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Towards Sustainable E-Commerce: Consumer Preferences for Reducing Packaging Waste in Indonesia—A PLS-SEM Analysis

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Abstract
This study examines how Indonesian e-commerce platforms, particularly Tokopedia, can mitigate the environmental impact of overpackaging waste by exploring the effects of sustainable packaging materials, recycling systems, and environmental awareness campaigns on consumer preferences. The research hypothesizes that consumer support for eco-friendly packaging is positively influenced by advancements in packaging design, recycling infrastructure, and environmental education, and highlights the role of government interventions in shaping business and consumer behaviors. Using Partial Least Squares Structural Equation Modelling (PLS-SEM), the study provides insights into sustainable practices within Indonesia's e-commerce sector, emphasizing value co-creation among consumers, businesses, and policymakers. Findings reveal that consumers highly value optimized packaging, recycling systems with incentives, and eco-conscious brand practices, though incentives and taxes alone are insufficient for driving change. This research offers actionable recommendations for reducing the environmental impact of e-commerce packaging waste and aligns with consumer expectations for sustainability in online shopping.

Keywords: E-Commerce Packaging, Overpackaging, Plastic Waste, Environmental Sustainability, PLS-SEM

1. Introduction

The rapid growth of e-commerce in Indonesia has led to significant environmental challenges, particularly due to the excessive use of plastic packaging materials like bubble wrap and tape. E-commerce platforms, such as Tokopedia (Andariesta & Wasesa, 2023), have facilitated convenient access to goods, but this convenience has resulted in increased packaging waste. This issue was exacerbated during the COVID-19 pandemic, which saw a surge in online shopping and, consequently, packaging waste (Yuniar, 2020; Lestari et al., 2021; Ricky et al.,

2022). Indonesia's limited waste management infrastructure has struggled to cope with the rising volume of waste, which poses threats to both local ecosystems and broader global sustainability efforts (Wasesa et al. 2022).

Research has shown that packaging materials significantly contribute to the carbon footprint of the logistics sector, with studies in China and Germany demonstrating the substantial environmental impact of packaging in e-commerce (Su et al., 2020; Zimmermann & Bliklen, 2020). However, there is a gap in understanding how consumers in emerging markets like Indonesia perceive sustainable packaging solutions and how these preferences could drive more environmentally friendly practices in the e-commerce sector. This study seeks to explore how digital marketplace platforms like Tokopedia can reduce the environmental impact of packaging waste by examining the influence of improvements in packaging materials, recycling systems, and environmental awareness campaigns on consumer preferences.

The study centers on the hypothesis that consumer preferences for sustainable packaging solutions are positively influenced by advancements in packaging design, waste recycling systems, and environmental education. The study also proposes that government interventions, such as regulatory frameworks and financial incentives, play a crucial role in shaping both business practices and consumer behavior. Using Partial Least Squares Structural Equation Modelling (PLS-SEM), this research aims to provide a comprehensive understanding of how sustainable practices can be integrated into Indonesia's e-commerce sector. Furthermore, by emphasizing value co-creation among consumers, businesses, and policymakers, the study offers practical insights for promoting sustainability and provides actionable recommendations for reducing the environmental impact of packaging waste. Through this research, two key questions are addressed: first, what are the globally discussed solutions to addressing the issue of overpackaging in e-commerce; and second, which solutions to the issue of e-commerce overpackaging are preferred by Indonesian consumers.

2. Literature Review

2.1. Digital Transformation and Environmental Sustainability

Digital transformation refers to the strategic shift in organizations driven by emerging technologies that fundamentally alter how value is delivered to customers (Gebayew et al., 2018; Tang, 2021). Technologies such as artificial intelligence (AI), blockchain, cloud computing, social media, and the Internet of Things (IoT) have been increasingly adopted since Industry 4.0. These technologies enable businesses to create new operational models, streamline processes, and enhance customer experiences. At the same time, environmental sustainability emphasizes the responsible use of resources to meet current needs without compromising the ability of future generations to meet theirs (Elleuch et al., 2018; Gaughran et al., 2007). This concept encompasses reducing waste, pollution, and resource conservation.

