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Assessing the E-Commerce Sustainability Readiness: A Green Logistics Study on Online Sellers

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Abstract: The increasing trend of technological advancement has led to significant changes in how customers purchase goods. Currently, buying products can be done most effectively from the comfort of one's home through online shopping. Customers send and receive thousands of shipments daily, contributing to many materials and packaging that go to waste. While environmental sustainability is becoming increasingly important in all industries, little is known about the factors that drive e-commerce enterprises to adopt green logistical practices. The current study aims to identify the factors that have the most significance in creating sustainable e-commerce in the future of logistics and marketing. This study performed a statewide online seller survey in the Philippines to acquire data on product characteristics, including how internal processes and external partnerships are used and perceived to minimize the carbon footprint connected with order fulfillment and delivery. It encompassed a sample of 286 online sellers nationwide and employed structural equation modeling to identify the factors influencing green logistics practices within the e-commerce industry. The findings underscore that technology has a positive relationship in fostering sustainability. The results also establish significant positive correlations between sustainable e-commerce practices, government laws, seller behavior, and reverse logistics. Notably, this research sheds light on the intricate dynamics of drivers promoting green logistics within the Philippine e-commerce landscape.

Keywords: e-commerce; green logistics; sustainability; structural equation modelling

Citation: Jou, Y.-T.; Lo, C.-Y.; Mariñas, K.A.; Saflor, C.S.; Gutierrez, C.J.; Sanchez, C.; Songco, D.; Redston, J.; Devara, M.B.; Bucal, M.J. Assessing the E-Commerce Sustainability Readiness: A Green Logistics Study on Online Sellers. *Sustainability* **2024**, *16*, 2954. https://doi.org/10.3390/su16072954

Received: 20 February 2024
Revised: 27 March 2024
Accepted: 1 April 2024
Published: 2 April 2024

1. Introduction

Green logistics is a fundamental and progressive aspect of modern-day logistics, representing the prevailing development trend. Green logistics acts as a bridge, connecting resources with products and products with consumers. By emphasizing environmental responsibility and optimizing logistics operations, green logistics contributes to the overall development of a circular and sustainable economy. Green logistics is a systematic approach that focuses on adopting best practices to minimize the environmental impact of logistics and delivery processes. The aim is to reduce carbon emissions and overhead costs by implementing eco-friendly strategies. It involves optimizing transportation routes, utilizing alternative fuel vehicles, and leveraging advanced technologies to improve efficiency. It encompasses various aspects such as material handling, waste management, packaging, and transportation. The primary objective of green logistics is to reduce the carbon footprint and overall environmental impact associated with the movement of goods throughout the supply chain. By adopting sustainable practices in these areas, companies can contribute to a more environmentally responsible and energy-efficient approach to freight distribution. This term was defined by [1]. According to [2], green logistics can be considered

green supply chain management. It entails incorporating environmental concerns into an organization's activities and integrating them into the supply chain management.

E-commerce, short for electronic commerce, refers to the buying and selling of products and services using digital platforms. E-commerce has transformed the business landscape, reshaping competition through the Internet and computer communication networks and establishing a marketplace accessible to consumers and businesses. The Philippines is among the nations experiencing notable growth in e-commerce, offering new avenues for business expansion. With a supportive policy environment, the business community in the Philippines is poised to enhance e-commerce adoption and growth, potentially amplifying participation in regional trade and the global value chain [3]. This paper primarily focuses on examining the significance of e-commerce in contemporary business operations.

Over the past few years, the e-commerce industry has experienced significant growth, leading to a rise in greenhouse gas emissions from the transportation sector. According to the United Nations Environment Program, the transport sector is responsible for approximately 23–24% of global CO_2 emissions from fossil fuel combustion. Moreover, these emissions are projected to increase by one-third by 2050. Nevertheless, companies worldwide have a growing awareness regarding the significance of reducing their environmental footprint. Companies are actively incorporating inventive green logistics approaches to their operations. These approaches encompass a range of strategies, including using electric vehicles. The optimization process helps reduce the environmental impact while ensuring efficient and sustainable transportation. Consumers increasingly demand sustainable products and services, and companies are responding by adopting green practices in their operations and implementing stringent environmental regulations. Green logistics practices can help companies improve their logistics performance by reducing fuel costs, optimizing delivery times, and improving customer satisfaction.

Sustainability refers to actions that maintain long-term, global ecological equilibrium while not depleting natural resources. An immense increase in e-commerce has upended the global supply chain and changed industrial transportation networks as consumers anticipate same-day delivery of goods to their homes. The goal of "green logistics" in e-commerce is to lessen the environmental impact of delivering items to customers. According to [4], sustainable transportation refers to economical, low- and zero-emission, energy-efficient means of transportation. According to ref. [5], green logistics enables industrial activities to lessen the risks associated with non-green operations and achieve environmental [6] research; businesses can cut down on their negative environmental impacts by 80% by implementing environmental controls into their daily operations. According to ref. [7]'s study, green logistics management practices can promote environmental sustainability by lowering carbon emissions while increasing waste reduction and energy efficiency.

The current situation of green logistics in e-commerce sustainability in the Philippines is working positively; companies in the Philippines are exploring ways to reduce carbon emissions, such as optimizing delivery routes and using electric vehicles. Some companies have also started investing in their electric vehicle fleet to reduce their carbon footprint further. In the Philippines, companies are starting to minimize packaging waste. Shopee and Lazada, the two prominent e-commerce platforms in the Philippines, often likened to their Amazon counterparts in the country, are striving towards achieving zero carbon waste within the next few years.

Green logistics and sustainability have become increasingly important in recent years as businesses and consumers alike are becoming more conscious of the impact of their actions on the environment. With the rise of e-commerce and online shopping, there has been a significant increase in materials and packaging used. Studies are still needed to explore the barriers and challenges that hinder the adoption of sustainable logistics practices in the country.

This study examines and investigates the various factors influencing the sustainability of the online platform markets in terms of packaging, transportation, and energy consumption. In addition, this study aims to provide a comprehensive understanding of the

synergistic effects of green logistics for e-commerce sustainability and identify practical applications for technology integration to enhance sustainability.

This study might contribute to studies on consumer demand for eco-friendly packaging, delivery options, and energy sources. Additionally, it studies the impact of existing and potential future regulations on materials and packaging, transportation emissions, and energy consumption within the e-commerce sector.

Packaging logistics and product packaging system packaging are essential for the seller and the customer. While the seller uses it to distribute, store, and promote, the customer uses it as an essential identification and usage tool [8].

