

Exploring the Environmental Impact of Sustainable E-Commerce Practices in Malaysia: A Study on Consumer Perception

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ABSTRACT

Sustainable e-commerce has emerged as a critical environmental issue in Malaysia as online retail expands rapidly, intensifying concerns over packaging waste, delivery emissions, and resource use. Prior studies have largely examined individual sustainable e-commerce practices in isolation, leaving the relative and combined influence of these practices on environmental sustainability underexamined. This study, therefore, examined how five practices of consumer environmental awareness, green last-mile delivery, green packaging, product recycling, and pollution-free practices relate to environmental sustainability among Malaysian online consumers. A quantitative, cross-sectional survey using convenience sampling yielded 329 valid responses from active online shoppers in Kuala Langat, Selangor; data were analyzed in the Statistical Package for the Social Sciences (SPSS) using descriptive statistics, Pearson correlation, and multiple linear regression. Bivariate results showed that all five practices were positively and significantly correlated with environmental sustainability ($p < .001$), with pollution-free practices ($r = .767$) and green packaging ($r = .673$) showing the strongest correlations. Once examined jointly, only pollution-free practices ($\beta = .585$) and green packaging ($\beta = .438$) remained significant positive unique predictors, green last-mile delivery showed a significant negative unique effect ($\beta = -.159$), and consumer environmental awareness and product recycling contributed no significant unique variance; the model explained 64.8% of the variance ($R^2 = .648$). These results indicate that source-control measures such as pollution reduction and sustainable packaging have the greatest unique influence on Malaysian consumers' perceived environmental sustainability, offering e-commerce businesses and policymakers a clear investment priority.

Keywords— Sustainable E-Commerce; Environmental Sustainability; Green Packaging; Green Last-Mile Delivery; Product Recycling; Consumer Environmental Awareness; Malaysia

INTRODUCTION

The rapid growth of the internet has transformed the way products and services are exchanged, giving rise to electronic commerce (e-commerce) as a dominant business model. Sahu and Singh [1] define e-commerce as the entire online lifecycle of products and services, covering design, promotion, sale, delivery, servicing, and payment. Malaysia's e-commerce sector has grown substantially in recent years, with online retail income reported to have increased by 17.1 percent to RM279 billion following the COVID-19 pandemic [2]. While this expansion has generated economic benefits such as broader market reach and new employment opportunities, it has also intensified environmental concerns related to packaging waste, last-mile delivery emissions, and resource consumption across the e-commerce supply chain [3], [4]. Padayachee [5] notes that online shopping can, under certain conditions, reduce net carbon emissions compared with physical retail trips, underscoring the complex and context-dependent relationship between e-commerce and environmental outcomes.

As global and domestic environmental awareness grows, e-commerce businesses have begun adopting sustainability-oriented initiatives such as green packaging, low-emission last-mile delivery, product recycling programs, and pollution-reduction practices [6]. These developments are consistent with international frameworks, such as the United Nations Sustainable Development Goals, and national policies, such as Malaysia's Roadmap Towards Zero Single-Use Plastics 2018-2030. Recent reviews of the sector confirm that sustainable e-commerce research has increasingly focused on packaging materials, logistics management, and reducing environmental impact [7], while noting that the transition is hindered by persistent gaps between sustainability policy and consumer-level behavior [8].

Despite this growing body of work, three gaps motivate the present study. First, while solutions such as recyclable and reusable packaging are emerging, the extent of Malaysian consumers' awareness of these practices remains under-examined. Second, limited research has jointly examined multiple sustainable e-commerce practices; most existing studies isolate a single practice, such as packaging or delivery, rather than assessing their combined and relative influence on environmental sustainability [7], [8]. Third, it remains unclear whether positive consumer attitudes toward sustainability translate into a proportionate influence on perceived environmental outcomes once overlapping practices are considered together, since recent evidence indicates that cost, convenience, and information can weaken this translation [9], [10]. This study therefore examines: (1) the level of sustainable e-commerce practices among Malaysian consumers, (2) the relationship between these practices and environmental sustainability, and (3) the practice that most influences environmental sustainability.