As digitalization accelerates, its intersection with sustainability becomes apparent. Feroz et al. (2021) categorize the impact of digital transformation on environmental sustainability into four areas: pollution control, waste management, sustainable production, and urban sustainability. These areas illustrate how digital technologies can support pollution measurement, waste reduction, and sustainable production practices across industries. However, achieving environmental sustainability through digital transformation is not without challenges. Organizations face internal and external barriers such as unclear environmental regulations, bureaucratic obstacles, and limited access to sustainable materials (Murillo-Luna et al., 2011). Overcoming these barriers requires strong support from top management and strategic planning to integrate both digital transformation and sustainability goals effectively.

2.2. The Overpackaging Issue in E-Commerce

In the context of e-commerce, overpackaging has become a significant environmental concern. E-commerce transactions, especially in business-to-consumer (B2C) models, involve multiple layers of packaging—primary, secondary, and tertiary—to ensure product safety and branding. These layers, while necessary for logistical reasons, contribute heavily to environmental degradation (Hellström & Saghir, 2007). The challenge lies in

balancing the need for protective packaging with environmental responsibility. The concept of cleaner production has been proposed as a solution, emphasizing waste reduction at every stage of the production process, including packaging (Chueamuangphan et al., 2020).

Cleaner production methods aim to minimize environmental impact by optimizing packaging design and using sustainable materials. These methods address the overuse of plastic and cardboard, which are commonly used in e-commerce packaging, by promoting recyclable materials and innovative designs that reduce the amount of packaging required while maintaining product protection. Countries with large e-commerce sectors, such as China and India, are particularly affected by the waste generated from daily online deliveries, highlighting the need for supply chain optimization and more sustainable packaging solutions (Zimmermann & Bliklen, 2020). Involving consumers in this process is also essential, as their preferences for recyclable and sustainable packaging drive demand for eco-friendly products.

2.3. Solutions to E-Commerce Overpackaging

There are three key actors involved in addressing the overpackaging issue: government, enterprises, and individual consumers. Each plays a vital role in mitigating the environmental impact of packaging waste (Lu et al., 2020; Xie et al., 2021).

2.3.1. Government

Governmental interventions are crucial in regulating and shaping sustainable packaging practices. Policies such as product taxes, eco-design standards, and extended-producer-responsibility (EPR) incentivize businesses to adopt environmentally friendly packaging solutions (Foschi & Bonoli, 2019; Watkins et al., 2019). Governments can also set packaging standards, enforce recycling systems, and provide subsidies to support sustainable packaging practices (Tencati et al., 2016). In China, for instance, the Environmental Protection Tax (EPT) was introduced in 2016, requiring businesses to reduce their environmental impact or face financial penalties (M. Zhang et al., 2016). Through such governance systems, countries can promote a shift towards more sustainable consumption and production practices.

2.3.2. Enterprises

Enterprises play a critical role in reducing packaging waste by adopting sustainable materials and optimizing packaging strategies. Innovations in biodegradable and reusable materials, such as cellulose-based packaging, reduce the environmental impact of e-commerce (Escursell et al., 2021). Companies like IKEA and JD.com have implemented recycling systems and utilized algorithms to optimize packaging designs, minimizing the use of unnecessary materials (Carlin, 2019; Wang et al., 2020). Enterprises are also adopting circular economy principles, where packaging waste is reintegrated as secondary raw material. Training and management of logistics personnel to use packaging more efficiently and prevent product damage during transportation are additional measures that companies can take to enhance their environmental impact (Elgaaïed-Gambier, 2016).

2.3.3. Individual Consumers

Individual consumers also play an essential role in addressing the overpackaging issue. Consumer preferences drive demand for sustainable packaging, with an increasing number of consumers prioritizing recyclability and environmental impact when making purchasing decisions (Prakash & Pathak, 2017). Educating consumers about the consequences of overpackaging and encouraging them to choose eco-friendly options can significantly influence the packaging strategies of businesses. Additionally, behavioral changes, such as consolidating multiple purchases into single transactions, can help reduce the environmental impact of e-commerce deliveries (Gręboszz-

Krawczyk & Siuda, 2019). Raising public awareness about the importance of sustainable practices is key to fostering a societal shift towards environmentally responsible consumption.

