

Article

Assessing Sustainability Communication and Corporate ESG Transparency in Plant-Based Meat Alternatives: A Multi-Level Analysis of Product–Corporate Alignment

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Abstract

The plant-based meat alternatives sector increasingly promotes its products as sustainable, yet the extent to which these claims are supported by transparent corporate disclosure remains insufficiently understood. This study investigates the alignment between product-level sustainability claims and corporate environmental, social, and governance (ESG) transparency in the Italian online plant-based meat alternatives (PBMA) market, considered as a case study within the broader European regulatory context. A dataset of 200 PBMA products from 11 companies was analyzed. Sustainability claims were collected from packaging and online materials, classified into textual, symbolic, and certification-based categories, and evaluated for specificity, substantiation, and transparency. Corporate ESG transparency was measured using an ESG Transparency Index based on 45 indicators from the “Sustainability Dialogue between SMEs and Banks” framework. Descriptive statistics, correlation analysis, cluster analysis, and multivariate regression were used to examine the relationship between claim intensity, ESG disclosure quality, and firm characteristics. The results reveal substantial variation in the alignment between product communication and corporate transparency. While specialized plant-based companies and some large retailers show higher ESG disclosure, several firms combine intensive sustainability messaging with limited reporting, indicating product–corporate communication gaps that may warrant further investigation. Regression results show that ESG transparency significantly predicts claim intensity, certifications are positively associated with claim intensity, and company size is not a significant predictor. By providing a multi-level assessment of sustainability communication, this study contributes to research on ESG disclosure, transparency alignment, and the screening of communication–disclosure gaps in environmental marketing. The findings offer insights for policymakers, regulators, and firms, particularly in the context of the European Union’s Directive 2024/825 on consumer protection against misleading environmental claims.



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1. Introduction

The global agri-food sector is undergoing profound transformation, driven by escalating concerns over climate change, resource depletion, and the environmental impacts

of animal agriculture. Livestock systems account for an estimated 14% of global anthropogenic greenhouse gas (GHG) emissions [1], while in the European Union agriculture contributes around 10% of total emissions, with nearly 68% of cultivated land devoted to feed production [2]. In this context, dietary shifts toward plant-based proteins are increasingly viewed as a key pathway for reducing environmental pressures and supporting sustainability transitions.

As a result, the market for plant-based meat alternatives (PBMA), i.e., products formulated from plant-derived proteins to replicate the sensory and functional properties of conventional meat, has expanded rapidly. This growth has been supported by a combination of environmental, health, and ethical motivations [3]. Alongside this expansion, sustainability communication has become a central element of competitive positioning within the sector. Claims related to reduced carbon footprint, animal welfare, sustainable sourcing, and eco-friendly packaging are now widely used across product packaging and digital marketing channels, although their evidentiary basis and comparability often remain unclear.

While such claims can influence consumer perceptions, trust, and willingness to pay [4], their increasing prevalence has also raised concerns about greenwashing, defined as the practice of conveying misleading or unsubstantiated environmental benefits [5]. The risk of greenwashing is particularly salient in the PBMA sector. First, consumers often assume that plant-based products are inherently sustainable, despite evidence of significant variation in environmental performance across products and supply chains. Second, product-level sustainability claims are not always subject to systematic verification, especially in the absence of third-party certifications or transparent corporate reporting.

Recent regulatory developments have increased scrutiny of environmental claims. In particular, the European Union's Directive 2024/825 ("Empowering Consumers for the Green Transition") [6] strengthens consumer protection against potentially misleading sustainability communication, including generic environmental claims and unsupported sustainability labels. Although the present study does not assess firms' compliance with the Directive, this evolving regulatory framework provides an important context for examining the consistency between product-level sustainability communication and company-level ESG disclosure.

Despite the relevance of this issue, empirical research assessing the alignment between product-level sustainability claims and company-level environmental, social, and governance (ESG) disclosure remains limited. Existing studies have examined greenwashing through analyses of corporate reporting [7], advertising narratives [8], or environmental performance assessments [9], but rarely integrate detailed product-level communication with structured evaluation of corporate transparency. This gap is particularly notable in the PBMA sector, where sustainability is both a core value proposition and a potential source of reputational vulnerability.

This study addresses this gap by providing a multi-level empirical assessment of sustainability communication in the Italian online PBMA market as a case study within the broader European regulatory context. It investigates the relationship between product-level sustainability claims and corporate ESG transparency, with the aim of identifying patterns of alignment and communication-disclosure gaps that may warrant further investigation. The analysis is guided by three research questions:

- RQ1—How are sustainability claims articulated at the product level in the Italian online PBMA market, and which communicative strategies dominate across packaging and digital materials?

- RQ2—How comprehensive is company-level ESG disclosure in the sector when evaluated through a standardized framework, and which sustainability dimensions are emphasized or underreported?
- RQ3—To what extent is there alignment or divergence between product-level communication and corporate ESG disclosure?

To address these questions, the study combines systematic coding of sustainability claims across 200 PBMA products with an evaluation of corporate ESG transparency for 11 companies, using a structured 45-indicator framework. It further develops three indices—the Product Sustainability Claims Index (PSCI), the ESG Transparency Index (ETI), and the Green Communication Alignment Index (GCAI)—to quantify communication intensity, disclosure quality, and their divergence. Statistical analyses, including correlation, cluster analysis, and multivariate regression, are used to examine relationships between these dimensions. Given that products are nested within companies and the study is cross-sectional, the regression results are interpreted as evidence of association rather than causality.

This study contributes to the literature in three ways. First, it develops a multi-level analytical framework linking product-level sustainability communication with firm-level ESG transparency, enabling a more comprehensive assessment of sustainability signaling. Second, it introduces a replicable measurement approach based on three indices (PSCI, ETI, and GCAI) to quantify claim intensity, disclosure quality, and potential misalignment. Third, it provides empirical evidence from a rapidly expanding and policy-relevant sector, offering insights for firms and regulators in the context of evolving EU requirements on environmental claims. These contributions are particularly relevant for food categories in which sustainability claims are highly visible but difficult for consumers to verify.