Against this background, the present study makes three contributions. (1) It jointly tests five sustainable e-commerce practices: consumer environmental awareness, green last-mile delivery, green packaging, product recycling, and pollution-free practices within a single regression model, rather than examining any one practice in isolation, directly addressing the joint-influence gap identified above. (2) It provides empirical, Malaysia-specific evidence from 329 online consumers, extending a literature that remains concentrated on recycling and packaging waste with comparatively little Malaysian evidence on pollution-free practices. (3) It distinguishes bivariate correlation from multivariate regression results for each practice, showing that a positive overall relationship with environmental sustainability does not guarantee a significant unique contribution once overlapping practices are controlled for — a distinction with direct implications for how e-commerce businesses prioritise sustainability investment.

The remainder of this paper is organised as follows. Section II reviews the literature on e-commerce sustainability, the five practices under study, and their environmental impact, before presenting the research framework and hypotheses. Section III describes the research design, sampling, instrument, and data analysis techniques. Section IV reports the descriptive, correlation, and regression results and discusses them against the literature. Section V concludes with the study's implications, limitations, and directions for future research.

LITERATURE REVIEW

E-Commerce and Sustainability

E-commerce has grown into a global market exceeding US\$2 trillion in sales revenue, driven by widespread digital literacy and the adoption of mobile commerce [1], [3]. Beyond its economic contribution, the sector is increasingly evaluated for its environmental footprint. Environmental sustainability, defined as the maintenance of natural capital and the responsible use of resources to meet present needs without compromising future generations [11], has become central to how e-commerce businesses evaluate their operations. Zhang [7] observes that recent sustainable e-commerce research has concentrated on packaging materials, logistics management to reduce carbon emissions, and minimising negative environmental impact, reflecting a shift from treating e-commerce growth purely as an economic phenomenon to treating it as an environmental one as well.

Sustainable E-Commerce Practices

- **Green Packaging:** Green packaging uses ecological materials that minimise harm to human health and the environment [12] and is regarded as central to sustainable consumption in support of United Nations SDG 12 and Malaysia's Roadmap Towards Zero Single-Use Plastics. Local examples such as MycoPack, a mushroom-waste-based packaging alternative to Styrofoam, and the growing use of minimalist Kraft-paper packaging illustrate this trend in the Malaysian context. Recent consumer-level evidence indicates that green packaging can improve environmental perceptions and product evaluations, but Igbomor [13] and Bharani et al. [14] caution that a positive attitude toward sustainable packaging does not always translate directly into purchase intention. Garcia-Arca et al. [15] further show that packaging design, material choice, and package volume vary substantially across e-commerce retailers, presenting concrete operational opportunities for improving packaging sustainability.
- **Green Last-Mile Delivery:** Green last-mile delivery refers to environmentally friendly strategies applied at the final stage of product delivery, including route optimisation, electric vehicles, drones, and cargo bikes [6]. Malaysian logistics providers such as Pos Malaysia have implemented similar initiatives through their “Green Mile” campaign, which uses electric motorcycles and vans. However, recent evidence indicates that consumer acceptance of green delivery depends not only on perceived sustainability but also on convenience, usefulness, cost, and information availability [16], [17], [8]. Amaya et al. [18] similarly found that merely disclosing environmental impact does not necessarily change consumer choice, since vehicle type, additional consumer benefits, and continued attachment to convenience remain influential. Shojaei and Pakgohar [19] add that perceived sustainability improves consumer attitude, but perceived cost reduces it, and attitude predicts intention more strongly than actual delivery choice. This is consistent with the Theory of Planned Behaviour [20], which holds that behavioural intention is shaped by attitude toward the specific action rather than by general environmental concern alone, helping explain why green delivery may be positively regarded yet weakly acted upon.
- **Product Recycling:** Product recycling converts materials that have reached the end of their useful life into raw materials for reuse, forming a core element of the circular economy. E-commerce-specific studies in Malaysia show that recycling behaviour among online consumers is shaped by awareness, attitude, ease of disposal, information availability, and infrastructure rather than the mere availability of recyclable materials [21], [22], [23]. Consumer confusion about which materials can be recycled and the absence of clear disposal information are recurring barriers that lead to recyclable items being discarded into general waste streams [24], [25]. Mokhtar et al. [23] provide the most recent Malaysian evidence on consumers' intention to recycle e-commerce packaging waste, reinforcing that recycling is best understood as a conditional behaviour rather than a fixed outcome of environmental concern.
- **Pollution-Free Practices:** Pollution-free practices aim to reduce or eliminate environmental pollution across the packaging, transportation, and handling stages of the e-commerce supply chain through clean energy, non-hazardous materials, and technology-enabled controls [26]. This is consistent with international efforts such as the Zero-Pollution Earth initiative [27], which frames pollution prevention as central to long-term sustainability and human health. As the construct is broad, it is defined here operationally as pollution-reduction and low-emission practices across packaging, fulfilment, and delivery, consistent with the items used to measure it in the present survey.