2.4. Theory of Value Co-Creations

Value co-creation (VCC) refers to a collaborative approach in which businesses and consumers work together to create value, moving away from traditional, product-centric business models (Prahalad & Ramaswamy, 2004). In the context of e-commerce overpackaging, VCC can foster innovative solutions that meet both consumer and environmental needs. By engaging consumers through collaborative platforms, businesses can gather feedback on packaging preferences and develop sustainable packaging solutions that align with consumer expectations (Galvagno & Dalli, 2014). For instance, customers can contribute ideas for reusable packaging or participate in recycling programs, helping businesses implement eco-friendly practices.

Moreover, VCC extends beyond packaging materials to include logistics and recycling processes. By involving consumers in decisions related to delivery routes and recycling participation, businesses can reduce carbon footprints and improve the efficiency of recycling systems (Elgaaïed-Gambier, 2016). This collaborative effort not only addresses the immediate issue of overpackaging but also supports broader environmental sustainability goals, creating a competitive advantage for companies that focus on consumer-driven, co-created value (de Almeida Oroski & da Silva, 2023).

2.5. Conceptual Framework

The conceptual framework highlights that addressing the issue of e-commerce overpackaging requires an integrated approach involving digital transformation, sustainability, and collaboration among key stakeholders—governments, enterprises, and consumers, as shown in Figure 1. While digital technologies enhance operational efficiency, the environmental impact of packaging waste remains significant. Cleaner production methods and innovative packaging designs are crucial, but their success depends on supportive government regulations, business strategies that adopt eco-friendly materials, and consumer participation in sustainable practices. Through value co-creation, these stakeholders must collaborate to develop and implement solutions that align environmental sustainability with shared value creation. The framework emphasizes the interconnected roles of these elements in mitigating the environmental impact of e-commerce packaging.

