providing foundational knowledge helps participants differentiate between substantiated and unsubstantiated claims (H6). This approach minimizes information asymmetry, increases sensitivity to legitimate *carbon-neutral* claims and mitigates carbon-washing risks (Birkenberg et al. 2021; Brunner et al. 2018; Emberger-Klein and Menrad 2018; Ertz et al. 2017; Nguyen et al. 2019; Upham et al. 2011). Simple, user-friendly and standard-aligned information streamlines the cognitive process, enabling consumers to quickly assess claim legitimacy based on just-learned parameters, rather than interpreting advertising from scratch.

However, increased knowledge, while aiding in carbon-washing detection, does not necessarily translate into better low-carbon purchasing choices. Substantiated claims consistently boost PI, but PEs do not amplify this positive effect (H7). Other factors, such as perceived product quality, brand loyalty, and consumer mood, likely also influence decisions.

Although a cognitive shift is readily achievable, inducing knowledge just before purchase may not be enough to drive behavioral change, as consumers may need more time to internalize these

concepts. Research on information processing (Sweller 2010) suggests that cognitive strain can hinder perceived behavioral control and decision-making confidence. Consistent with this idea, Naderer and Opree (2021) observed that literacy interventions requiring cognitive effort enhance consumers' ability to recognize greenwashing but simultaneously reduce their confidence. Peng et al. (2021) explained this mechanism through neural evidence, showing that cognitive overload reduces decision-making confidence via changes in the P3 amplitude, a brainwave involved in information processing and evaluation.

Beyond testing our main hypotheses, we examined the role of individual differences—including age, gender, education, income, and PK—across all structural models (see Appendix B). While the main relationships remained robust, some meaningful patterns emerged. Gender and income do not consistently affect PGW or PI, in line with the branch of studies supporting the idea that sociodemographic variables are not sufficient to explain green behaviors and attitudes (Diamantopoulos et al. 2003).

However, age appears to be a relevant factor, particularly in shaping perceptions of greenwashing. Across studies, younger individuals are generally more likely to question carbon-related claims and tend to be more skeptical. When comprehension is limited, older consumers seem to rely more on heuristic cues and trust carbon-neutral claims, which increases their intention to buy. Our findings extend prior research on generational differences in sustainability habits (Batelli et al. 2024), demonstrating that such differences also manifest in how individuals evaluate green and carbon-related claims. Accordingly, younger consumers' skepticism may stem from higher environmental literacy and critical awareness rather than disengagement.

Education, by contrast, does not show a significant effect on PGW, whereas lower education levels are occasionally associated with higher PI. However, when claim comprehension is low, more educated individuals tend to interpret the *carbon-neutral* label as a signal of legitimacy, overestimating their ability to assess claim credibility and ultimately showing a higher intention to buy. This dynamic is consistent with Iovino et al. (2023), who found that even highly educated consumers can be misled by exaggerated or ambiguous environmental claims, as greater competence does not automatically protect them from greenwashing nor from overly confident interpretations.

The effect of PK on PGW is more nuanced. Contrasting patterns across studies and comprehension levels suggest that greenwashing perceptions depend more on actual understanding of the claim—namely, objective comprehension—than on PK (Parguel et al. 2015). In contrast, the relationship between PK and PI is remarkably consistent across models. As this construct reflects individuals' perceived ability to act against climate change, it enhances consumer sense of efficacy and fosters more responsible consumption choices. This aligns with previous research showing that perceived rather than objective knowledge drives pro-environmental behavior, as individuals act upon what they believe they know and can effectively do to address environmental issues (Kaiser and Fuhrer 2003; Tao et al. 2021).

In summary, proper comprehension primarily shapes cognitive evaluations and protects consumers from carbon-washing risks, whereas individual perceptions act as motivational drivers that support behavioral intentions. Overall, these findings support the view that sustainable decision-making depends more on how consumers process and interpret environmental information than on structural demographic characteristics.