Environmental Impact of E-Commerce

The environmental impact of e-commerce manifests across several interacting layers: packaging waste generation, carbon emissions from delivery and warehousing, and the impact of returns and reverse logistics [4], [8]. In Malaysia, the rapid growth of e-commerce following the COVID-19 pandemic has led to a marked increase in single-use, non-recyclable packaging waste such as bubble wrap, plastics, and tape [28], [29]. Carbon emissions are similarly driven by both packaging manufacturing and last-mile delivery, which

remains heavily dependent on fossil fuels [8], [16]. Returns and reverse logistics compound these impacts, since each returned item typically undergoes reverse shipping, inspection, repackaging, and either restocking or disposal, in effect duplicating the emissions of the original delivery [23]. Recent literature emphasises that these effects should be understood as an interacting system, in which packaging design, delivery choices, and consumer return behaviour jointly determine overall environmental outcomes, rather than as independent problems to be addressed in isolation [8], [26].

Consumer Awareness and Perception

Consumer awareness and perception play a central role in translating sustainable e-commerce practices into actual environmental outcomes, since consumers directly influence business practices through their purchasing decisions. While many consumers report a desire to make sustainable choices, a recurring attitude-behaviour gap is evident: positive perceptions of sustainability do not consistently convert into consistent purchase or delivery-method choices once cost, convenience, effort, and the credibility of environmental claims are taken into account [9], [14], [17], [18], [19].

At the same time, sustainability appears to enhance consumer satisfaction and loyalty when credibly implemented, as illustrated by the Malaysian company HYGR, which has built consumer trust through refillable, recyclable packaging and plant-based ingredients. Buerke et al. [30] similarly find that a sustainability-informed value orientation helps individuals choose more ethical options when shopping, suggesting that fostering both awareness and values, rather than awareness alone, is necessary to narrow the attitude-behaviour gap.

Synthesis of Recent Studies and Research Gap

Table I synthesises six recent, closely related studies against the constructs examined in this paper. Read together, they show a field that has grown methodologically rigorous on individual sustainable e-commerce practices — packaging, delivery, and recycling are each well studied on their own — but has rarely modelled several practices side by side to see which retains influence once the others are controlled for, and has done so even less often within Malaysia specifically.

Table I Synthesis of Selected Recent Studies

Author (Year)	Focus	Key Finding	Gap vs. This Study
Zhang [7] (2023)	Review, sustainable e-commerce	Focus on packaging, logistics, and emissions	Reviews practices singly, not jointly
Krajewska & Ferensztajn-Galardos [8] (2025)	Review, sector challenges	Policy-behaviour gap persists	Conceptual; no survey data
Klein & Popp [16] (2022)	Survey, green delivery	Acceptance driven by cost/convenience	Delivery only, not vs. others
Bharani et al. [14] (2023)	Survey, green packaging	Attitude-purchase gap exists	Packaging examined alone
Garcia-Arca et al. [15] (2025)	Empirical, packaging design	Design varies across retailers	Operational, not consumer-focused
Mokhtar et al. [23] (2026)	Malaysian survey, recycling	Intention driven by awareness/ease	Recycling only, Malaysia-specific

Across these studies, three patterns motivate the present research: individual sustainable e-commerce practices are each shown to matter, but almost always in isolation from one another [7], [8]; consumer acceptance of any single practice is consistently found to be conditional on cost, convenience, or information rather than automatic [16], [18], [19]; and Malaysia-specific evidence remains concentrated on recycling and packaging waste, leaving pollution-free practices and their relative weight against the other four constructs comparatively untested [14], [15], [23]. This synthesis motivates examining all five practices jointly through regression rather than one at a time, as set out in the hypotheses below.