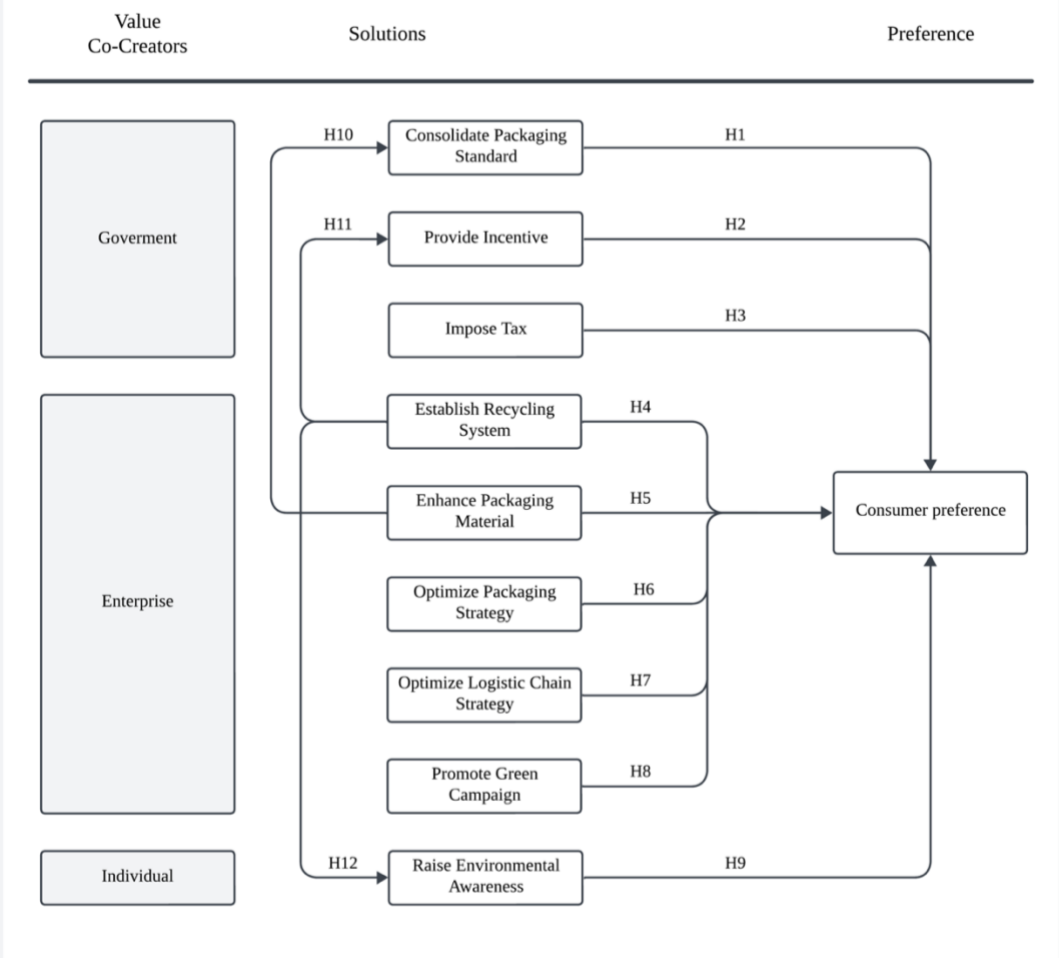

Figure 1: Conceptual Framework

Aligned with the conceptual framework, we present the following hypotheses:

- **Hypothesis 1 (H1)**: Consolidate packaging standard is positively correlated with consumer preferences.
- **Hypothesis 2 (H2)**: Provide incentive is positively correlated with consumer preferences.
- **Hypothesis 3 (H3)**: Impose tax is positively correlated with consumer preferences.
- **Hypothesis 4 (H4)**: Establish recycling system is positively correlated with consumer preferences
- **Hypothesis 5 (H5)**: Enhance packaging material is positively correlated with consumer preferences.
- **Hypothesis 6 (H6)**: Optimize packaging strategy is positively correlated with consumer preferences.
- **Hypothesis 7 (H7)**: Improve logistic service excellency is positively correlated with consumer preferences.
- **Hypothesis 8 (H8)**: Promote green campaign is positively correlated with consumer preferences.
- **Hypothesis 9 (H9)**: Raise environmental awareness is positively correlated with consumer preferences.
- **Hypothesis 10 (H10)**: Consolidated packaging standard is positively mediating between enhance packaging material with consumer preferences.
- **Hypothesis 11 (H11)**: Provide incentive is positively mediating between establish recycling system with consumer preferences.
- **Hypothesis 12 (H12)**: Raise environmental awareness is positively mediating between establish recycling system with consumer preferences.

3. Method

This research employs a quantitative approach to address the issue of overpackaging in Indonesian e-commerce, using a carefully structured methodology. The study begins with the development of a comprehensive research design, which includes identifying business problems, reviewing relevant literature, and constructing a

questionnaire for data collection. The quantitative data collection process involves a survey distributed in the larger Jakarta (Jabodetabek) area, focusing on consumer preferences for sustainable packaging solutions. The survey captures respondents' demographics and opinions using a five-level Likert scale to assess various variables, such as government policies, recycling systems, and packaging innovations. A sample size of 100 respondents, chosen through convenience sampling, is deemed appropriate for Structural Equation Modeling (SEM) analysis. Data analysis is performed using Partial Least Squares Structural Equation Modeling (PLS-SEM), a method suitable for small sample sizes and non-normal data distribution, ensuring a thorough evaluation of relationships between variables. The analysis process includes validating factor loadings, assessing reliability and validity, and testing the hypotheses through bootstrapping to ensure statistically significant results.