The remainder of the paper is structured as follows. Section 2 reviews the literature on sustainability communication, green marketing, greenwashing, and ESG disclosure. Section 3 presents the research design and methodology. Section 4 reports the empirical results. Section 5 discusses theoretical and practical implications. Section 6 concludes with limitations and directions for future research.

2. Literature Review

2.1. Sustainability, Alternative Proteins, and the Environmental Context

Growing awareness of climate change, resource scarcity, and environmental degradation has intensified global discussions on sustainable food systems. The livestock sector is a major contributor to environmental pressures, accounting for an estimated 14% of global anthropogenic greenhouse gas (GHG) emissions [1]. In the European Union alone, agriculture contributes approximately 10% of total GHG emissions, with nearly 68% of cultivated land used for feed production [2]. These patterns have heightened the urgency of adopting more sustainable dietary choices.

PBMA products have emerged as a key strategy for reducing environmental impacts. Life cycle assessment (LCA) studies consistently demonstrate that plant-based proteins generate significantly lower emissions, land use, and water consumption compared with conventional meat [10]. As a result, consumers increasingly perceive PBMA foods as healthier, more ethical, and more sustainable [11]. This perception plays a critical role in market expansion and influences corporate positioning strategies across the food industry.

Yet, despite these environmental advantages, the sustainability performance of PBMA products varies considerably depending on ingredients, processing intensity, transportation, and packaging [12]. Consequently, companies' sustainability communication on PBMA offerings requires careful scrutiny, as environmental claims may not always reflect

consistent corporate practices or verifiable environmental gains. This heterogeneity makes PBMA a suitable empirical setting for examining the credibility of sustainability signaling.

2.2. Green Marketing and Sustainability Communication

Green marketing refers to strategies that promote environmentally responsible products and corporate practices [13]. In the food sector, green marketing frequently includes claims related to reduced carbon footprints, recyclable packaging, natural ingredients, and ethical sourcing. Consumers rely heavily on such claims due to the experience and credence nature of food sustainability attributes, characteristics that cannot be directly evaluated even after consumption [14].

Sustainability communication is particularly influential in the PBMA sector, where environmental expectations are high. Research shows that consumers often interpret green claims as indicators of superior social and environmental performance, leading to increased trust and willingness to pay [4]. However, green marketing may also become misleading when firms overstate benefits or provide inadequate evidence, thereby increasing exposure to perceived or actual greenwashing risk.

Therefore, credible sustainability communication requires alignment between claims made on product packaging and actual corporate actions, governance structures, and environmental performance. This alignment is the foundation of corporate legitimacy and long-term consumer trust in environmentally positioned brands.

2.3. Greenwashing and Green Communication–Disclosure Gap: Concept, Motivations, and Typologies

Greenwashing is commonly defined as the act of misleading consumers regarding the environmental practices of a company or the environmental benefits of a product [5]. It can occur through vague language, selective disclosure, irrelevant claims, unsubstantiated assertions, or fabricated certifications. In sectors where sustainability carries strong consumer appeal, such as PBMA foods, the incentive for firms to exaggerate their environmental performance is heightened.

Delmas and Burbano's influential framework [5] identifies two drivers of greenwashing: (1) external pressures (e.g., consumer expectations, investor pressure, regulatory requirements), and (2) organizational incentives (e.g., reputational management, competitive advantage). The PBMA sector aligns strongly with both drivers. Companies face intense pressure to demonstrate sustainability leadership, yet many lack mature ESG reporting structures to substantiate claims.

Greenwashing typologies relevant to this study include: executional greenwashing, involving misleading visuals such as nature imagery or green-colored packaging; claim-based greenwashing, involving vague statements such as “eco-friendly” without substantiation; reporting-based greenwashing, involving discrepancies between corporate sustainability reporting and product marketing claims; and selective disclosure, involving the emphasis of favorable indicators while omitting less favorable performance areas.

This study focuses primarily on reporting-based greenwashing by assessing the alignment between product-level claims and corporate ESG transparency.

2.4. ESG Disclosure and Corporate Sustainability Reporting

Environmental, Social, and Governance (ESG) reporting has evolved into a widely adopted framework for communicating corporate sustainability performance. High-quality ESG disclosure enhances corporate accountability, reduces information asymmetry, and builds stakeholder trust [15]. However, ESG reporting is highly heterogeneous across sectors and regions, with substantial variation in metrics, scope, and completeness. In the European context, ESG reporting has been shaped by several regulatory milestones,

including Directive 2014/95/EU (Non-Financial Reporting Directive—NFRD); Corporate Sustainability Reporting Directive (CSRD); EU Taxonomy Regulation; Sustainable Finance Disclosure Regulation (SFDR).

These frameworks contribute to greater standardization but do not directly govern product-level sustainability claims. This gap leaves room for inconsistencies between corporate ESG reporting and marketing communication. The 45-indicator framework used in this study, drawn from the “Sustainability Dialogue between SMEs and Banks”, provides a structured and comparable system for evaluating corporate transparency. The indicators span five thematic areas: General Information, Climate Change Mitigation and Adaptation, Environment, Social and Workforce, and Governance and Conduct. This allows for a comprehensive assessment of ESG disclosure quality. The “Sustainability Dialogue between SMEs and Banks” is a structured framework for evaluating corporate transparency that is consistent with the direction of recent EU sustainable finance and SME reporting initiatives, including the Corporate Sustainability Reporting Directive [16], the EU Taxonomy [17], and EFRAG’s VSME standard [18,19]. This framework is appropriate for the PBMA sector because it captures comparable disclosure dimensions across companies with different sizes, ownership structures, and reporting maturity.

2.5. The EU Directive 2024/825 on Green Claims

European regulatory policy has recently intensified its focus on combating greenwashing. The EU Directive 2024/825 (“Empowering Consumers for the Green Transition”) [6] strengthens consumer protection against misleading environmental claims by restricting generic sustainability statements, limiting the use of unsupported sustainability labels, and requiring clearer substantiation of environmental information.

This directive marks a major shift toward enforceable sustainability communication and heightens expectations for transparency in product-level environmental claims. For PBMA companies, compliance requires alignment between packaging claims, digital communication, and ESG reporting. The directive’s emphasis on pre-publication verification reinforces the need for empirical research assessing the validity of environmental claims, as provided in this study.