Consumers have been paying attention to packaging sustainability and eco-friendliness in recent years. Many consumers now make long-term purchasing decisions based on whether the materials used to pack the product are respectful of the environment. Packaging includes the interrelated functions of primary, secondary, and tertiary packaging. All three types of shipping products are from the production line to the consumer [9]. Primary packaging is the type of packaging in direct contact with the products. Its primary purpose is to protect them and maintain their ideal characteristics [10]. Secondary packaging stabilizes the primary packaged product within to prevent damage during shipping and scuffing or scratching to the product's primary packaging [11]. Tertiary packaging ships the goods in transit from the manufacturer to the retailer. Typically, this type of packaging is rarely seen by the consumer [12].

1.1. Theoretical Research Framework

E-commerce has been one of the leading trends since the onset of the global pandemic. Most people have adopted the use of e-commerce platforms. The current study investigated e-commerce sustainability readiness through a green logistics approach. The researchers developed a theoretical framework based on past studies. The variables to be observed are environmental impact (EI), materials and packaging (MP), online seller behavior (OB), consumer behavior (CB), technological advancement (TA), government rules and policies (GL), reverse logistics (RL), and sustainable e-commerce (SU). This study delves into e-commerce sustainability readiness through green logistics, aiming to address critical factors impacting its environmental footprint. By establishing a theoretical framework informed by past research, the study sets the stage for comprehensive exploration. Ultimately, understanding these variables' current practices will pave the way for more sustainable e-commerce models in the future (Figure 1).

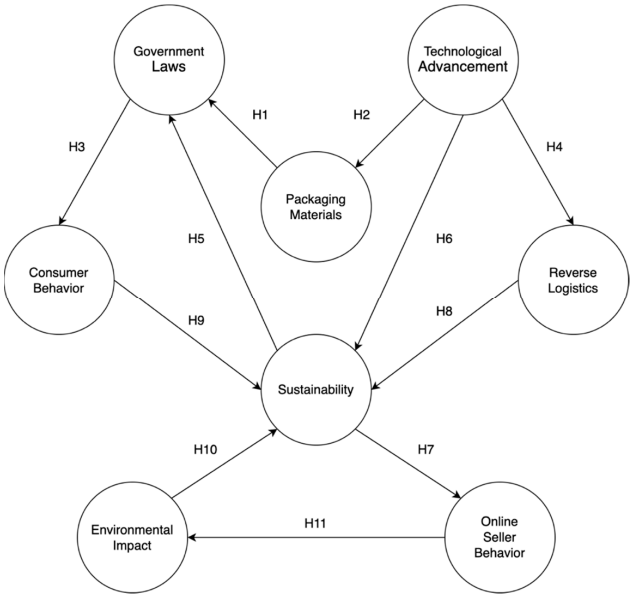

Figure 1. Theoretical research framework.

1.2. Hypothesis Developments and Literature Review

The study hypothesizes that these factors are intricately linked, with environmental sustainability influenced by the collective actions and decisions within the e-commerce ecosystem. The researchers speculate the following:

H1. *There is a significant relationship between materials and packaging and government laws.*

Several studies have linked the relationship between government regulations and policies that substantially influence materials and packaging in various industries [13,14]. Notably, government regulations about packaging waste management and environmental sustainability in the context of e-commerce can significantly influence the materials that online retailers decide to use [15,16]. A study stated that government regulations significantly impact materials and packaging [14]. This implies that a strong correlation is assumed to exist between e-commerce decisions about materials and packaging and the legal structure that governs them.

H2. *There is a significant relationship between technological advancement and materials and packaging.*

Previous research has indicated that technological advancement directly affects materials and packaging practices [17,18]. Technological advancements such as digital manufacturing and advanced materials science make more sustainable materials and packaging solutions possible, transforming package design and production processes [19,20]. Furthermore, digital technologies, such as big data analytics and Internet of Things (IoT) devices, offer opportunities for optimizing packaging materials usage and supply chain efficiency [21,22]. Thus, it is hypothesized that a significant relationship exists between technological advancement and materials and packaging practices in e-commerce.

H3. *There is a significant relationship between government laws and consumer behavior.*

Previous studies that show how government rules and regulations affect consumer behavior support this idea [23,24]. Government initiatives, such as tax exemptions and subsidies for environmentally friendly goods, have been shown by Achmad et al. (2023), to motivate consumers to change to more sustainable purchasing habits [25]. Government policies, such as environmental laws and labeling requirements, can influence customer preferences and purchase decisions, especially in ecologically sensitive product categories [26]. Moreover, they also stated that government laws affect consumer behavior through a combination of subsidy and penalty policy, which is required to motivate green consumption behavior [26]. Consequently, it is hypothesized that there is a strong correlation between consumer behavior and government regulations since legislative actions can influence consumer attitudes, perceptions, and behaviors regarding sustainable e-commerce practices.

H4. *There is a significant relationship between technological advancement and reverse logistics.*

Guide and Van Wassenhove (2009) emphasized the role of GPS tracking and mobile applications in enhancing visibility and coordination in reverse logistics processes [27]. Similarly, Fleischmann et al. (2001) explored the impact of technology-enabled decision support systems on optimizing product returns in reverse logistics [28]. De Koster et al. (2007) also investigated integrating advanced warehouse automation technologies with reverse logistics operations, highlighting improvements in inventory management and processing efficiency [29]. These studies collectively suggest that technological advancements play a crucial role in shaping the effectiveness and efficiency of reverse logistics activities, thus supporting the hypothesis of a significant relationship between technological advancement and reverse logistics.

H5. *There is a significant relationship between sustainability and government laws.*

Delmas and Toffel (2008) conducted a comprehensive study examining the impact of environmental regulations on firms' adoption of sustainable practices, revealing a positive relationship between regulatory strictness and the implementation of environmental management systems [30]. Similarly, a study investigated the influence of government policies on corporate environmental strategies, finding that stringent regulations encourage firms to integrate sustainability into their operations to ensure compliance and maintain legitimacy [31]. Additionally, King and Lenox (2001) investigated the role of regulatory pressures in driving firms towards proactive environmental management practices, highlighting the importance of government laws in shaping corporate sustainability initiatives [32]. These studies collectively provide evidence supporting the hypothesis of a significant relationship between sustainability and government laws.