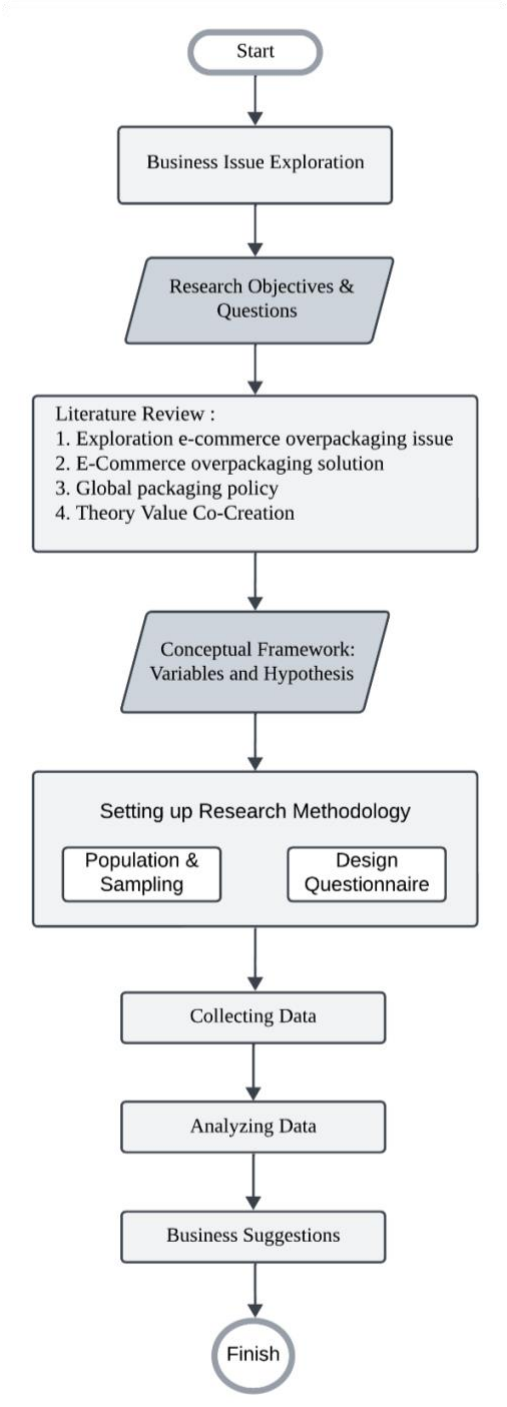

Figure 2: Research Design

4. Results

4.1. Respondents' Profile

Table 2: Respondents' Profile (n= 105 respondents)

Variable	Item	Result
Gender	Male	43%
	Female	57%
Age	<25	14%
	25-34	60%
	35-44	22%
	45-54	4%
	>54	0%
Education	Undergraduate	6%
	Graduate	79%
	Postgraduate	15%
Occupation	Student	12%
	Entrepreneur	10%
	Professional	63%
	Civil servant	3%
	Other	11%
Cities	DKI Jakarta	39%
	Bogor	9%
	Depok	15%
	Tangerang	31%
	Bekasi	6%
Have you ever been doing e-commerce transaction?		100%
Years e-commerce transaction experience	1 year	4%
	1-3 year(s)	9%
	3-5 years	21%
	>5 years	70%
Number of transactions in 1 Month	1 transaction	5%
	2-3 transactions	37%
	4-5 transactions	20%
	More 5 transactions	38%
Awareness to e-commerce overpacking issue	Yes	66%
	No	34%

Table 2 shows that most respondents possess significant expertise and experience in e-commerce. Notably, 70% have more than five years of experience with online shopping platforms, and 58% conduct over three transactions per month. This high level of engagement underscores their familiarity with online purchasing behavior, adding practical insight to their responses. Additionally, the educational and professional backgrounds of the participants enhance the credibility of the findings, with 79% holding graduate degrees, 15% possessing postgraduate degrees, and 63% working as professionals. These qualifications suggest that respondents are discerning consumers who value efficiency, convenience, and informed decision-making in their online shopping experiences. Moreover, 66% of respondents expressed concerns about e-commerce overpackaging, signaling a growing awareness of environmental sustainability as a factor in their purchasing choices. This study, leveraging SmartPLS PLS-SEM analysis, seeks to reveal how sustainability considerations shape consumer behavior and preferences, highlighting the importance of these issues in modern e-commerce strategies.

4.2. Statistics and Data Analysis

PLS-SEM analysis involves assessing the correlation between each variable and its indicators. According to Hair et al. (2014), factor loadings above 0.70 are considered significant, indicating a strong relationship between the indicator and the corresponding variable. Loadings between 0.55 and 0.70 suggest a moderate association, while those below 0.55 are generally regarded as measurement error and may be excluded from the model. Following

the removal of unrelated factor loadings and calculation of relevant values, the results of the analysis are presented in Table 3.