2.6. Integrating Product-Level Claims with Corporate-Level ESG Disclosure

Despite extensive research on sustainability reporting and a growing body of literature on greenwashing, few empirical studies have integrated product-level claim analysis with corporate ESG assessment. Existing greenwashing research primarily focuses on corporate sustainability reports [20], advertising and marketing campaigns [8], environmental labels and certifications [21]. However, product-level communication, especially packaging, is often consumers’ primary source of sustainability information at the point of purchase. In the PBMA sector, where sustainability expectations are especially high, misalignment between product claims and corporate performance can undermine trust and distort consumer choices.

This study contributes to filling this gap by establishing an empirical link between sustainability claims made at the product level and corporate-level ESG transparency scores. By combining these two dimensions, the research offers a more comprehensive assessment of communication–disclosure gaps that may warrant further investigation as potential indicators of greenwashing risk. It also establishes a methodological foundation for similar assessments across other food categories.

3. Methodology

3.1. Research Design

This study employs a multi-level quantitative research design to evaluate the alignment between sustainability information communicated at the product level and the transparency of corporate ESG reporting among companies operating in the Italian online PBMA market within the European regulatory context. The approach combines three methodological pillars: systematic coding and quantification of sustainability claims on product packaging and online descriptions; evaluation of firm-level ESG disclosure using a structured 45-indicator ESG Transparency Index (ETI); and statistical analysis to examine relationships between communication patterns and to identify potential communication-disclosure gaps that may warrant further investigation. Data elaboration was carried out the SPSS software V31. This integrated design enables a comprehensive assessment of how companies market and substantiate sustainability. The design is cross-sectional; therefore, the findings capture observed associations at a specific point in time rather than causal dynamics.

3.2. Data Collection Procedures

3.2.1. Product-Level Data

The product-level dataset comprised 200 plant-based meat alternative products available on the Italian online retail market and collected between October and November 2025 from the e-commerce platforms of four major national food retailers. These retailers were purposively selected because they all operated through structured e-commerce platforms and were broadly comparable in size, market reach, and organizational capacity. This provided a relatively homogeneous retail context and supported consistency and comparability in the availability of product descriptions, packaging images, and sustainability-related information. Products were included when they were explicitly marketed as plant-based substitutes for meat or fish products, including analogues of beef, chicken, pork, fish, salmon, and tuna, and covered formats such as burgers, cutlets, nuggets, meatballs, sausages, minced meat, sliced meat, fillets, strips, sticks, and related ready-to-use preparations. Products were excluded when they were not clearly positioned as meat or fish alternatives, belonged to unrelated plant-based categories, represented generic ingredients rather than finished substitute products, were duplicates, or lacked accessible packaging or online claim information. All sustainability-related information visible on product packaging and digital materials was recorded. Textual claims included direct references to environmental benefits, reduced impact, recyclable packaging, sustainable sourcing, or natural and organic ingredients. Symbolic sustainability cues were also recorded, such as the use of green color tones, leaf imagery, or icons traditionally associated with environmental friendliness. The October–November 2025 period was deliberately selected as a relatively neutral pre-Christmas window to reduce the influence of seasonal promotions, holiday campaigns, and temporary changes in product assortments.

3.2.2. Corporate-Level ESG Data

Corporate ESG information was collected for the 11 companies producing all sampled products. The company-level sample therefore reflects the firms represented in the product-level dataset, rather than an independently selected population of PBMA firms. Sources included sustainability reports, annual reports containing non-financial statements, ESG sections of corporate websites, and codes of conduct or environmental policy documents. For firms without formal ESG reporting, all relevant sustainability-related content available online was consolidated to maximize coverage and comparability. Corporate disclosure materials were retrieved during the same data-collection period, and only publicly available

company reports, websites, and policy documents accessible at the time of collection were considered.

3.3. Coding of Sustainability Claims

Each product was evaluated using a structured codebook. Claims were classified into major thematic categories—environmental impact, packaging sustainability, ingredient-based sustainability, ethical commitments, and general green claims—and assessed in terms of presence, thematic category, level of specificity (vague versus precise), and support by third-party certification. The full dataset was independently coded by both researchers. An intercoder reliability procedure was then conducted through systematic joint verification meetings, which revealed a high degree of consistency across coding outcomes. All remaining discrepancies were resolved through consensus, resulting in aligned interpretations and a finalized dataset. This procedure strengthened analytical consistency and reliability. The resulting dual quantitative-qualitative approach enabled assessment not only of the frequency of sustainability claims, but also of their credibility and degree of substantiation.

3.4. Product Sustainability Claims Index (PSCI)

The PSCI quantifies the intensity and credibility of sustainability communication at the product level. Weights were assigned to different claim types as follows: generic claims = 1; specific claims = 2; certified claims = 3. For each product i , the unnormalized PSCI score (PSCI_raw) was calculated as:

$$\text{PSCI_raw}(i) = (\text{sum of all present claims} \times \text{corresponding weights})$$

Normalization was applied using min–max scaling:

$$\text{PSCI_normalized}(i) = (\text{PSCI_raw}(i) - \text{minimum PSCI_raw}) / (\text{maximum PSCI_raw} - \text{minimum PSCI_raw})$$

The normalized PSCI ranges from 0 (lowest claim intensity) to 1 (highest).

Because the 1-2-3 weighting scheme operationalizes an ordinal hierarchy rather than empirically estimated intervals, its robustness was assessed by recalculating the PSCI under four alternative specifications (1-1-1, 1-1.5-2, 1-2-4, and 1-3-5) and comparing product- and firm-level rankings, GRI direction, and cluster membership (Appendix A).

3.5. ESG Transparency Index (ETI)

The ETI evaluates corporate disclosure across 45 indicators grouped into five areas: general information, climate mitigation and adaptation, environmental management practices, social and workforce conditions, and governance and conduct. Each indicator was scored as follows: 0 = no disclosure; 1 = partial disclosure; 2 = full disclosure. For each company j :

$$\text{ETI_raw}(j) = \text{sum of all indicator scores}$$

Normalization applied:

$$\text{ETI_normalized}(j) = (\text{ETI_raw}(j) - \text{minimum ETI_raw}) / (\text{maximum ETI_raw} - \text{minimum ETI_raw})$$

Values closer to 1 represent more transparent and complete ESG reporting. Moreover, for a more granular assessment, the ETI was disaggregated into five normalized sub-dimensions: general information, climate, environmental management, social, and governance. Each sub-dimensional score was normalized to a 0–1 scale by dividing the firm's score by the maximum possible score for that dimension. Their associations with average firm-level PSCI were examined using two-sided Spearman correlations and in-

terpreted. Given the limited sample of 11 firms, this analysis was considered exploratory (Appendix B).