H6. *There is a significant relationship between technological advancement and sustainability.*

Sarkis et al. (2020) investigated the role of technological advancements, such as renewable energy technologies and eco-friendly production processes, in promoting sustainable development across various industries [33]. Their findings indicated that technological innovation directly affects sustainability initiatives and reduces environmental impact. Similarly, Zhu et al. (2012) explored the influence of digital technologies, such as the Internet of Things (IoT), on enhancing sustainability performance in supply chains, highlighting the potential for technology-driven solutions to address sustainability challenges [34]. Additionally, Schaltegger et al. (2015) looked at the connection between corporate sustainability policies and technical innovation, and they discovered that companies that make innovative technology investments had a higher chance of achieving long-term sustainability objectives [35]. These studies collectively provide evidence supporting the hypothesis of a significant relationship between technological advancement and sustainability.

H7. *There is a significant relationship between sustainability and online seller behavior.*

Oláh et al. (2023) investigated adopting sustainable practices among online sellers; they showed that sustainable practices directly influence seller behavior and decision-making processes [36]. Similarly, Ghaffar et al. (2023) explored the role of sustainability values in shaping online retailers' strategies. They found that sellers prioritizing sustainability were more likely to adopt eco-friendly practices throughout their operations [37]. Additionally, Das and Hassan (2021) examined the impact of sustainable supply chain practices on online seller behavior and performance, highlighting the importance of sustainability considerations in driving seller engagement with green initiatives [38]. Thus, these studies collectively provide evidence supporting the hypothesis of a significant relationship between sustainability and online seller behavior.

H8. *There is a significant relationship between reverse logistics and sustainability.*

Dabees et al. (2023) proved a correlation between the role of reverse logistics in achieving sustainability goals, highlighting the potential for reverse logistics processes such as product returns and remanufacturing to reduce waste and promote resource conservation [39]. Similarly, Banihashemi et al. (2019) investigated how reverse logistics techniques affected environmental performance and discovered that effective reverse logistics systems help to reduce environmental impact and advance sustainability [40]. Furthermore, Nikolaou et al. (2013) examined the relationship between reverse logistics and corporate social responsibility, emphasizing the role of reverse logistics in facilitating sustainable business practices and ethical supply chain management [41]. The cited studies collectively deliver proof supporting the hypothesis of a significant relationship between reverse logistics and sustainability.

H9. *There is a significant relationship between consumer behavior and sustainability.*

Lopes et al. (2024) investigated consumer attitudes and behaviors towards sustainable products, finding that individuals prioritizing sustainability are likelier to engage in environmentally friendly purchasing decisions [42]. Similarly, Vermeir et al. (2020) investigated the connection between consumer values and sustainable food consumption, finding that those who care deeply about the environment tend to favor sustainable food products [43]. Additionally, Mandarić et al. (2022) examined the impact of consumer behavior on sustainable fashion consumption, highlighting the role of consumer awareness and ethical considerations in shaping purchasing behaviors. Moreover, a positive correlation was found between the importance of fashion brand sustainability and consumers' decisions to buy sustainable clothing products [44]. These studies significantly provide evidence supporting the hypothesis of the relationship between consumer behavior and sustainability.

H10. *There is a significant relationship between environmental impact and sustainability.*

Manrique and Martí-Ballester (2017) explored the connection between sustainable business practices and corporate environmental performance, concluding that companies with less environmental impact are more inclined to use sustainable business practices to stay in business over the long run. The results indicated that adopting environmental practices significantly and positively affects corporate financial performance [45]. Similarly, Hejazi et al. (2023) stressed the significance of minimizing environmental impact to accomplish sustainability targets by examining the environmental factors' role in sustainability practices in the context of green supply chain management [46]. Furthermore, Cheng et al. (2023) emphasized the significance of sustainability practices in minimizing environmental harm by investigating the influence of sustainability initiatives on reducing environmental footprints across various industries [47]. When taken as a whole, these studies offer proof in favor of the hypothesis that sustainability and environmental effects are significantly correlated.

H11. *There is a significant relationship between online seller behavior and environmental impact.*

Biancolin and Rotaris (2024) examined the environmental impact of online seller behavior, specifically focusing on packaging waste and transportation emissions associated with e-commerce activities. Their findings indicated that sellers significantly increased their willingness to pay to reduce the environmental impact of last-mile logistics when they were provided with information on the amount of pollution reduction/offset and the type of project implemented [48]. Similarly, Kamruddin et al. (2024) performed an analysis of the carbon footprint of online retail businesses, which focused on how online sellers' actions along the logistics and distribution chain contribute to greenhouse gas emissions [49]. Furthermore, Mangiaracina et al. (2015) investigated how logistics operations affect the environment, highlighting the significance of environmentally friendly delivery and transportation methods [50]. These studies prove the hypothesis that there is a substantial correlation between the actions of online sellers and the environment.

2. Materials and Methods

2.1. Respondents

Structural equation modelling (SEM) is considered a big sample approach and typically requires a sample size of 200 or more. The sample size is often determined by the following three factors: the type of distribution (observed variables), the complexity of the model, and the estimation methodology [51,52]. The Department of Trade and Industry (DTI) reported 2 million online sellers as of 2022; researchers selected a sample size of the population for this study. The study employed a random sampling design, documenting

each participant's responses through a Google Forms survey. The researchers also ensured data confidentiality through compliance with the Philippine Data Privacy Act of 2012, and informed consent was obtained from all respondents. Researchers were trained to explain the importance of data confidentiality and discuss the survey's benefits and potential risks. We utilized a simple random sampling method through a Filipino online sellers group page, where we assigned identification numbers to participant names. Using a randomized number generator, we proceeded to contact each selected sample. In total, we collected responses from 286 participants [53]. Out of one thousand online surveys distributed, 286 online forms were received, resulting in a response rate of 28.6% [54]. Furthermore, the researchers thoroughly and meticulously evaluated all the collected data. This process entailed carefully examining each aspect to ensure the completeness and accuracy of the information. Notably, 100% of the gathered data successfully passed this evaluation. Through this rigorous assessment process, the researchers sought to uphold the integrity and reliability of the data collected for their study.

2.2. Questionnaire

In order to analyze the insights of online sellers for green logistics and sustainability, a self-administered questionnaire was created based on our theoretical framework. Eight areas make up the questionnaire: (1) environmental impact; (2) materials and packaging; (3) online seller behavior; (4) consumer behavior; (5) technical advancement; (6) government regulations and policies; (7) reverse logistics; and (8) sustainable e-commerce. With the exception of the demographic, each latent segment in SEM comprises five to eight observable factors evaluated using a Likert scale with a maximum score of five. To collect the data, a 61-item questionnaire was developed and distributed online in both Tagalog, the native language, and English formats (Table 1).

Table 1. Construct and Measures Table.