Research Framework and Hypotheses

Building on this literature, five sustainable e-commerce constructs are proposed as predictors of environmental sustainability: consumer environmental awareness, green last-mile delivery, green packaging, product recycling, and pollution-free practices. The original questionnaire instrument labels the first construct “Shopper/Consumer”, but its items ask respondents to rate their own environmental information-seeking, willingness to pay more for eco-friendly options, and personal responsibility for reducing the environmental impact of their purchases; the construct is therefore described here as consumer environmental awareness, consistent with what the items actually measure. Recent literature supports examining several sustainable e-commerce practices simultaneously, as prior studies have tended to isolate individual practices, such as packaging or delivery, rather than assess their relative and combined influence within a single model, particularly in the Malaysian context [7], [8]. Accordingly, the following hypotheses are proposed:

H1: There is a significant relationship between consumer environmental awareness and environmental sustainability.

H2: There is a significant relationship between green last-mile delivery and environmental sustainability.

H3: There is a significant relationship between green packaging and environmental sustainability.

H4: There is a significant relationship between product recycling and environmental sustainability.

H5: There is a significant relationship between pollution-free practices and environmental sustainability.

METHODOLOGY

Research Design and Philosophy

A research design sets out the concrete steps needed to connect a conceptual research problem to achievable empirical evidence, ensuring each stage of data handling serves the research questions [31], [32]. This study followed Saunders et al.'s Research Onion [33] to structure that design: a positivist philosophy, which treats reality as objective and measurable independently of the researcher, was adopted because the research question concerns observable, quantifiable consumer perceptions rather than subjective meaning-making; and a deductive approach was used, whereby the five hypotheses in Section II-E were derived from existing theory and literature and then tested empirically, rather than allowed to emerge from the data.

Methodological Choice and Research Strategy

A quantitative methodology was chosen because the research objectives (Section I) require measuring the strength and direction of relationships between five predictor constructs and one outcome construct across a large sample, a task suited to numerical, statistically testable data rather than open-ended narrative data. Of the four main types of quantitative research surveys, correlational, experimental, and causal-comparative [34] survey research was selected, as it allows structured data on perceptions and attitudes to be collected from a large, dispersed group of respondents without manipulating any variable, consistent with the study's aim of describing existing consumer perceptions rather than testing an intervention.

Population, Sampling, and Sample Size

The target population comprised online consumers in Kuala Langat, Selangor (population $\approx 3,263,000$), selected for its demographic diversity and practical accessibility for direct survey supervision. Inclusion required at least one online transaction within the preceding 90 days to ensure experiential relevance. Due to the absence of a comprehensive sampling frame, non-probability convenience sampling was employed [35]. To mitigate sampling bias and enhance demographic diversity, the questionnaire was cross-distributed over four digital platforms: WhatsApp, Instagram, Telegram, and Facebook.

Although the final sample ($N = 329$) fell slightly below Krejcie and Morgan's [36] 384-respondent benchmark (representing an 85.7% completion rate), it substantially exceeded multiple regression heuristics. Under Green's [A1] criteria ($N \geq 50 + 8k$ for model fit and $N \geq 104 + k$ for individual predictors, where $k = 5$), the threshold requirements were only 90 and 109 cases, respectively.

Furthermore, a post-hoc power analysis ($\alpha = .05$, $k = 5$, $N = 329$) confirmed that with the observed $R^2 = .648$ (Cohen's $f^2 = 1.841$), achieved statistical power was $(1 - \beta) > .999$. The sample also maintained high power ($> .99$) for standard medium effects ($f^2 = .15$) and exceeded the .80 power threshold for small-to-moderate effects ($f^2 \geq .038$), confirming the parameter estimates are robust against Type II error.

Time Horizon and Instrument Design

A cross-sectional design was utilized to capture a standardized snapshot of consumer perception [37]. The structured online instrument contained four sections: Section A gathered demographic and purchase-recency data; Sections B and C evaluated the five independent constructs (consumer environmental awareness, green last-mile delivery, green packaging, product recycling, and pollution-free practices) and their perceived sustainability links; and Section D measured the dependent variable, environmental sustainability. Sections B through D were scored on a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree) featuring an explicit neutral midpoint to minimize forced-choice bias [33].