Table 3: Indicator Reliability and Validity

Variable	Indicator	Factor Loading	Variable	Indicator	Factor Loading	Variable	Indicator	Factor Loading
Consolidated Packaging Standard (CPS)	CPS2	0,858	Enhance Packaging Material (EPM)	EPM1	0,747	Promote Green Campaign (PGC)	PGC2	0,818
	CPS3	0,894		EPM2	0,825		PGC3	0,868
	CPS4	0,916		EPM3	0,800		PGC4	0,850
Provide Incentive (PI)	PI2	0,913		EPM4	0,731	Raise Environmental Awareness (REA)	REA1	0,681
	PI3	0,957	Optimize Packaging Strategy (OPS)	OPS1	0,632		REA2	0,657
	PI4	0,909		OPS2	0,670		REA3	0,701
	PI5	0,876		OPS3	0,816		REA4	0,621
Impose Tax (ITAX)	ITAX2	0,936		OPS4	0,664		REA5	0,690
	ITAX3	0,970		OPS5	0,665	Consumer Preference (CP)	CP1	0,843
	ITAX4	0,949	Improve Logistic Service Excellency (ILSE)	ILSE2	0,570		CP2	0,849
Establish Recycling System (ERS)	ERS2	0,833		ILSE4	0,659		CP3	0,692
	ERS3	0,914		ILSE5	0,815			

After the evaluating the factor loading process, analysis continues with break down the reliability and convergent validity of the collected questionnaire data by addressing the value of Composite Reliability or CR (ρA) and Average Variance Extracted (AVE) respectively. Criterion for acceptable value of CR should around 0,7 and 0,9, while acceptable AVE should more than 0,5. Therefore, unacceptable number in the Table 4 marked in a red ink.

Table 4: Variable Reliability and Validity

	CA	**CR (ρ_A)**	**CR (ρ_C)**	**AVE**
CPS	0,871	0,927	0,919	0,792
PI	0,935	0,961	0,953	0,836
ITAX	0,948	0,97	0,966	0,906
ERS	0,698	0,744	0,866	0,764
EPM	0,784	0,794	0,859	0,603
OPS	0,73	0,734	0,82	0,480
ILSE	0,451	0,476	0,726	0,474
PGC	0,802	0,815	0,883	0,715
REA	0,696	0,698	0,803	0,450

CP	0,711	0,726	0,839	0,637

While to read the acceptance criterion of discriminant validity in Table 5, it has to understand the table structurally which consists of diagonal elements and off-diagonal elements. The diagonal elements are the square root of Average Variance Extracted (AVE). The diagonal elements become the reference for the off-diagonal elements that it must not exceed the diagonal elements.

Table 5: Fornell-Lorcker's Discriminant Validity

	CPS	**PI**	**ITAX**	**ERS**	**EPM**	**OPS**	**ILSE**	**PGC**	**REA**	**CP**
CPS	0,890									
PI	0,510	0,914								
ITAX	0,187	0,211	0,952							
ERS	0,234	0,351	0,104	0,874						
EPM	0,357	0,297	0,250	0,596	0,777					
OPS	0,068	0,047	0,123	0,262	0,532	0,693				
ILSE	0,209	0,107	0,021	0,285	0,430	0,514	0,689			
PGC	0,369	0,290	0,169	0,392	0,474	0,403	0,336	0,845		
REA	0,279	0,323	0,339	0,206	0,418	0,411	0,390	0,589	0,671	
CP	0,022	0,095	0,216	0,146	0,364	0,528	0,424	0,372	0,497	0,798

The next step involves assessing multicollinearity using the Variance Inflation Factor (VIF), which is reflected in Table 7. The VIF values range from 1,000 to 2,382. Since none of these values exceed the commonly accepted threshold of 3, it can be concluded that there is no significant multicollinearity among the constructs in the data set. This suggests that the predictor variables do not have a high degree of correlation with each other, which guarantees the stability and dependability of the regression coefficients. A VIF score below 3 indicates that each construct contributes distinct and autonomous information, hence strengthening the model's validity and confirming the reliability of the findings.

Table 6: Collinearity or Variance Inflation Factor (VIF)

	CPS	**PI**	**ITAX**	**ERS**	**EPM**	**OPS**	**ILSE**	**PGC**	**REA**
CP	1,589	1,574	1,209	1,781	2,382	1,820	1,557	1,906	1,976
CPS					1,000				
PI				1,000					
REA				1,000					

Table 8 presents the results of the structural equation modeling, evaluating the significance of various hypothesized paths between variables. A hypothesis is considered supported if the p-value is less than 0.05. Out of the twelve hypotheses, four are supported: H6 (OPS → CP), H9 (REA → CP), H10 (EPM → CPS), and H11 (ERS → PI),

with p-values of 0.030, 0.023, 0.004, and 0.000, respectively. The remaining hypotheses are not supported, as indicated by their p-values exceeding the 0.05 threshold, which suggests that the relationships in those paths are not statistically significant.