Construct	Items	Measures	Supporting Measures
Environmental Impact	EI1	The type of packaging I use is eco-friendly and has a good environmental impact	[55]
	EI2	I know that plastic packaging contributes to pollution	[56]
	EI3	I know the importance of sustainable production and packaging	[57]
	EI4	I prefer recyclable materials and packaging rather than the non-recyclable ones	[58]
	EI5	I put recyclable signages on my express package	[59]
	EI6	Vehicles use to delivery items contribute to carbon dioxide emission	[60]
	EI7	I look forward that someday delivery vehicles will also become eco-friendly	[61]
	EI8	E-bike is the future of sustainable e-commerce	[62]
Materials and Packaging	MP1	Sustainable packaging increases customer sales	[63]
	MP2	Plastics has its advantage than sustainable packaging	[64]
	MP3	Having a good knowledge about sustainable packaging will increase seller's profile	[65]
	MP4	Sustainable packaging reduced environmental impact/problem	[66]
	MP5	Online sellers should be prepared for environmentally friendly packaging	[67]
	MP6	Businesses and industries should utilize eco- friendly packaging for environment	[68]
	MP7	It is important to use sustainable packaging	[69]
	MP8	Electric vehicle is a good substitute for vehicles that uses fuel for reducing fuel consumption	[70]
Online Seller Behavior	OB1	The customer can approach easily	[71]
	OB2	Available for customer concerns without hesitation	[72]
	OB3	Communicate with the customer properly	[73]
	OB4	Easiness to access when delay online transactions	[74]
	OB5	Sellers popularity engaged more customers purchases	[75]
	OB6	Knowledgeable and approachable to inform about the status of the products or items to buyers	[76]
	OB7	Creative in promoting their products online	[77]

Table 1. *Cont.*

Construct	Items	Measures	Supporting Measures
Consumer Behavior	CB1	Seller shipped the parcel, then buyer were asking for cancelation	[78]
	CB2	Buyer didn't accept and pay the parcel from the delivery rider	[79]
	CB3	Consumer that directly posted their concerns on the product review without asking the seller first	[80]
	CB4	Buyer lost their connection because they not want to receive the parcel	[81]
	CB5	Buyer that wasting your time on inquiries but didn't buy your product	[81]
	CB6	Customer expecting high quality product at low price	[81]
	CB7	Consumers did not posting their rating and product reviews	[80]
Technological Advancement	TA1	E-commerce tools enable sellers to perform easier transactions with the customers	[82]
	TA2	Electronic forms of commerce have become a natural way of making purchases and sales	[83]
	TA3	The impact of technological change on the development of e-commerce is significant	[83]
	TA4	Social media is playing a pivotal role in E-Commerce	[84]
	TA5	Internet today influence every business entity across the world	[85]
	TA6	Technology helps to improve the efficiency, quality, and cost-effectiveness of the services provided by businesses	[86]
	TA7	The growing inventions and innovations in technology have impacted the way of doing E-commerce	[87]
	TA8	E-commerce is a vital component of our national economy	[88]
Government Rules and Policies	GL1	Online Sellers follows government local and national rules in packaging	[89]
	GL2	Government affects packaging and distribution of products	[90]
	GL3	Packaging should meet the government rules and qualifications before releasing to market	[91]
	GL4	Government supports sustainable packaging and renewable energy for E-commerce	[92]
	GL5	Seller and Government should collaborate in sustaining Environmental consideration for packaging	[93]
Reverse Logistics	RL1	Receiving delay orders	[94]
	RL2	Receiving broken or bad orders	[95]
	RL3	Encounter defective orders	[96]
	RL4	Receiving unsealed orders	[96]
	RL5	Misinformation of orders or parcels	[96]
Sustainable E-commerce	SU1	Economic sustainability is maximizing profits and ensuring sufficient money for stakeholders	[97]
	SU2	Sustainable e-commerce can be achieved by increasing customer satisfaction, loyalty, and trust through customer support	[97]
	SU3	Sustainability principle has become widespread among consumers	[98]
	SU4	Sustainability is seen as an effective tool to ensure competitiveness and achieve success	[98]
	SU5	If sustainability is not ensured, there will be some negative consequences	[98]
	SU6	Sustainability is one of the most important socio-economic-environmental topics of the time	[36]
	SU7	It is essential to enact and implement policies that are in line with businesses and e-commerce sustainability	[36]
	SU8	Sustainable e-commerce is the backbone of the sustainability and growth of online businesses	[36]

2.3. Structural Equation Modelling

SEM has several advantages over traditional data-analytic methods. Researchers can assess the effects of hypothetical or theoretical constructs, sometimes known as "latent variables" [99]. SEM offers a comprehensive statistical approach for testing observable and hidden variables [100]. All of the variables were modified from various studies found in the literature. AMOS version 26 software was used to analyze the data after the observable factors were rated on a Likert scale from 1 to 5, with one denoting "strongly disagree" and five denoting "strongly agree", as shown in Figure 2.