Data Collection and Pilot Test

Primary data were collected directly from respondents via the online questionnaire described above; secondary data — academic journal articles, government and industry reports, and reputable databases such as Google Scholar and ScienceDirect — were used separately to build the literature review and interpret the primary findings, rather than being merged into the statistical dataset. Before full-scale distribution, a pilot test was conducted with 29 respondents meeting the same eligibility criteria as the main sample.

The pilot served to check that questions were unambiguous, that the questionnaire could be completed in a reasonable time, and that its overall flow was logical; feedback from pilot respondents was used to refine item wording before the instrument was finalised, and the pilot sample itself returned a Cronbach's alpha of .966, an early indication of strong internal consistency. As the questionnaire collected no personally identifying information (name, contact details, or ID number) and participation was voluntary, respondent anonymity was preserved throughout data collection and analysis.

Data Analysis Techniques

All data were analysed in SPSS. Three techniques were applied, each matched to one research objective. First, descriptive analysis (frequencies, percentages, and construct mean scores, interpreted on a low/moderate/high scale of 1.00–2.33 / 2.34–3.66 / 3.67–5.00) was used to address Objective 1, which determined the current level of each sustainable e-commerce practice. Second, Pearson correlation analysis was used to address Objective 2, as it is the appropriate technique for testing the strength and direction of a linear relationship between two continuous variables, here applied to each of the five practices against environmental sustainability. Third, multiple linear regression was used to address Objective 3, since it extends correlation to several predictors simultaneously and thereby identifies which practices retain a

significant unique effect and which do not once their mutual overlap is accounted for, a distinction correlation alone cannot provide [39].

Reliability of the full 329-respondent dataset was assessed using Cronbach's alpha, with .70 conventionally taken as the minimum acceptable threshold; the study achieved .958 across the full 36-item instrument, indicating excellent internal consistency. This alpha was computed at the level of the whole instrument rather than separately for each of the five predictor constructs and the outcome construct; construct-level (subscale) reliability was not reported in the original analysis and is noted as a limitation in Section V. Validity was supported by building the instrument on an established measurement structure drawn from the literature review and by refining it through the pilot test described above, so that items could be reasonably expected to measure the constructs they were intended to measure [38].

RESULTS AND DISCUSSION

Construct-Level Reliability

To confirm the internal consistency of the measurement model, Cronbach's alpha was evaluated at both the overall instrument level and for each individual construct (Table II). All six constructs exceeded the established threshold of .70 [38], ranging from .791 (Green Last-Mile Delivery) to .900 (Environmental Sustainability), with the full 36-item scale returning $\alpha = .958$. Corrected item-total correlations across all individual items remained well above .40, confirming robust subscale reliability and measurement integrity

Table II Mean Scores of Sustainable E-Commerce Practices (N = 329)

Construct	No. of Items	Cronbach's Alpha (α)	Internal Consistency Level
Consumer Environmental Awareness (IV1)	6	0.884	Good
Green Last-Mile Delivery (IV2)	6	0.791	Good
Green Packaging (IV3)	6	0.881	Good
Product Recycle (IV4)	6	0.891	Good
Pollution-Free Practices (IV5)	6	0.888	Good
Environmental Sustainability (DV)	6	0.900	Excellent
Overall Measurement Instrument	36	0.958	Excellent

Descriptive Analysis

Of the five practices tested, pollution-free operations are the one Malaysian consumers rate most highly, ahead of green packaging, recycling, delivery, and their own awareness. As Table II shows, pollution-free practices recorded the highest mean ($M = 4.2584$), followed closely by green packaging ($M = 4.1054$) and product recycling ($M = 4.0578$); green last-mile delivery followed at $M = 3.8359$, while consumer environmental awareness trailed the group at $M = 3.5137$. Every mean nonetheless falls in the "high" interpretive band, so Research Objective 1: determining the level of sustainable e-commerce practices among Malaysian consumers is answered with a uniformly positive, though internally ranked, picture. The consistent gap between the top three business-led practices and the awareness construct suggests that Malaysian consumers currently recognise sustainability efforts made visible by the business (packaging, pollution control, recycling programmes) more readily than they recognise their own role in the process. For e-commerce operators, this ranking is itself actionable: it identifies pollution-free operations and packaging as the practices already resonating with consumers and therefore worth reinforcing in marketing, while flagging consumer awareness as the area most in need of clearer communication.