3.6. Green Communication Alignment Index (GCAI)

The Green Communication Alignment Index compares product-level sustainability claim intensity with corporate ESG transparency. For each company:

$$\text{GCAI}(j) = \text{Average PSCI_normalized}(j) - \text{ETI_normalized}(j)$$

The GCAI interpretation is as follows: $\text{GCAI} > 0$ indicates that sustainability claims exceed ESG transparency, suggesting divergence or misalignment between product-level communication and corporate ESG disclosure; $\text{GCAI} = 0$ indicates alignment between claims and reporting; and $\text{GCAI} < 0$ indicates under-communication relative to disclosure. Because GCAI measures misalignment, it is interpreted as a communication–disclosure gap rather than as direct evidence of intentional deception. A high GCAI identifies a divergence between product-level sustainability communication and corporate ESG disclosure that may warrant further investigation, while also potentially reflecting reporting lags, differences in disclosure strategies, or reliance on product-specific certification schemes.

3.7. Analytical Methods

Descriptive statistics were used to summarize claim frequencies, PSCI scores, ETI scores, and company-level variability. Spearman’s rank correlation assessed relationships between PSCI, ETI, GCAI, certifications, and company size due to the non-normal distribution of some variables. A hierarchical cluster analysis using Ward’s method and squared Euclidean distances grouped companies by similarity in PSCI, ETI, and certification patterns. Then, a multivariate regression model evaluated whether ESG transparency predicts sustainability claim intensity. The dependent variable was the normalized PSCI for each product. Independent variables included the producing company’s ETI, number of certifications on the product, company size, and product category controls. Because products are nested within firms, the regression was interpreted together with company-clustered robust standard errors and a random-intercept specification to account for within-firm dependence.

The regression model was:

$$\text{PSCI_normalized}(i) = \beta_0 + \beta_1 \times \text{ETI_normalized}(j) + \beta_2 \times \text{Certifications}(i) + \beta_3 \times \text{CompanySize}(j) + \beta_4 \times \text{ProductCategory}(i) + \text{error}$$

This model tests whether more transparent ESG disclosure is associated with stronger and more credible sustainability communication. The interpretation is therefore kept associative, as the cross-sectional design does not support causal inference.

4. Results

4.1. Key Results

4.1.1. Sustainability Claims

The analysis of 200 PBMA products showed that sustainability communication is widespread across the sector. A total of 92% of all products displayed at least one sustainability-related claim. Visual or symbolic sustainability cues, such as green color palettes, leaf motifs, or environmental imagery, were present on 68% of the products. Generic sustainability statements such as “eco-friendly” or “green choice” appeared on 54% of the sample, while 37% of products included at least one third-party certification, such as organic labels, FSC labels, or carbon reduction seals.

Across the entire dataset, the average number of sustainability claims per product was 3.41, with a standard deviation of 1.88, indicating substantial variation in communication intensity. Environmental impact claims were the most common (present on 71% of products), followed by packaging-related sustainability claims (58%), ethical claims (45%), and ingredient-based sustainability messages (41%).

These patterns suggest that sustainability communication functions as a central competitive and positioning strategy in the PBMA market, despite varying levels of specificity and substantiation (Table 1). The high prevalence of claims is therefore interpreted alongside their evidentiary quality, rather than merely their frequency.

Table 1. Summary of sustainability claims in the product sample.

Indicator	Value
Products with at least one sustainability-related claim	92%
Products with visual or symbolic sustainability cues	68%
Products with generic sustainability statements	54%
Products with at least one third-party certification	37%
Average number of sustainability claims per product	3.41
Standard deviation of claims per product	1.88
Products with environmental impact claims	71%
Products with packaging-related sustainability claims	58%
Products with ethical claims	45%
Products with ingredient-based sustainability claims	41%

4.1.2. Product Sustainability Claims Index (PSCI) Results

The normalized PSCI values ranged from 0.00 to 1.00, with a mean value of 0.54, suggesting moderate sustainability communication intensity across the product sample. Differences emerged across company types. In particular, specialized PBMA brands exhibited the highest PSCI values, with an average normalized score of 0.63; retailers showed moderately high PSCI scores, averaging 0.48; and conventional manufacturers scored lower, with an average PSCI of 0.33. These differences suggest that sustainability communication intensity is closely tied to firms' strategic orientation, with PBMA specialists more strongly leveraging sustainability as a core element of brand identity, while diversified manufacturers appear to treat it as a secondary or supporting attribute (Table 2).

Table 2. Product Sustainability Claims Index (PSCI) results.

PSCI Metric/Company Type	Value
Minimum normalized PSCI	0.00
Maximum normalized PSCI	1.00
Mean normalized PSCI	0.54
Specialized PBMA brands (average PSCI)	0.63
Retailers (average PSCI)	0.48
Conventional manufacturers (average PSCI)	0.33

To assess whether these results depended on the baseline weighting structure, the PSCI was recalculated using four alternative specifications. Product-level Spearman correlations between the alternative indices and the baseline 1–2–3 index ranged from 0.983 to 0.999,

while correlations between alternative and baseline firm-level mean PSCI rankings ranged from 0.945 to 1.000. These results indicate that product- and firm-level PSCI rankings are highly robust to reasonable alternative weighting assumptions (Appendix A).

4.1.3. ESG Transparency Index (ETI) Results

The company-level ESG Transparency Index (ETI) revealed substantial heterogeneity in disclosure practices across firms. Normalized ETI scores ranged from 0.00 to 1.00, with a mean value of 0.42, indicating an overall moderate and uneven level of ESG transparency within the sector. Marked differences emerged across the five ESG dimensions. Disclosure was most developed in General Information (0.51), followed by Social and Workforce issues (0.45) and Governance and Conduct (0.40), suggesting that firms prioritize organizational, social, and procedural aspects of sustainability reporting. In contrast, Climate Mitigation and Adaptation (0.38) and Environmental Management (0.36) received the lowest scores, indicating limited transparency in areas most directly related to environmental performance. The results therefore distinguish between disclosure quantity and disclosure quality: firms may report formal governance information while providing fewer measurable environmental indicators directly linked to product sustainability claims.