Table 7: Path Analysis

Hypothesis	Path	Path Coefficient	t-values	p-values	Hypothesis Supported?
H1	**CPS → CP**	-0,180	1,595	0,111	N
H2	**PI → CP**	0,036	0,347	0,728	N
H3	**ITAX → CP**	0,093	1,057	0,291	N
H4	**ERS → CP**	-0,090	0,937	0,349	N
H5	**EPM → CP**	0,075	0,588	0,556	N
H6	**OPS → CP**	0,279	2,177	0,030	Y
H7	**ILSE → CP**	0,176	1,654	0,098	N
H8	**PGC → CP**	0,090	0,836	0,403	N
H9	**REA → CP**	0,255	2,273	0,023	Y
H10	**EPM → CPS**	0,357	2,911	0,004	Y
H11	**ERS → PI**	0,351	3,614	0,000	Y
H12	**ERS → REA**	0,206	1,718	0,086	N

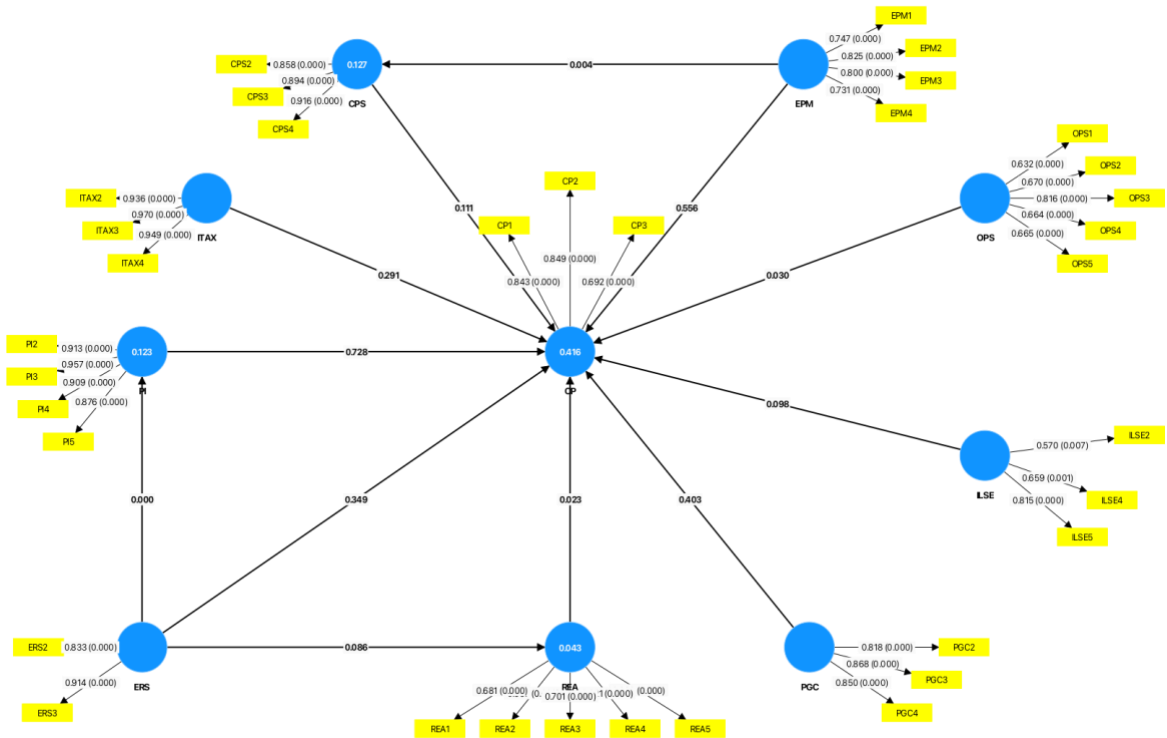

Figure 3: The Model Result

5. Discussion

The study's results provide key insights into consumer behavior and preferences related to e-commerce overpackaging, offering a foundation for both immediate and long-term business strategies. The majority of respondents have significant experience in online shopping, with 70% having more than five years of experience, and 58% conducting over three transactions per month. This experience strengthens the credibility of their insights, while the 66% awareness rate of overpackaging highlights growing consumer concern for sustainability. Research highlights that environmental awareness and sustainability are increasingly important factors influencing consumer behavior, with many preferring companies that address overpackaging and promote sustainable practices (Soedibyo & Kusumawati, 2023), and other studies emphasize that consumers are sensitive to packaging practices that align with eco-friendliness and recyclability (Magnier & Schoormans, 2015). This also aligns with findings that excessive packaging leads to negative brand perceptions and lower purchase intentions, further motivating businesses to adopt more sustainable practices (Elgaaied-Gambier, 2016). The PLS-SEM analysis revealed that optimizing packaging strategies, raising environmental awareness, enhancing packaging materials, and establishing recycling systems with incentives are areas where businesses can effectively align with consumer preferences. Conversely, factors like incentives and taxes alone were insufficient to drive substantial change, indicating that a more comprehensive, integrated approach is needed to address consumer demands and environmental concerns effectively.

In light of these findings, the study suggests both short- and long-term strategies that businesses can adopt to meet consumer preferences and environmental goals. In the short term, businesses must prioritize strategies that respond to immediate consumer concerns, focusing on optimizing packaging strategies and promoting environmental awareness. These measures not only reduce waste but also foster sustainability by minimizing unnecessary packaging materials while maintaining product integrity. By addressing the increasing demand for eco-friendly practices, companies can quickly build consumer trust and satisfaction. Prior studies confirm that consumers show strong preference for optimized packaging strategies and sustainable packaging innovations, which significantly boost consumer trust and loyalty (Rita & Ramos, 2022), and consumer behavior studies also reveal that effective eco-design and recycling systems can strongly influence consumer purchase intentions (Martinho et al., 2015). This also aligns with research showing that transparent communication through eco-labeling significantly enhances consumer confidence in a brand's commitment to sustainability (Wozniak et al., 2022). Additionally, educational campaigns and sustainability initiatives will help position the company as environmentally responsible, positively shaping consumer perceptions in the near future.