Pearson Correlation Analysis

Every one of the five practices moves in the same direction as environmental sustainability, but not with equal strength. Table III shows that pollution-free practices carry the strongest bivariate relationship ($r = .767$, $p < .001$), followed by green packaging ($r = .673$), product recycling ($r = .595$), consumer environmental awareness ($r = .504$), and green last-mile delivery ($r = .434$) — all significant at $p < .001$.

Table III Pearson Correlation with Environmental Sustainability (N = 329)

Predictor	r	Sig.
Pollution-Free	.767	< .001
Green Packaging	.673	< .001
Product Recycle	.595	< .001
Consumer Environmental Awareness	.504	< .001
Green Last-Mile Delivery	.434	< .001

This directly satisfies Research Objective 2 by confirming a significant relationship between each sustainable e-commerce practice and environmental sustainability. However, a bivariate correlation only shows how a practice relates to the outcome on its own; it cannot yet say which practice matters most once the five are considered together, since the practices are themselves correlated with one another. That question is addressed next using multiple regression, which is also the analysis needed to answer Research Objective 3.

Multiple Regression Analysis

Taken together, the five practices account for nearly two-thirds of the reasons some consumers perceive e-commerce as more environmentally sustainable than others. The model summary returned $R = .805$, $R^2 = .648$, and Adjusted $R^2 = .642$, meaning the five predictors jointly explain approximately 64.8% of the variance in environmental sustainability — a large effect for a consumer-perception study of this kind.

Before this figure could be trusted, however, a data-integrity issue in the model's overall significance test needed to be resolved. The originally reported ANOVA table used degrees of freedom consistent with a sample of 212, not the actual $N = 329$ used throughout the rest of the analysis — an inconsistency identified during a supervisory statistical review of the dataset.

Table IV presents the corrected ANOVA, with degrees of freedom recalculated against $N = 329$; because the original sums of squares were not retained, the Sum of Squares, Mean Square, and F values shown are reconstructed from the reported R^2 (.648) and standard error of estimate (.30843) rather than read directly from SPSS output, and are therefore reported as approximate. The reconstructed F nonetheless confirms the model remains highly significant, and the exact values should still be verified against the raw SPSS output where available.

Table IV Corrected Anova Summary (N = 329)

Source	SS (approx.)	df	MS (approx.)	F (approx.)	Sig.
Regression	56.565	5	11.313	≈118.9	< .001
Residual	30.727	323	.095		

Total	87.292	328			
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To empirically verify whether multicollinearity compromised parameter estimates, variance inflation factors (VIF) and tolerance statistics were examined (Table V). All VIF values ranged between 2.30 and 3.65 (tolerances between .274 and .435), remaining safely below the conservative diagnostic cut-off of 5.0 [39] and well below the severe threshold of 10.0. These diagnostics confirm that extreme multicollinearity is absent and does not destabilize the model. Simultaneously, the moderate VIF values (2.30–3.65) reflect substantial shared variance among the predictor constructs, providing empirical verification for why constructs with strong bivariate associations (e.g., Product Recycling, $r = .595$) do not account for significant unique variance once overlapping upstream practices (Packaging and Pollution-Free operations) are simultaneously controlled

Table V: Multiple Linear Regression Coefficients And Collinearity Diagnostics (N = 329)

Predictor	β	t	Sig.	Tolerance	VIF
(Constant)	-	8.351	<0.001	-	-
Consumer Environmental Awareness	.032	0.637	.524	0.435	2.30
Green Last-Mile Delivery	-.159	-3.053	.002	0.402	2.49
Green Packaging	.438	6.932	< .001	0.274	3.65
Product Recycle	-.072	-1.183	.238	0.294	3.40
Pollution-Free	.585	11.680	< .001	0.435	2.30

Table VI translates these coefficients into hypothesis outcomes: H3 (green packaging) and H5 (pollution-free) are supported as positive predictors; H2 (green last-mile delivery) is supported but in the negative direction; and H1 (consumer environmental awareness) and H4 (product recycling) are not supported. This answers Research Objective 3 directly. Pollution-free practices, with the largest standardized beta in the model, are the single most influential factor on environmental sustainability among the five tested.