The comparatively weak disclosure in climate- and environment-related dimensions suggests that many companies have not yet established comprehensive environmental measurement and reporting systems, despite the central role of environmental impact in the PBMA value proposition. This imbalance may reflect lower reporting maturity, higher data collection costs, or strategic caution in disclosing metrics that are more complex, uncertain, or potentially exposed to scrutiny.

Consistent with patterns observed for product-level sustainability communication (PSCI), specialized PBMA brands and several large retailers exhibited relatively higher ETI scores, whereas conventional manufacturers generally disclosed minimal ESG information. This alignment points to differentiated sustainability strategies across firm types, where sustainability-oriented firms appear more willing to engage in transparent ESG reporting, while diversified manufacturers may adopt a more limited or selective disclosure approach (Table 3).

Table 3. ESG Transparency Index (ETI) descriptive results.

ETI Metric/Dimension	Value
Minimum normalized ETI	0.00
Maximum normalized ETI	1.00
Mean normalized ETI	0.42
General Information	0.51
Social and Workforce	0.45
Governance and Conduct	0.40
Climate Mitigation and Adaptation	0.38
Environmental Management	0.36
Highest ETI pattern	Specialized PBMA brands and some large retailers
Lowest ETI pattern	Conventional manufacturers

Furthermore, the ETI was disaggregated into its five constituent dimensions and examined separately in relation to average firm-level PSCI. None of the dimension-specific associations reached statistical significance at the 5% level. Environmental management transparency showed the strongest relationship with PSCI, with a moderate negative

association (Spearman's $\rho = -0.558$, $p = 0.075$). The remaining associations were weaker: general information ($\rho = -0.200$, $p = 0.555$), climate mitigation and adaptation ($\rho = -0.139$, $p = 0.684$), social and workforce disclosure ($\rho = -0.272$, $p = 0.419$), and governance and business conduct ($\rho = -0.341$, $p = 0.304$) (Appendix B).

4.1.4. Green Communication Alignment Index (GCAI) Results

The Green Communication Alignment Index (GCAI), calculated as the difference between product-level sustainability communication intensity (PSCI) and company-level ESG transparency (ETI), identifies the degree of observed misalignment between the two communication levels. The positive mean GCAI value (+0.12) indicates that, on average, firms emphasize sustainability more strongly in product marketing than is substantiated by their corporate-level ESG disclosures. This finding indicates an observable communication–disclosure gap, but does not establish its underlying causes or demonstrate misleading intent.

The presence of three firms with GCAI values exceeding +0.30 highlights cases of pronounced misalignment, where sustainability claims at the product level substantially exceed documented ESG disclosure. Such divergence represents a potential signal requiring further investigation rather than direct evidence of greenwashing. It may reflect limited substantiation, but could also result from reporting time lags, recent sustainability initiatives, different communication priorities, or reliance on product-level certifications not fully reflected in corporate reporting.

Overall, the distribution of GCAI scores suggests that indications of alignment or divergence between product-level communication and corporate ESG disclosure in the PBMA sector are not uniform but concentrated among specific firms, underscoring the importance of assessing sustainability claims in relation to company-level disclosure rather than in isolation (Table 4).

Table 4. Green Communication Alignment Index (GCAI) summary.

GCAI Indicator	Value/Interpretation
Mean GCAI	+0.12
Interpretation of mean GCAI	Claims exceed ESG transparency on average
Firms with GCAI above +0.30	3
High-GCAI interpretation	Pronounced product–corporate disclosure misalignment requiring further investigation
Negative GCAI interpretation	Under-communication relative to disclosure

4.2. Correlation Analysis

Spearman correlation analysis provided further insight into relationships between sustainability communication, corporate transparency, certifications, and company characteristics (Table 5). A statistically significant positive correlation ($\rho = 0.41$, $p < 0.05$) was observed between PSCI and ETI. This finding indicates that firms with more transparent ESG reporting tend to make more structured and credible sustainability claims on their products. The strongest positive correlation was between PSCI and the number of third-party certifications ($\rho = 0.56$, $p < 0.01$). Certifications therefore appear to play a meaningful role in shaping the intensity and credibility of sustainability communication. Moreover, the correlation between ETI and company size was positive but not statistically significant ($\rho = 0.32$), suggesting, rather than confirming, that larger companies do not necessarily disclose more ESG information than smaller ones in this sample. Finally, a strong negative correlation ($\rho = -0.62$, $p < 0.01$) emerged between GCAI and ETI, meaning that companies

with poor ESG transparency tend to exhibit disproportionately strong sustainability claims on their products.

Table 5. Spearman correlation analysis.

Relationship	Spearman ρ	Significance
PSCI and ETI	0.41	$p < 0.05$
PSCI and number of certifications	0.56	$p < 0.01$
ETI and company size	0.32	Not significant
GCAI and ETI	−0.62	$p < 0.01$

4.3. Cluster Analysis

Hierarchical cluster analysis using Ward’s method identified three distinct clusters of companies (Table 6). The first cluster comprised firms that combined high PSCI scores with high ETI scores. These companies, primarily specialized PBMA brands, had an average PSCI of 0.68 and an average ETI of 0.71. Their alignment between product-level communication and ESG disclosure suggests relatively low potential communication–disclosure gaps and indicates that sustainability commitments are integrated across both marketing and reporting. The second cluster was characterized by moderate PSCI values and low ETI scores, typical of several retail chains. These companies reported an average PSCI of 0.48 but only 0.33 on ETI, suggesting a notable imbalance: retailers communicate sustainability moderately at the product level but do not fully substantiate these messages in their corporate ESG reporting. The third cluster included conventional manufacturers with comparatively high PSCI values but very low ETI scores. These firms averaged 0.57 on PSCI yet only 0.12 on ETI. This group demonstrated the highest potential communication–disclosure gaps, as their strong reliance on sustainability communication is not supported by corresponding transparency or reporting structures.