8 | Conclusion and Theoretical Contributions

Existing literature has primarily focused on consumer responses to carbon footprints and labeling strategies, such as numerical estimates versus visual aids (e.g., Feucht and Zander 2018; Thøgersen and Nielsen 2016), and to voluntary carbon offsetting (VCO) practices (e.g., Babakhani et al. 2017; Warburg et al. 2021). However, carbon neutrality remains underexplored, given its relatively recent introduction to the marketplace. Our research addresses this gap, shedding light on a multifaceted interplay between claim architecture and consumer elaboration of information, and exploring consumer response to carbon-washing, a pervasive issue in green marketing. Specifically, our empirical findings contribute to the academic debate on several topics:

1. *Lifecyle versus firm-level information*: Carbon claims incorporating lifecycle rather than firm-level emissions information reduce skepticism and perceptions of greenwashing while increasing PI (Dihr et al. 2021; Ertz et al. 2017; Testa et al. 2015).
2. *Role of claim understanding*: Environmental information does not straightforwardly guarantee positive responses (Cerri et al. 2018; Taufique et al. 2017). Comprehension emerged as decisive, capable of nullifying or reversing the abovementioned positive effects. We argue it likely underpins downstream process like meaning attribution and cognitive dissonance or bias, hindering the translation of information into positive behaviors (Edenbrandt et al. 2021; Nyilasy et al. 2014).
3. *Obejective measurement of knowledge*: We addressed to Taufique et al.'s (2017) call for the objective evaluation of environmental information comprehension, moving beyond reliance on self-reported or generalized knowledge (e.g., Kim et al. 2016; Iovino et al. 2023).
4. *Impact of greenwashing on PI*: We confirmed the negative relationship between perceived carbon-washing and intention to buy (Chen and Chang 2013; Leonidou and Skarmeas 2015; Nguyen et al. 2019), consistently observed across two experimental scenarios, thereby strengthening the reliability, robustness, and external validity of our research.
5. *Heuristic versus analytical processing*: Consumers adopt deliberative or automatic cognitive processes (Ajzen 1991; Kahneman 2011) based on their claim comprehension. Poor understanding leads to intuitive, effortless, and emotion-led thinking, while adequate comprehension fosters slower, more analytical reasoning.
6. *Explicit carbon-neutral labels*: We further expanded the discussion on heuristics in green marketing (Naderer et al. 2017; Santa and Drews 2023), more focused on

emotional appeals in imagery. *Carbon-neutral* claims serve as evocative verbal triggers that simplify decision-making but risk misleading consumers by inferring unverified benefits and undermining claim substantiation.

7. *Heuristics and carbon-washing*: The aforementioned dynamic introduces carbon-washing as a highly problematic subcategory of greenwashing (Christiansen et al. 2023; Hale et al. 2022). It falls under the broad spectrum of psychological phenomena, such as the halo effect and the footprint illusion (Gorissen and Weijters 2016), which may lead to adverse behavioral rebound effects (Barkemeyer et al. 2023).
8. *Balancing information disclosure*: A balanced approach to explaining carbon neutrality enables consumers to identify carbon-washing practices without causing cognitive overload (Sweller 2010). This enriches prior research highlighting the value of providing clear but complete information to consumers to avoid deception (Eng et al. 2021; Fernandes et al. 2020; Feucht and Zander 2018).
9. *Limits on behavioral changes*: Although one-off explanations may improve short-term information processing and retention, they fail to affect PI. Sporadic interventions lack the necessary time for consumers to internalize complex concepts and translate them into lasting behavioral changes. Moreover, the cognitive effort required can diminish perceived control and confidence (Peng et al. 2021; Naderer and Opree 2021).

9 | Managerial and Policy Implications

Over time, carbon-washing undermines trust and produces detrimental effects on the market for low-carbon products, potentially delaying the achievement of international climate objectives. To combat unfounded carbon claims, stricter regulatory measures like the European "Green Claims" and "Empowering Consumers" directives require clear claim substantiation (e.g., reserving carbon-neutrality labels for lifecycle-based initiatives), detailed disclosures (e.g., separating reduction activities from offsets), and independent monitoring. This research provides actionable prescriptions for practitioners navigating this period of regulatory transition by exploring consumer responses to these initiatives.

Despite challenges in tracking data across the entire value chain, our findings show that comprehensive disclosures covering both direct and indirect emissions enhance consumer cognitive and behavioral responses. Likewise, to decrease information asymmetry, substantiating *carbon-neutral* claims with lifecycle-based information is highly valued by consumers. Explicit slogans, when backed by concrete actions, can activate positive mental associations and reinforce a product's credentials, while simplifying the accessibility of technical topics.

However, when consumers fail to comprehend claims, carbon-related jargon serves as an uncritical guarantee of sustainability and risks equating truly committed companies with those practicing carbon-washing or less engaged in climate action. As a result, *carbon-neutral* labels—which ostensibly suggest unsubstantiated benefits—may temporarily lead consumers to project an inflated corporate commitment based on minimal information, exposing them to the carbon-washing trap. This distorts consumer behavioral responses and increases the likelihood of irrational or unintended outcomes.