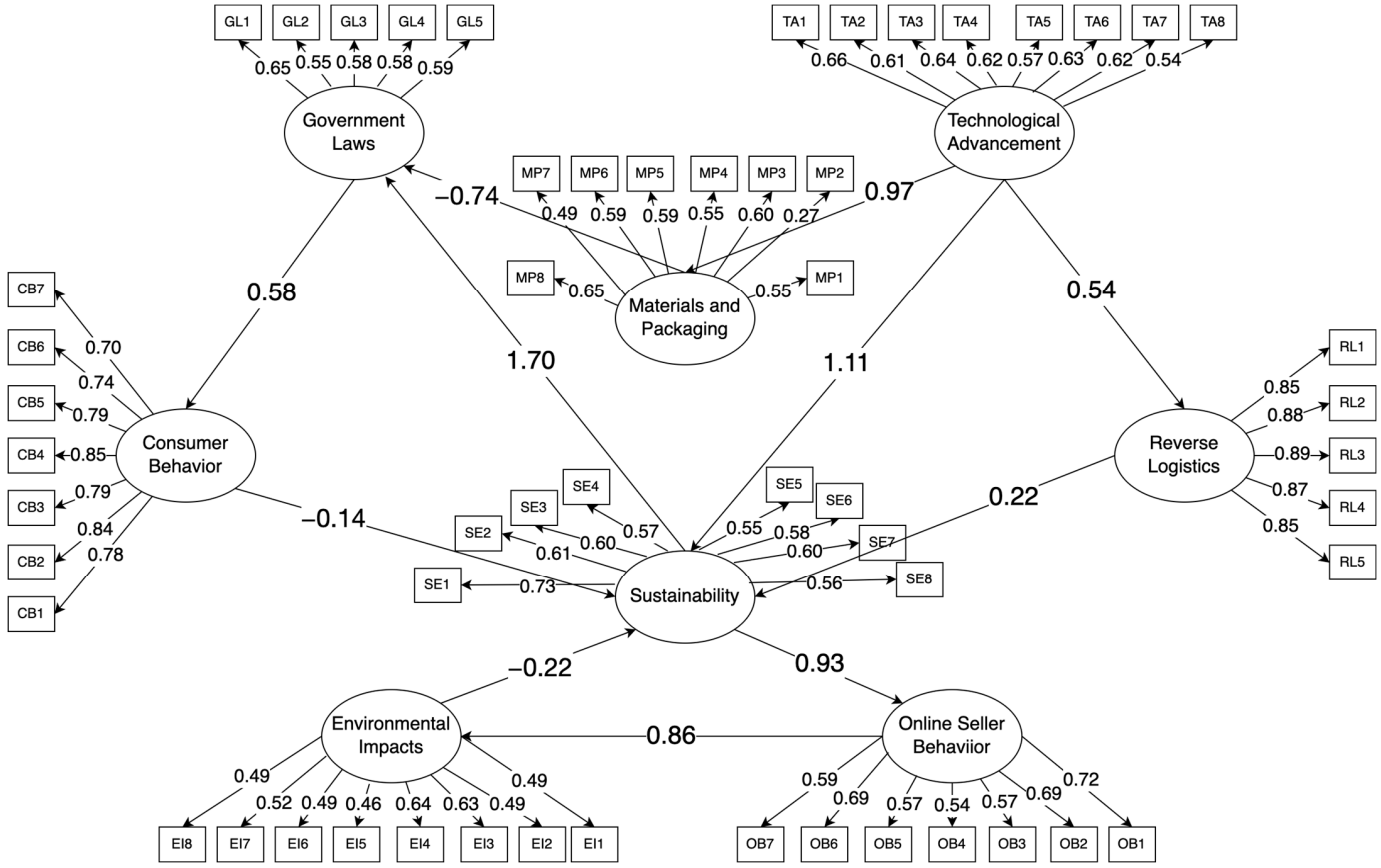

Figure 2. Initial Structural Equation Modeling.

3. Results and Discussion

3.1. Results

This study aims to assess the factors influencing green logistics in e-commerce in the Philippines, specifically focusing on packaging, energy, and transportation. Eight hypotheses were examined using structural equation modeling to explore the relationships among environmental impact (EI), materials and packaging (PM), technological advancement (TA), reverse logistics (RL), online seller behavior (OB), consumer behavior (CB), government laws (GL), and sustainability (SU). The initial SEM results indicate that out of 11 hypotheses, only one is insignificant where the *p*-value does not meet the criteria of 0.05 based on the SEM standards on cut-off procedures, which pertains to Materials and Packaging and Government Laws and Policies. Therefore, a new and revised SEM is derived by removing this hypothesis, the following studies utilized a similar approach [101], as shown in Figure 3.

Factor loadings from both the initial and final structural equation models are displayed in this table. The correlation between each indicator and the latent factor that it is thought to assess is represented by factor loadings. Stronger correlations between the indicator and the underlying construct are indicated by higher factor loadings closer to a value of 1.0. Factor loadings in the initial model range from 0.272 to 0.890; one indicator from the initial model, with a low loading below the accepted value of 0.4 [102], the MP2 with a value of 0.272, was eliminated from the final model. It made the model fit better overall. The remaining loadings in the final model show moderate to powerful connections between the hypothesized components and indicators, ranging from 0.431 to 0.890. When comparing the original and final models, most factor loadings rose or remained relatively constant; however, some variables slightly decreased (Table 2).