Table 6. Cluster analysis results.

Cluster	Typical Firms	Average PSCI	Average ETI	Interpretation
Cluster 1	Specialized PBMA brands	0.68	0.71	Strong alignment; low potential communication–disclosure gaps
Cluster 2	Several retail chains	0.48	0.33	Moderate claims, weaker disclosure
Cluster 3	Conventional manufacturers	0.57	0.12	Highest potential communication–disclosure gaps

4.4. Regression Analysis

A multivariate linear regression was conducted with the normalized PSCI as the dependent variable. The regression model included four predictors: normalized ETI, number of certifications per product, company size, and product category (Table 7). The model’s explanatory power was substantial, with an R^2 of 0.43, indicating that 43% of the variance in sustainability claim intensity is explained by the included variables. Additional standard errors, p -values, 95% confidence intervals, and diagnostic checks are reported in Section 4.5 to assess the precision and reliability of the regression estimates.

Table 7. Regression results.

Predictor	Coefficient (β)	Significance
ESG Transparency (ETI)	0.37	$p < 0.01$
Number of Certifications	0.22	$p < 0.05$
Company Size	−0.05	Not significant
Product Category	0.09	$p < 0.10$

These coefficients indicate that ESG transparency is the strongest predictor of sustainability claim intensity. Certifications also contribute positively and significantly, reinforcing the importance of third-party verification. Company size does not meaningfully influence sustainability communication, while product category exerts a smaller but noteworthy effect, suggesting that certain categories, such as burgers, are more likely to be marketed with sustainability language. Because product-level observations are nested within companies, inference was checked using company-clustered robust standard errors and random-intercept estimates.

The results collectively demonstrate that sustainability communication in the PBMA sector is widespread but unevenly substantiated. Specialized PBMA brands exhibit strong alignment between product-level claims and ESG transparency, while conventional manufacturers present a noticeable gap, with PSCI scores considerably exceeding ETI performance. Correlation and regression analyses both show that companies with higher ESG transparency tend to produce more credible sustainability claims, whereas companies with low transparency exhibit greater communication–disclosure gaps. Certifications play an important supporting role, enhancing the credibility and intensity of sustainability communication. Overall, the findings underscore the need for stronger reporting structures and more accountable sustainability communication practices in this rapidly expanding sector.

4.5. Additional Statistical Robustness and Diagnostics

Given the hierarchical structure of the dataset, with 200 products nested within 11 companies, the baseline ordinary least squares model was complemented by company-clustered robust standard errors and a random-intercept multilevel specification. This approach accounts for the possibility that products marketed by the same company share common branding, reporting practices, and sustainability communication strategies.

The baseline estimates showed a positive association between the ESG Transparency Index and the Product Sustainability Claims Index ($\beta = 0.37$, SE = 0.11, 95% CI: 0.15 to 0.59, $p = 0.002$). Certifications were also positively associated with claim intensity ($\beta = 0.22$, SE = 0.09, 95% CI: 0.04 to 0.40, $p = 0.018$), while company size was not statistically significant ($\beta = -0.05$, SE = 0.07, 95% CI: −0.19 to 0.09, $p = 0.482$). Product category showed a weaker association ($\beta = 0.09$, SE = 0.05, 95% CI: −0.01 to 0.19, $p = 0.074$).

The company-clustered specification produced the same substantive interpretation. The ETI coefficient remained positive and statistically significant ($\beta = 0.37$, clustered SE = 0.13, 95% CI: 0.10 to 0.64, $p = 0.009$). The certification coefficient remained positive but became marginally significant after clustering ($\beta = 0.22$, clustered SE = 0.11, 95% CI: −0.01 to 0.45, $p = 0.061$), whereas company size and product category did not materially alter the model interpretation. The random-intercept specification also confirmed a positive ETI-PSCI relationship ($\beta = 0.34$, SE = 0.14, 95% CI: 0.07 to 0.61, $p = 0.014$), indicating that the main finding is robust after accounting for company-level heterogeneity.

Model diagnostics did not indicate serious specification problems. Variance inflation factors were below 2.5 for all predictors, suggesting limited multicollinearity. Residual inspection did not reveal substantial departures from linearity or influential observations

driving the main coefficients. Mild heteroskedasticity was observed; therefore, robust and clustered standard errors were used as sensitivity checks. Overall, the diagnostic and robustness results support the interpretation that ESG transparency is positively associated with sustainability claim intensity, while the small number of company clusters requires cautious interpretation of clustered estimates (Table 8).

Table 8. Summary of robustness and diagnostic checks.

Check	Result	Interpretation
Baseline OLS	ETI positively associated with PSCI ($\beta = 0.37$, $SE = 0.11$, 95% CI: 0.15 to 0.59, $p = 0.002$).	Main relationship statistically supported.
Company-clustered SEs	ETI remained positive and significant ($\beta = 0.37$, clustered $SE = 0.13$, 95% CI: 0.10 to 0.64, $p = 0.009$).	Inference robust to within-company dependence.
Random-intercept model	ETI-PSCI relationship remained positive ($\beta = 0.34$, $SE = 0.14$, 95% CI: 0.07 to 0.61, $p = 0.014$).	Main result robust to company-level heterogeneity.
Diagnostics	VIF values were below 2.5; residual inspection did not indicate influential observations; mild heteroskedasticity was addressed through robust checks.	No serious specification problems detected; clustered estimates interpreted cautiously due to 11 firms.

5. Discussion

This section discusses the findings in relation to the three research questions, integrating product-level sustainability communication, company-level ESG disclosure, and their alignment to assess potential alignment or divergence between product-level communication and corporate ESG disclosure in the Italian online PBMA market.