For long-term sustainability, more complex strategies are necessary, requiring collaboration with government bodies and industry stakeholders. Improving packaging materials and establishing efficient recycling systems depend on external factors such as regulatory frameworks and government incentives. Collaboration with governments and regulatory bodies has been shown to be crucial for long-term sustainability, especially in areas like recycling systems and green packaging innovations (Hollaus & Schantl, 2022; Lu et al., 2020; Wozniak et al., 2022). This aligns with the understanding that businesses that collaborate with regulators can better navigate evolving environmental standards and lead industry-wide sustainability initiatives (Soedibyo & Kusumawati, 2023). These efforts will help create a sustainable business model that not only complies with environmental regulations but also influences industry standards. By working closely with governments to set clear packaging standards and investing in recycling infrastructure, companies can establish themselves as leaders in sustainability. Integrating both short- and long-term strategies will ensure businesses meet current market demands while laying the groundwork for long-term success in sustainable practices.

6. Conclusion

This study offers valuable insights into consumer preferences regarding solutions for e-commerce overpackaging in Indonesia. Findings reveal that 'Optimize Packaging' and 'Raise Awareness' strategies are the most favored solutions among Indonesian e-commerce users. Although 'Enhance Packaging Materials' and 'Consolidate Packaging Standards' are not directly preferred as standalone solutions, the results show that packaging standards positively mediate the relationship between enhanced materials and consumer preferences. Similarly, while

'Establish Recycling Systems' and 'Provide Incentives' are not directly preferred, incentives effectively mediate the impact of recycling systems on consumer preferences. These findings suggest that government support through incentives could significantly enhance the adoption of sustainable practices in e-commerce.

Looking forward, future research should broaden the scope to include perspectives from e-commerce platform owners and management, focusing on the decision-making processes that influence packaging choices and the integration of sustainable practices within business models. Additionally, exploring methods to enhance the economic value of e-commerce waste, particularly excess plastic, could offer valuable insights for creating a more sustainable e-commerce ecosystem. This may involve examining advanced recycling technologies, fostering partnerships with recycling companies, and implementing market-based incentives for the use of recovered materials. These proposed research directions, together with the current findings, can support the development of solutions that are both environmentally and economically sustainable within the e-commerce sector.

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