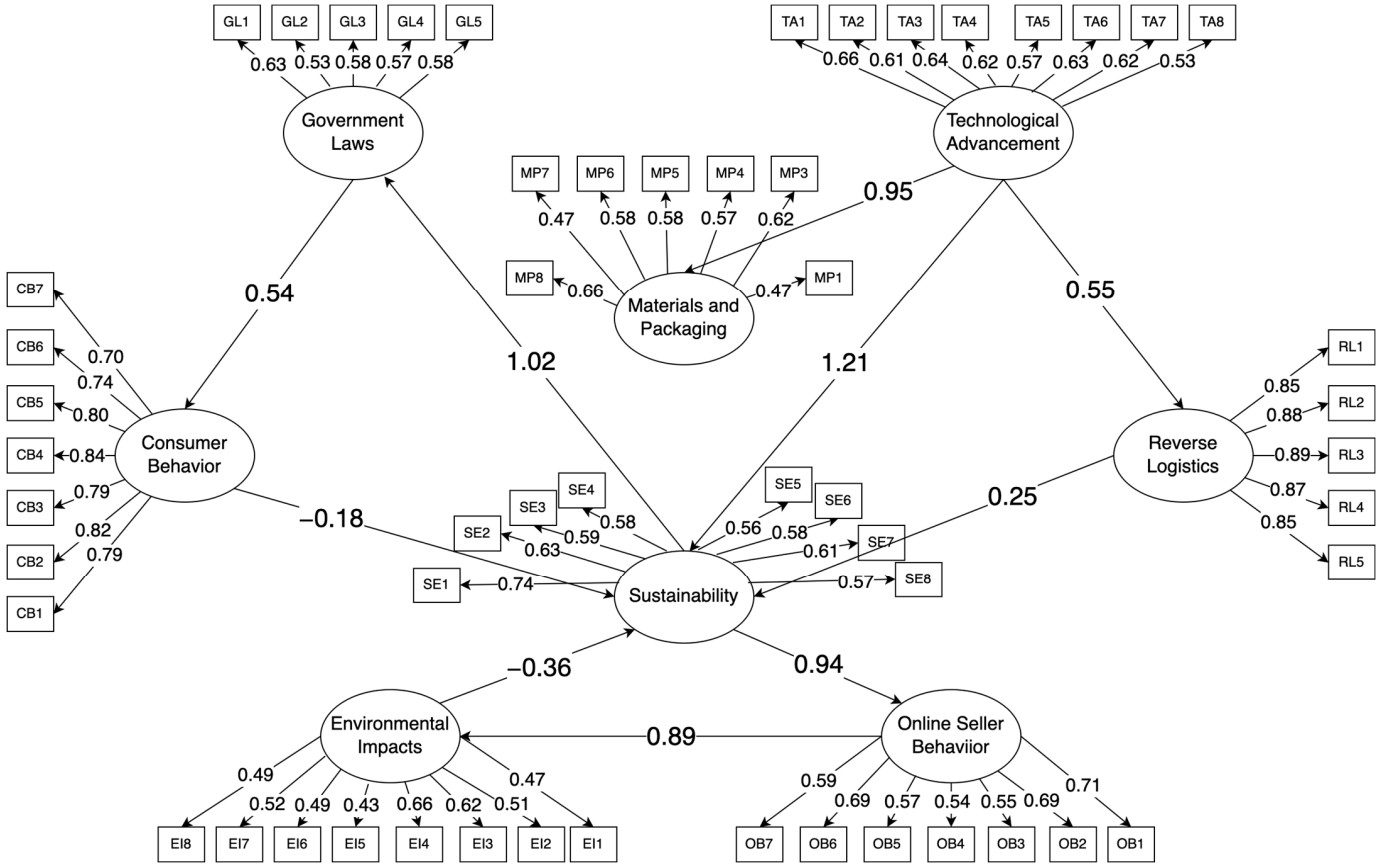

Figure 3. Final Structural Equation Modeling.

Table 2. Descriptive statistics results.

Factor	Item	Mean	StDev	Factor Loading	
				Initial Model	Final Model
Environmental Impact	EI1	4.182	0.8003	0.493	0.465
	EI2	4.430	0.7816	0.489	0.505
	EI3	4.371	0.7785	0.630	0.624
	EI4	4.255	0.7999	0.639	0.658
	EI5	4.192	0.7823	0.462	0.431
	EI6	4.259	0.7877	0.486	0.486
	EI7	4.402	0.7416	0.520	0.521
	EI8	4.199	0.7050	0.487	0.489
Materials and Packaging	MP1	4.080	0.8104	0.546	0.465
	MP2	3.867	1.0743	0.272	-
	MP3	4.206	0.7559	0.598	0.618
	MP4	4.315	0.7485	0.548	0.565
	MP5	4.322	0.7595	0.588	0.583
	MP6	4.392	0.7354	0.588	0.581
	MP7	4.402	0.6876	0.490	0.471
	MP8	4.077	0.8129	0.647	0.658
Online Seller Behavior	OB1	4.164	0.8106	0.715	0.709
	OB2	4.203	0.8084	0.686	0.688
	OB3	4.406	0.7421	0.566	0.554
	OB4	4.266	0.7581	0.537	0.540
	OB5	4.301	0.6962	0.571	0.574
	OB6	4.290	0.7325	0.686	0.691
	OB7	4.280	0.7389	0.589	0.590

Table 2. *Cont.*

Factor	Item	Mean	StDev	Factor Loading	
				Initial Model	Final Model
Consumer Behavior	CB1	3.804	1.1003	0.782	0.785
	CB2	3.811	1.1755	0.836	0.824
	CB3	3.920	1.1319	0.790	0.794
	CB4	3.769	1.2151	0.854	0.842
	CB5	3.951	1.1567	0.793	0.796
	CB6	4.010	0.9894	0.742	0.742
	CB7	3.934	0.9172	0.699	0.697
Technological Advancement	TA1	4.199	0.7437	0.659	0.661
	TA2	4.178	0.7676	0.610	0.614
	TA3	4.234	0.6941	0.641	0.642
	TA4	4.346	0.7224	0.621	0.624
	TA5	4.343	0.7168	0.574	0.571
	TA6	4.238	0.7489	0.634	0.631
	TA7	4.339	0.7353	0.619	0.615
	TA8	4.259	0.6776	0.543	0.534
Government Rules and Policies	GL1	4.224	0.7670	0.648	0.628
	GL2	4.112	0.7503	0.549	0.534
	GL3	4.199	0.7342	0.575	0.580
	GL4	4.283	0.7256	0.580	0.569
	GL5	4.231	0.7321	0.585	0.583
Reverse Logistics	RL1	3.706	1.2472	0.847	0.847
	RL2	3.654	1.3465	0.883	0.883
	RL3	3.668	1.2724	0.890	0.890
	RL4	3.661	1.2870	0.869	0.868
	RL5	3.559	1.3462	0.849	0.849
Sustainable E-commerce	SE1	4.111	0.8387	0.729	0.741
	SE2	4.087	0.8053	0.611	0.628
	SE3	4.189	0.7764	0.596	0.594
	SE4	4.157	0.7301	0.571	0.578
	SE5	4.262	0.7287	0.547	0.555
	SE6	4.266	0.7346	0.580	0.582
	SE7	4.178	0.7443	0.602	0.608
	SE8	4.231	0.7176	0.557	0.566

Table 3 shows the results of the hypothesis tests carried out as a part of an examination of structural equation modeling. A list of eleven hypotheses provides suggested connections between various model constructs. Based on a probable 0.05 alpha level cutoff, the *p*-value and final significance level are displayed for each row. The *p*-value of 0.187, higher than the significance level, indicates that H1 is the only non-significant connection because there is no straightforward national policy approach to tackling plastic pollution in the Philippines as of 2021. However, lawmakers and advocacy groups have made multiple attempts to make one [103]. *p*-values less than 0.05 indicate that the data support rejecting the null hypothesis and that the associations in questions H2 to H11 are statistically significant.

Table 4 includes instructions from the previous literature regarding optimal thresholds and several standard model fit statistics computed for a structural equation model. Evaluating the model fit indices is essential in determining how the given model accurately replicates the observed covariance matrix among all indicators. An acceptable model fit, and empirical validation of the proposed associations is shown by values that meet or surpass recommended guidelines and references from recent studies. The incremental fit index (IFI), Tucker Lewis Index (TLI), and Comparative Fit Index (CFI) have the following values of 0.899, 0.891, and 0.898, respectively, which are all above the minimal values that are suggested to indicate a satisfactory fit. Even though the researchers connected all modification indices in the same variable to increase the model fit, the absolute fit indexes GFI and AGFI are still marginally above acceptable levels. Thus, there is still room for improvement. Lastly, RMSEA meets the criteria at 0.044, with smaller values signaling a better fit.

Table 3. Summary of Hypotheses.