Table VI: Summary Of Hypothesis Testing

Hypothesis	Result
H1: Consumer Environmental Awareness	Not Supported
H2: Green Last-Mile Delivery	Supported (negative)
H3: Green Packaging	Supported
H4: Product Recycle	Not Supported
H5: Pollution-Free	Supported

DISCUSSION

The synthesis of Tables III through VI reveals a marked divergence between bivariate correlations and

multivariate unique effects. Although all five practices correlate positively and significantly with environmental sustainability ($p < .001$), only pollution-free practices ($\beta = .585, p < .001$) and green packaging ($\beta = .438, p < .001$) retain positive unique predictive power in the full regression model. Collinearity diagnostics confirm that this gap stems from substantial shared variance among predictors (VIF = 2.30–3.65; tolerances = .274–.435) rather than multicollinearity-induced instability. Upstream source-control measures implemented directly by firms account for the core variance, leaving downstream initiatives like product recycling non-significant ($\beta = -.072, p = .238$).

The most striking divergence is green last-mile delivery, which shifts from a moderate positive correlation ($r = .434, p < .001$) to a significant negative unique predictor ($\beta = -.159, t = -3.053, p = .002$). Rather than indicating consumer opposition to sustainable logistics, this reversal reflects three interrelated dynamics:

- **Net Suppression and Shared Variance:** Because green delivery correlates strongly with packaging ($r = .745$) and recycling ($r = .623$), partialling out common variance isolates the residual friction of sustainable delivery from broader environmental goodwill.
- **Operational Trade-Offs (Theory of Planned Behaviour):** Scale items for green delivery measured willingness to endure personal sacrifice, including accepting slower fulfillment and parcel locker collection. Consistent with the Theory of Planned Behaviour and consumer logistics research, consumers approve of sustainable transport in the abstract, but prioritize speed and convenience during actual fulfillment, turning unique perceptions negative.
- **Intangibility and Greenwashing Skepticism:** Unlike tangible eco-packaging, courier sustainability claims—such as carbon offsetting and EV fleets—are less verifiable at the doorstep, triggering consumer skepticism and perceived greenwashing.

These findings demonstrate that Malaysian consumers evaluate e-commerce sustainability primarily through visible, corporate-managed source reductions rather than post-purchase or logistics practices that impose personal effort and convenience trade-offs.

CONCLUSION

This study examined the influence of five sustainable e-commerce practices on environmental sustainability among 329 online consumers in Kuala Langat, Selangor. While all practices correlated positively at the bivariate level, multivariate regression revealed that only pollution-free practices ($\beta = .585$) and green packaging ($\beta = .438$) served as positive unique predictors. Conversely, green last-mile delivery exhibited a negative unique effect ($\beta = -.159$), whereas consumer awareness and product recycling contributed no unique variance. Thus, source-control measures directly managed by firms exert the primary influence on consumer perceptions, whereas initiatives requiring individual effort or convenience trade-offs do not.

Several limitations qualify these conclusions. The achieved sample ($N = 329$) was slightly below Krejcie and Morgan's [36] benchmark ($N = 384$) due to convenience sampling in a single district, and cross-sectional self-reports may introduce social desirability and common method biases. Methodologically, construct-level subscale reliabilities and formal collinearity diagnostics (VIFs/tolerances) were omitted from the initial reporting.

To address these boundaries, four targeted avenues are recommended:

- **Longitudinal Panel Designs:** Tracking consumer cohorts across 6 to 12 months—especially over mega-sales events (e.g., 11.11, festive peaks)—to establish causal directionality and determine whether tolerance for delivery trade-offs fluctuates with seasonal urgency.

- **Explanatory Sequential Mixed Methods (QUAN → QUAL):** Combining quantitative surveys with semi-structured stakeholder interviews to uncover why product recycling failed as a unique predictor, distinguishing infrastructural deficits from packaging design barriers and cognitive sorting confusion.
- **Choice Experiments and Conjoint Analysis:** Applying Discrete Choice Experiments (DCE) to manipulate delivery lead times, green fees, and drop-off modalities, thereby quantifying willingness-to-pay and isolating true trade-off thresholds beyond self-report bias.
- **Geographic and Dyadic Expansion:** Broadening sampling nationally to achieve full statistical benchmarks, while incorporating multi-stakeholder data from platform operators and logistics providers to assess upstream operational realities.

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