5.1. RQ1—Product-Level Sustainability Communication Strategies

The analysis of 200 PBMA products indicates that sustainability communication is pervasive and has become a normalized feature of product-level marketing within the sector. Sustainability claims are articulated through a combination of textual statements, visual cues, and symbolic elements, reflecting multiple underlying sustainability dimensions, including environmental impact, packaging sustainability, ethical commitments, and ingredient-related attributes. Environmental impact claims emerged as the dominant category, followed by packaging-related messages and ethical claims, while ingredient-based sustainability appeared less consistently. Visual and symbolic cues, such as green color palettes, leaf imagery, and nature-related symbols, were frequently employed, often in combination with generic statements (e.g., “eco-friendly” or “green choice”). This pattern suggests a communicative strategy oriented toward rapid consumer recognition rather than detailed informational depth [5]. The predominance of ready-to-use and frozen formats further contextualizes these strategies. By positioning PBMA products as convenient substitutes for mainstream meat consumption, firms align sustainability narratives with ease of use and familiarity. However, this convenience-oriented model may simultaneously amplify the environmental relevance of packaging and logistics, increasing pressure on sustainability communication in precisely those areas where substantiation is most complex. The differentiated use of communication channels reinforces this interpretation. Packaging is primarily used to convey immediate, purchase-oriented messages related to diet, ethics, or identity (e.g., vegan labels), while digital channels tend to provide more detailed information, including supply-chain narratives and selected certifications. This strategic separation of communicative functions suggests that sustainability at the product level operates as both a market-facing signal and a reputational device, rather than as a comprehensive disclosure mechanism. This interpretation is consistent with consumer information

asymmetry and the credence nature of sustainability attributes in food markets, where consumers cannot directly verify many environmental claims at the point of purchase.

5.2. RQ2—Company-Level ESG Disclosure and Reporting Priorities

The company-level ESG Transparency Index (ETI) reveals substantial heterogeneity in disclosure practices across firms. Although most companies meet basic requirements related to general information and governance structures, overall ESG transparency remains moderate, with notable gaps across key sustainability dimensions. Disclosure is most developed in General Information and Governance and Conduct, indicating a widespread emphasis on formal organizational structures and ethical commitments. Social and workforce-related reporting shows greater variability, reflecting the challenges of monitoring labor practices within complex and often outsourced supply chains. By contrast, Climate Mitigation and Adaptation and Environmental Management represent the weakest areas of disclosure. This finding points to a structural imbalance in ESG reporting: while environmental impact constitutes the core legitimacy claim of the PBMA sector, it is precisely in this domain that reporting systems appear least mature and least standardized. The absence of comprehensive environmental metrics may reflect data availability constraints, resource limitations, or strategic caution in disclosing performance areas subject to heightened scrutiny [22,23]. The resulting patterns suggest that ESG disclosure in the PBMA sector prioritizes dimensions that are easier to formalize and communicate, while systematically underreporting those most closely tied to measurable environmental performance. The results therefore distinguish between disclosure quantity and disclosure quality: firms may report formal governance information while providing fewer measurable environmental indicators directly linked to product sustainability claims.

The sub-dimensional analysis did not identify any ESG disclosure area that clearly drives product-level claim intensity. Environmental management showed the strongest exploratory association with PSCI, but it was not statistically significant at the 5% level. This suggests that the aggregate ETI captures a broader transparency profile.

5.3. RQ3—Alignment, Divergence, and Communication–Disclosure Gaps

The comparison between product-level sustainability communication (PSCI) and company-level ESG transparency (ETI) reveals meaningful patterns of alignment and divergence. On average, firms communicate sustainability more intensively at the product level than they substantiate through corporate disclosure, as indicated by the positive mean Green Communication Alignment Index (GCAI). Specialized PBMA brands tend to exhibit stronger alignment between claims and disclosure, likely reflecting mission-driven origins and more integrated sustainability governance. In contrast, conventional manufacturers entering the PBMA segment often display high claim intensity combined with limited ESG transparency, suggesting a reliance on market-facing sustainability narratives without equivalent institutional support. The analysis further highlights the presence of selective transparency strategies, particularly among brands managing multiple product lines. Sustainability commitments and disclosures are frequently concentrated on flagship or ethically positioned lines, while remaining less developed across the broader portfolio. This intra-brand asymmetry may suggest communication–disclosure gaps, as alignment is achieved selectively rather than systematically [8]. Retailers occupy a distinctive position within this landscape. Large retailers with private-label PBMA products may influence the visibility and standardization of sustainability claims within the category, combining relatively high transparency with extensive assortments and strong digital integration. Their role extends beyond distribution to active governance of sustainability standards within the category, particularly in online environments where claim visibility and comparability

are heightened [24]. This distinction is important because firm-level ESG reporting does not automatically substantiate individual product-line claims, particularly when sustainability communication is concentrated on selected brands or formats.

Across the three research questions, the findings converge on a central insight: sustainability communication in the Italian online PBMA market has advanced more rapidly than the formalization of ESG governance and reporting systems. This temporal and structural misalignment creates a landscape in which sustainability claims are widespread and highly visible, while corporate substantiation remains uneven. From a policy perspective, these dynamics are particularly relevant in light of evolving EU regulatory frameworks on environmental claims. Firms exhibiting high divergence between product-level communication and corporate disclosure are likely to face increased compliance challenges as substantiation, verification, and standardization requirements intensify [6,21].

In synthesis, the study demonstrates the value of a multi-level analytical approach for understanding sustainability communication and indications of communication–disclosure gaps in emerging food categories, highlighting how market structures, communicative strategies, and governance capacities interact to shape transparency outcomes. For this reason, the analysis identifies communication–disclosure gaps and transparency gaps.

5.4. Limitations and Future Research

This research is subject to some limitations. First, it relies on publicly disclosed ESG information, which may not fully capture firms' internal sustainability practices or performance. Moreover, the cross-sectional design cannot establish the causes of PSCI–ETI divergence which may result from reporting time lags, recent sustainability initiatives not yet reported, different disclosure priorities, or reliance on product-specific certifications. The GCAI should therefore be interpreted as a screening indicator of communication misalignment, not as evidence of intentional misconduct or actual greenwashing. Second, although the dataset includes 200 products, the purposive selection of four major online retailers may underrepresent smaller brands, discount retailers, specialist outlets, and offline channels. The findings therefore apply to the selected online market segment rather than the entire Italian PBMA market. Third, the framework assesses disclosure alignment rather than environmental performance. Without product-level LCA or other verified performance data, high GCAI values may reflect limited disclosure rather than poor environmental outcomes. Fourth, the company-level sample is limited to 11 firms, limiting statistical power and the generalizability of firm-level comparisons. The weighting of sustainability claim categories, although grounded in the literature, also involves subjective judgment. However, a sensitivity analysis using alternative weighting assumptions produced substantively similar firm ranking. Finally, the October–November 2025 period was deliberately selected to reduce the influence of seasonal promotions and temporary changes in product assortments. Despite these limitations, the methodology offers a robust and replicable framework for assessing product–corporate transparency gaps in emerging food markets.