	Hypothesis	*p*	Interpretation
H1	There is a significant relationship between materials and packaging, and Government Laws	0.187	Not Significant
H2	There is a significant relationship between technological advancement and materials and packaging	0.003	Significant
H3	There is a significant relationship between Government Laws and consumer behavior	0.002	Significant
H4	There is a significant relationship between Technological advancement and reverse logistics	0.005	Significant
H5	There is a significant relationship between sustainability and Government Laws	0.003	Significant
H6	There is a significant relationship between technological advancement and sustainability	0.002	Significant
H7	There is a significant relationship between sustainability and online seller behavior	0.006	Significant
H8	There is a significant relationship between reverse logistics and sustainability	0.001	Significant
H9	There is a significant relationship between consumer behavior and sustainability	0.026	Significant
H10	There is a significant relationship between environmental impact and sustainability	0.002	Significant
H11	There is a significant relationship between online seller behavior and environmental impact	0.006	Significant

Table 4. Model Fit.

Goodness of Fit Measures of the SEM	Parameter Estimates	Minimum Cut-Off	Suggested by
Incremental Fit Index (IFI)	0.899	>0.806	Akkus, 2020 [104]
Tucker Lewis Index (TLI)	0.891	>0.85	Carlback and Wong, 2018 [105]; Shadfar and Malekmohammadi, 2013 [106]
Comparative Fit Index (CFI)	0.898	>0.80	Akkus, 2020 [104]
Goodness of Fit Index (GFI)	0.782	>0.70	Ghmadi et al., 2021 [107]
Adjusted Goodness of Fit Index (AGFI)	0.760	>0.70	Ghmadi et al., 2021 [107]
Root Mean Square Error of Approximation (RMSEA)	0.044	<0.07	Steiger, 2007 [108]

Table 5 shows the specific findings of direct, indirect, and total effects for the proposed relationships in a structural equation model. Each of the 37 rows corresponds to a modeled path between the variables. The impacts are displayed as estimates of direct effects, indirect effects through mediators, and total effects, which add up to both. *p*-values determine whether an effect is statistically significant for each kind. Reverse logistics, packaging, and sustainability are all directly impacted by technological advancement (TA).

Additionally, it significantly affects every variable overall. Sustainability is directly impacted by reverse logistics (RL), which also has indirect implications on other outcomes. The mediated effects of online seller behavior (OB) and environmental impact (EI) negatively impact the downstream components. Experimental modification has the potential to yield objective assessments of both direct and indirect effects, while also ensuring that mediators have no link with other variables. We shall discuss a few potentially problematic insinuations that it also makes. Moreover, it is also mentioned by Wang et al. (2022) that

the overall impacts matched the total of the direct and indirect effects, which is the reason behind having both direct and indirect effects for some variables [80]. An analysis of total effects facilitates the assessment of the relative influence of various constructs and supports inferences regarding causal hypotheses in the theoretical SEM framework.

Table 5. Direct, indirect, and total effects.

No.	Variable	Direct Effects	*p*-Value	Indirect Effects	*p*-Value	Total Effects	*p*-Value
1	TA → RL	0.552	0.004	-	-	0.552	0.004
2	TA → OB	-	-	0.898	0.004	0.898	0.004
3	TA → EI	-	-	0.796	0.004	0.796	0.004
4	TA → CB	-	-	0.532	0.002	0.532	0.002
5	TA → SU	1.205	0.005	−0.246	0.009	0.960	0.002
6	TA → GL	-	-	0.978	0.002	0.978	0.002
7	TA → PM	0.954	0.004	-	-	0.954	0.004
8	RL → OB	-	-	0.169	0.001	0.169	0.001
9	RL → EI	-	-	0.150	0.001	0.150	0.001
10	RL → CB	-	-	0.100	0.001	0.100	0.001
11	RL → SU	0.253	0.003	−0.072	0.003	0.180	0.001
12	RL → GL	-	-	0.184	0.001	0.184	0.001
13	OB → OB	-	-	−0.216	0.003	−0.216	0.003
14	OB → EI	0.886	0.005	−0.191	0.003	0.695	0.000
15	OB → CB	-	-	−0.128	0.003	−0.128	0.003
16	OB → SU	-	-	−0.231	0.003	−0.231	0.003
17	OB → GL	-	-	−0.235	0.003	−0.235	0.003
18	EI → OB	-	-	−0.243	0.003	−0.243	0.003
19	EI → EI	-	-	−0.216	0.003	−0.216	0.003
20	EI → CB	-	-	−0.144	0.003	−0.144	0.003
21	EI → SU	−0.364	0.003	0.104	0.004	−0.260	0.003
22	EI → GL	-	-	−0.265	0.003	−0.265	0.003
23	CB → OB	-	-	−0.119	0.012	−0.119	0.012
24	CB → EI	-	-	−0.106	0.013	−0.106	0.013
25	CB → CB	-	-	−0.071	0.010	−0.071	0.010
26	CB → SU	−0.179	0.020	0.051	0.021	−0.127	0.012
27	CB → GL	-	-	−0.130	0.011	−0.130	0.011
28	SU → OB	0.936	0.004	−0.268	0.004	0.668	0.000
29	SU → EI	-	-	0.592	0.000	0.592	0.000
30	SU → CB	-	-	0.396	0.001	0.396	0.001
31	SU → SU	-	-	−0.286	0.005	−0.286	0.005
32	SU → GL	1.019	0.002	−0.292	0.004	0.727	0.001
33	GL → OB	-	-	−0.065	0.011	−0.065	0.011
34	GL → EI	-	-	−0.058	0.010	−0.058	0.010
35	GL → CB	0.544	0.003	−0.038	0.009	0.506	0.003
36	GL → SU	-	-	−0.069	0.010	−0.069	0.010
37	GL → GL	-	-	−0.071	0.010	−0.071	0.010

3.2. Discussion

The final SEM model illustrates the factors contributing to green logistics in e-commerce. SEM testing demonstrates that only 10 hypotheses have a significant and positive relationship in the green e-commerce industry. According to the results of SEM, technological advancement to sustainability (β = 1.205, p = 0.005) has a positive relationship. The results underscore the importance of technological innovation in promoting sustainability initiatives. This finding aligns with previous research highlighting the transformative potential of technological advancements in driving sustainable development [33,34,109]. The results emphasized that technological advancement enhances sustainability practices in the supply chain in general.

The observed positive relationship between sustainable e-commerce and government laws (β = 1.019, p = 0.002) indicated the significant influence of sustainable e-commerce practices on regulatory frameworks and government policies. Similarly, Delmas and Toffel (2008) discussed the impact of adopting sustainable practices, revealing a positive relationship between regulatory stringency, and implementing environmental management systems [30]. This implies that strict government regulations could lead to adopting sustainable e-commerce practices. The significant direct effect of technological advancement on materials and packaging (β = 0.954, p = 0.004), the integration of technology, such as intelligent packaging solutions and advanced materials, in e-commerce supply chains, emphasizes the potential for technological advancements to optimize packaging processes and reduce environmental impacts [19]. It underscores the transformative impact of technological innovations on materials and packaging practices within e-commerce operations.