Since carbon claims are often vague or poorly detailed, additional explanations in green advertising can help make carbon-neutrality information more accessible. Practitioners must strike a balance between detail and simplicity, as overly complex information can lead to cognitive overload and disengagement. Individuals particularly unfamiliar with these topics could benefit from more extensive and ongoing educational campaigns as well as innovative learning methods (Lewandowsky and van der Linden 2021).

As a guiding principle, we advocate for *comprehensive clarity* as essential in carbon-related communication. Companies should provide exhaustive yet straightforward information, reflecting the scope and intent of their efforts to tackle climate change, while ensuring all relevant impacts along the product lifecycle are covered. At the same time, such communications must remain clear and digestible. This approach enhances comprehension, facilitates informed decision-making, reduces consumer skepticism and fosters a carbon-neutral economy, supporting the global fight against climate change.

10 | Limitations and Future Research Avenues

Our study suggests several promising research directions.

10.1 | Experimental Design

First, while we used carbon claims from actual advertisements, investigating green marketing strategies not yet explored by companies could offer fresh insight. It would also be useful to examine the impact of novel and creative claims across different product categories. Second, we propose exploring alternative methods, such as enhancing persuasion knowledge, to educate consumers about green marketing tactics and help them identify misleading claims. Given that carbon-washing represents a specific form of disinformation (Naderer et al. 2017), techniques such as forewarning and prebunking (Lewandowsky and van der Linden 2021) could prepare individuals to be more skeptical of potential deceptive practices and provide them with effective counterarguments. Also, studying the long-term effects of sustained, periodic "booster doses" of information may reveal more effective methods for consumer education compared to one-off inoculation.

10.2 | Measurements

Our study measured objective knowledge through actual comprehension; however, employing a broader range of statements could enhance this approach. Additionally, future studies might consider in-field experiments to observe actual buying behavior, which would help avoid self-reporting biases.

10.3 | Sample Characteristics

Finally, extending our research beyond Italian consumers to include European and international populations could broaden the applicability of our findings.

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Appendix A

Perceived Knowledge (PK) Measurement

Construct	Items	Response scale	Adapted from	Cronbach's α
Perceived knowledge	I could explain the consequences of climate change for the planet and society.	7-point Likert agreement scale	Frick et al. (2004)	0.92
	I could explain which actions companies could take to address climate change issues.			
	I could explain which actions consumers could take to address climate change issues.			
	I could explain how I personally could contribute to tackling climate change.			

Appendix B

Standardized SEM Coefficients (β) With Controls: Single- and Multi-Group Models

	SEM coefficients					
	Study A	**Study A (low CU)**	**Study A (high CU)**	**Study B**	**Study B (low CU)**	**Study B (high CU)**
N	517	120	159	515	22	272
PGW ← LOI/LS	−0.010	0.161*	−0.201***	−0.033	0.407*	−0.107*
PGW ← PK	0.073	−0.112	0.253***	−0.106**	0.180	−0.066
PGW ← gender	−0.048	−0.104	0.058	−0.051	/	−0.101*
PGW ← age	−0.170***	−0.348***	−0.034	−0.104**	−0.030	−0.114*
PGW ← education	−0.002	−0.055	−0.082	0.028	0.031	−0.028
PGW ← income	−0.026	0.038	0.154*	−0.018	−0.007	0.012
PI ← PGW	−0.256***	−0.160*	−0.202***	−0.210***	−0.102	−0.191***
PI ← LOI/LS	0.034	−0.345***	0.263***	0.064*	0.138	0.152***
PI ← PK	0.550***	0.481***	0.529***	0.584***	0.871***	0.562***
PI ← gender	−0.050	0.065	−0.042	0.005	/	−0.013
PI ← age	0.042	0.082	0.017	0.108***	0.004	0.133
PI ← education	−0.134***	−0.028	−0.083	−0.062*	0.313***	−0.052
PI ← income	0.064*	−0.005	0.065	0.028	−0.047	0.080*

Note: ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$. In Study B (low CU), the coefficient for gender is not estimable due to non-convergence.
Abbreviations: CU, claim understanding; LOS, level of substantiation; PGW, perceived greenwashing; PI, purchase intention; PK, perceived knowledge.