Future research could address these limitations by incorporating LCA-based environmental performance metrics, expanding the dataset across additional countries and retail channels, and designing consumer perception studies to examine how individuals interpret and respond to varying levels of claim verifiability. Future studies could also draw on signaling theory or institutional theory to investigate the organizational motivations and external pressures underlying communication–disclosure gaps. Further work could also employ machine-learning techniques to automate the detection and classification of sustainability claims, enabling larger-scale and more efficient analysis. Longitudinal designs would also help assess whether disclosure practices converge with product-level

communication as regulation becomes stricter, and whether sustainability claims vary across seasons and promotional periods.

6. Conclusions

This study provides a comprehensive, multi-level assessment of sustainability communication in the Italian online PBMA market, revealing a structural gap between the prevalence of product-level sustainability claims and the maturity of corporate ESG transparency. While sustainability narratives are widely and prominently deployed, particularly through packaging and symbolic cues, company-level disclosure practices remain uneven and often underdeveloped in the environmental dimensions that underpin the sector's legitimacy.

The findings demonstrate that alignment between sustainability communication and ESG governance is not uniform across firm types. Specialized PBMA brands generally exhibit stronger coherence between claims and disclosure, reflecting more integrated sustainability strategies, whereas conventional manufacturers entering the sector tend to rely on intensive marketing narratives that are not matched by robust ESG reporting, thereby facing heightened potential misalignment between claims and disclosure. Importantly, the results show that ESG transparency is a significant predictor of claim intensity, highlighting governance capacity, rather than communicative intensity alone, as a key determinant of credible sustainability signaling.

By systematically linking product-level communication, corporate disclosure, and misalignment patterns, this research advances greenwashing and communication–disclosure gap scholarship beyond single-level analyses and introduces a replicable methodological framework for screening structural transparency gaps that may warrant further qualitative investigation. As regulatory scrutiny of environmental claims intensifies in the European Union, the study underscores the growing need for firms to align sustainability marketing with verifiable governance practices. More broadly, the findings contribute to environmental marketing and ESG reporting literature by demonstrating that sustainability transitions in sustainable food systems depend not only on innovative products, but also on the institutionalization of transparency across organizational levels. The proposed index therefore identifies communication–disclosure gap signals rather than definitive proof of greenwashing, supporting its use as a screening tool for transparency gaps.

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Appendix A. PSCI Weighting Sensitivity Analysis

To assess whether the results depended on the baseline weighting structure, the Product Sustainability Claims Index (PSCI) was recalculated using four alternative specifications: equal weighting (1-1-1), a compressed hierarchy (1-1.5-2), a stronger certification premium (1-2-4), and a steeper evidentiary gradient (1-3-5).

Table A1. Sensitivity of PSCI-based results to alternative weighting specifications.

Weighting Specification	Product-Level Rho	11-Firm Rho	Firms Retaining GCAI Direction	Firms Retaining Matched Cluster Membership
Baseline: 1-2-3	1.000	1.000	11/11	11/11
Equal: 1-1-1	0.983	0.945	11/11	9/11
Compressed: 1-1.5-2	0.998	1.000	11/11	11/11
Certification premium: 1-2-4	0.998	0.991	10/11	9/11
Steep gradient: 1-3-5	0.999	0.991	10/11	7/11

Spearman rank correlations compare each alternative specification with the baseline 1-2-3 PSCI. GCAI-direction stability indicates the number of firms retaining the same positive or negative PSCI-ETI gap. Cluster membership was assessed after matching corresponding clusters across specifications. The alternative weighting schemes produced highly similar PSCI rankings. Product-level correlations with the baseline index were all above 0.98, while firm-level correlations were all above 0.94. The direction of the GCAI remained unchanged for all firms under the equal and compressed schemes and for 10 of the 11 firms under the certification-premium and steep-gradient schemes. The only change concerned a firm whose baseline GCAI was close to zero, indicating a borderline rather than a substantive reclassification. Cluster membership was fully reproduced under the compressed scheme but was less stable under the stronger alternative specifications. Overall, the results support the robustness of product- and firm-level PSCI rankings.

Appendix B. Exploratory Analysis of ETI Sub-Dimensions

To provide a more granular assessment of corporate ESG transparency, the aggregate ESG Transparency Index (ETI) was disaggregated into five constituent dimensions: general information, climate mitigation and adaptation, environmental management, social and workforce disclosure, and governance and business conduct. For each firm, the score obtained within each dimension was divided by the maximum possible score for that dimension, producing normalized sub-indices ranging from 0 to 1. The association between each ETI sub-dimension and average firm-level Product Sustainability Communication Intensity (PSCI) was examined using two-sided Spearman rank correlations. Given the limited sample of 11 firms, the analysis is exploratory.

Table A2. Spearman correlations between average firm-level PSCI and ETI sub-dimensions.

ETI Sub-Dimension	Spearman Rho	<i>p</i> -Value	Interpretation
General information	−0.200	0.555	Not statistically significant
Climate mitigation and adaptation	−0.139	0.684	Not statistically significant
Environmental management	−0.558	0.075	Moderate negative association; marginal at the 10% level
Social and workforce disclosure	−0.272	0.419	Not statistically significant
Governance and business conduct	−0.341	0.304	Not statistically significant

None of the dimension-specific associations reached statistical significance at the 5% level. Environmental management transparency displayed the strongest relationship with PSCI (Spearman rho = −0.558, $p = 0.075$), although this result should be interpreted cautiously because of the small firm-level sample. Results show that the sub-dimensional analysis does not identify a single area of ESG disclosure that clearly drives product-level sustainability claim intensity. The strongest exploratory pattern concerns environmen-

tal management transparency, which shows a moderate negative association with PSCI. However, the absence of statistically significant associations at the conventional 5% level indicates that the aggregate ETI may capture a broader transparency profile that is not reducible to one specific disclosure dimension.

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