The positive relationship observed between sustainability and online seller behavior (β = 0.936, p = 0.004) underscores the influence of sustainable practices on shaping the behavior of online sellers, aligning with previous research emphasizing the impact of sustainability initiatives on business conduct in the e-commerce sector [36]. Additionally, the positive association between online seller behavior and environmental impact (β = 0.886, p = 0.005) highlights the role of online seller actions in influencing environmental outcomes, as evidenced by studies investigating the environmental implications of e-commerce activities and supply chain management practices [49]. These results highlight the potential for sustainable strategies to lead to favorable environmental outcomes by demonstrating the connections between online seller behavior, sustainability practices, and environmental impacts within the e-commerce sector.

The direct effect of technological advancement on reverse logistics (β = 0.552, p = 0.004) highlights the critical role of technology in optimizing reverse logistics processes within e-commerce operations, as evidenced by previous studies [110,111]. Concurrently, the significant relationship between government laws and consumer behavior (β = 0.544, p = 0.003) underlines the effect of regulatory frameworks on shaping consumer attitudes and intentions in the e-commerce context, as supported by prior research [23,24]. It emphasizes the correlations of technological advancements, regulatory environments, and consumer behavior in driving the dynamics of e-commerce operations.

There are positive interrelationships between reverse logistics and sustainable e-commerce (β = 0.253, p = 0.003). Similarly, it underscores the integral role of efficient reverse logistics processes in fostering sustainability within e-commerce operations [39,40]. Additionally, the significant relationship between consumer behavior and sustainable e-commerce (β = −0.179, p = 0.020) highlights the influence of consumer preferences and behaviors on the adoption of sustainable practices in e-commerce. Similarly, the study by Lopes et al. (2024) suggested that individuals who prioritize sustainability are more likely to engage in environmentally friendly purchasing decisions [42]. The current study suggests that effective reverse logistics management and alignment with consumer expectations are essential for promoting sustainability within e-commerce ecosystems.

The significant relationship between environmental impact and sustainable e-commerce (β = −0.364, p = 0.003) indicates the importance of environmental considerations in shaping sustainable practices within the e-commerce sector [46,47]. However, the lack of a significant

relationship between materials and packaging and government laws ($p = 0.187$) suggests that other factors may have a more pronounced influence on materials and packaging practices and regulatory compliance within the e-commerce context. In contrast, several studies indicated a direct relationship between government regulations and policies that substantially influence materials and packaging in various industries [13,14]. These findings highlight the complexity of factors influencing sustainability outcomes in e-commerce operations and show the need for further research to explain the underlying effects of materials and packaging practices and regulatory compliance.

Theoretical Implications

The findings of this study have several theoretical implications for understanding the dynamics of sustainability practices in e-commerce. Firstly, the significant relationship between environmental impact and sustainable e-commerce underscores the importance of environmental considerations in shaping sustainable practices within the e-commerce sector. Secondly, the lack of a significant relationship between materials and packaging and government laws suggests that other factors may have a more pronounced influence on e-commerce. Additionally, the positive interrelationships observed between reverse logistics and sustainable e-commerce highlight the integral role of efficient reverse logistics processes in facilitating sustainability within e-commerce operations. Finally, the significant relationship between consumer behavior and sustainable e-commerce emphasizes the influence of consumer choices and behaviors on adopting sustainable practices in e-commerce. These theoretical insights contribute to the broader insight into the interplay between environmental, regulatory, logistical, and consumer factors in driving sustainability initiatives in the e-commerce industry.

4. Conclusions

Amid the 2020 pandemic in the Philippines, a shift occurred in how people buy things, with online shopping gaining popularity due to safety concerns. The SEM results show that technological advancements positively impact sustainability. Sustainable e-commerce correlates positively with government laws, seller behavior, and reverse logistics. Government laws influence consumer behavior. The study demonstrates the complex dynamics of promoting green logistics in Philippine e-commerce, particularly in energy, packaging, and transportation.

Although the importance of environmental sustainability is rising across industries, little is known about the variables influencing e-commerce companies, particularly embracing green logistics methods. This study conducted a nationwide online seller survey in the Philippines to gather information regarding product variables, including how internal procedures and external partnerships are used and perceived to lower the carbon footprint associated with order fulfillment and delivery. A structural equation model was constructed with latent variables about government regulations, technology innovation, reverse logistics, environmental impact, materials and packaging, green packaging, and, of course, online sellers' behavior. The results of this study may strengthen the links between ecological, economic, and green logistics integration. Moreover, it can help future researchers who want to establish this type of study with different factors. Also, this study can help shape focused policy interventions and determine which aspects of green logistics should be addressed to speed up adoption across the rapidly expanding online retail industry by concentrating exclusively on e-commerce perspectives.

5. Limitations and Future Research

Even with the study's significant findings, the authors recognize and openly disclose its limitations. The study was limited to the Philippines; therefore, its generalizability to other nations may be compromised. Second, given the small sample size of 286 respondents, this research appears to lay the groundwork for future investigations into the variables influencing green logistics in online retail. An increase in the sample size to

300 or 400 respondents is advised to obtain more precise data. Additionally, as the study's conclusions may only apply to the Philippines, it is imperative to increase the respondent pool to include the entire country. Notwithstanding these limitations, the study's core focus on examining factors in E-commerce green logistics in the Philippines, a rapidly growing industry globally, positions it as a valuable reference for future studies encompassing a broader population. The insights from this research can contribute to government efforts to enhance and develop a more sustainable E-commerce industry through green logistics.

Future research should focus more on the social and cultural aspects of e-commerce that affect customer behavior and sustainability practices. Researchers can better understand the dynamics influencing consumer choices and sustainable practices in e-commerce operations by looking more closely at these issues. Furthermore, combining knowledge from sociology, anthropology, and cultural studies could offer insightful viewpoints on the many cultural norms, values, and perceptions that affect decisions about sustainability in various locales and societies. These multidisciplinary methods would improve the validity and relevance of study results, leading to more potent tactics for advancing sustainability in e-commerce ecosystems.

Author Contributions: Conceptualization, supervision, funding acquisition, writing—review and editing, Y.-T.J., C.-Y.L., K.A.M. and C.S.S.; formal analysis, investigation, methodology, visualization, writing—original draft, C.J.G., C.S., D.S., J.R., M.B.D. and M.J.B. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data are contained within the article.

Conflicts of Interest: The authors declare no conflict of interest.

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