

Analyzing the Impact of Paper Packaging and Online Food Delivery Service Apps on Sustainable Consumer Behavior — A Case Study in Indonesia

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Abstract—Indonesia generates approximately 11% of global plastic waste, with significant contributions from plastic food packaging, a material incompatible with circular economy principles. On the other hand, high vehicle usage in Indonesia further exacerbates environmental challenges, increasing greenhouse gas emissions and pollution. This study investigates the impact of paper packaging and online food delivery services on sustainable consumer behavior in Indonesia. Using a quantitative research approach, data from 710 respondents were analyzed with Artificial Neural Networks (ANN), achieving 97.75% model accuracy. Findings highlight that trust in paper packaging and online food delivery apps significantly influences sustainable consumer behavior. By prioritizing paper over plastic and online delivery over traditional takeaway, this study supports the transition to a circular economy by promoting resource optimization and waste reduction. Paper packaging, with its reduced ecological footprint, aligns with circular economy principles by enabling recyclability and biodegradability. Similarly, online delivery services reduce traffic congestion and vehicle emissions, contributing to sustainable urban living. These insights emphasize the importance of fostering eco-friendly consumer choices and robust governmental support to mitigate plastic waste, optimize resources, and promote sustainable practices in Indonesia.

Keywords—Circular Economy, Food Delivery Apps, Paper Packaging, Plastic Packaging, Sustainable Consumer.

I. INTRODUCTION

Plastic waste has become a major global environmental challenge [1]. Indonesia generates approximately 11% of total plastic waste worldwide [2]. Plastic food packaging is a significant contributor to global plastic waste, this material is poisonous and has no role in a circular economy [3].



Fig. 1. Food Packaging, (a) Paper Packaging; (b) Plastic Packaging

Plastic packaging is a predominant choice for wrapping food items due to its convenience, cost-effectiveness, and durability [4]. However, plastics are known to contribute significantly to pollution and waste due to their low

biodegradability [5]. On the other hand, the advantages of paper packaging, including reduced ecological footprint and lower resource consumption, make it an appealing option for food packaging [6], as shown in Fig. 1.

The growing reliance on plastic packaging in Indonesia is exacerbated by the country's rapidly increasing motor vehicle ownership, with motorbikes and cars now numbering in the hundred million. There are 121,209,304 units of motorcycle in Indonesia [7-8] and there are 18,714,651 units of car [7,9]. This surge contributes to higher air pollution levels and increased greenhouse gas emissions [10]. The traditional method of takeaway, which often requires consumers to drive to the location, exacerbates traffic congestion and contributes further to environmental degradation through emissions [11]. As an alternative, online food delivery service apps have gained traction, offering a more environmentally friendly solution by optimizing logistics and reducing the need for individual vehicle trips because one driver can deliver a lot of food at once to several customers in one trip [12-13].

In Indonesia, digital platforms like GoFood, GrabFood, and Shopee Food have become prominent players in the market [14]. During the Covid-19 pandemic, online food delivery services were considered to have lower emissions because they were able to reduce the number of vehicles on the roads and were considered safer than takeaway [15]. Table I illustrates the differences between takeaway and delivery services [16].

TABLE I. DIFFERENCE BETWEEN TAKEAWAY AND DELIVERY SERVICE

Feature	Takeaway	Online Delivery Service Apps
Order	Drive or ride own vehicle	Use apps
Payment	In-person (cash/card)	Online payment options
Food Collection	Customer picks up from restaurant	Food delivered to customer's location by driver or rider
Availability	Limited to restaurant operating hours	Extended hours (depends on app and driver availability)
Fees	Generally no extra charges	May include delivery fees, service fees, or surge pricing
Tracking	No tracking	Real-time tracking in app

In light of these considerations, the role of sustainable consumer behavior (SCB) becomes essential in fostering a shift toward environmentally friendly practices [17-18]. Previous studies have suggested that the use of paper packaging may be an influential factor in consumers' food purchasing decisions [19]. Similarly, the availability and convenience of food delivery services have been shown to

impact consumer behavior [20]. Choosing paper over plastic for packaging and opting for online delivery over traditional takeaway are significant actions that consumers can take to reduce their environmental footprint. This study seeks to explore these trends within the Indonesian context, evaluating the factors influencing sustainable consumer behavior in food packaging and delivery options to aim advancing circular economy.

This study employs an Artificial Neural Network (ANN) as its machine learning algorithm, providing a robust and advanced framework for data analysis [37-38]. The choice of ANN over vision-based methods is justified by the latter's primary focus on optimizing object detection, which does not directly contribute to behavioral analysis [39]. Furthermore, the interpretability challenges and high computational demands associated with AutoML render it less suitable for the scope of this research [40]. While vision-based methods [39-40] offer effective tools for object detection and analyzing human behavior, they may not be optimal across all contextual applications.

II. METHODOLOGY

This study employs a quantitative research methodology to empirically test the formulated hypotheses. Data collection was conducted online using Google Forms, targeting respondents from Indonesia and spanning the period from October 2023 to September 2024. Over the 11 months of data gathering, the collected data were systematically organized for subsequent analysis.

A. Research Design and Structure

To explore the complex statistical relationships between observed and latent variables, the researchers utilized Machine Learning Algorithms (MLA), with a specific focus on Artificial Neural Networks (ANN). Regression analysis within the ANN framework was employed to identify intricate patterns and associations within the dataset. The simultaneous application of ANNs is expected to yield a comprehensive and detailed understanding of the research hypotheses, enhancing the findings and providing deeper insights into the study's objectives. Fig. 2 illustrates the research design flowchart.

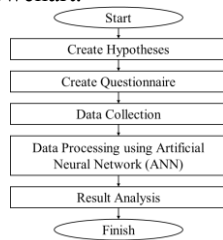


Fig. 2. Research Design Flowchart

B. Sampling and Respondent Profile

This study was conducted in Indonesia, a Southeast Asian nation, to examine the factors influencing individuals' intentions to select paper packaging over plastic for food products and to prefer online food delivery apps over traditional food delivery. To ensure a diversity of perspectives, purposive sampling was used, targeting individuals aged 18 and older from both urban and rural areas and with varied occupational backgrounds [36]. Total respondents for this study is 710 participants.

According to Table II, 53.24% of respondents were male and 46.76% were female. The majority were aged 25-34 (46.48%), followed by 18-24 (38.17%), with smaller

proportions aged 35-44 (13.80%) and above 44 (1.55%). In terms of employment, 51.83% were employed, 8.31% self-employed, 4.37% unemployed, and 35.49% students. Additionally, over 97% of respondents were familiar with paper packaging and online food delivery apps, reflecting high awareness within the sample.

TABLE II. DEMOGRAPHIC CHARACTERISTICS OF SAMPLE (N=710)

Items	Classification	Quantity	Percentage
Gender	Female	332	46.76
	Male	378	53.24
Age	18 – 24	271	38.17
	25 – 34	330	46.48
	35 – 44	98	13.80
	Above 44	11	1.55
Job	Student	252	35.49
	Entrepreneur	59	8.31
	Employed	368	51.83
	Unemployed	31	4.37
Are you familiar with paper packaging?	Yes	707	99.58
	No	3	0.42
Are you familiar with food delivery apps?	Yes	693	97.61
	No	17	2.39

C. Variables and Questionnaire Design

This study utilized an online survey to gather data from potential respondents, employing closed-ended questions [21]. This methodological choice offers several key advantages. First, online surveys provide convenience for participants, as they allow individuals to respond at their own pace and from any location with internet access, enhancing accessibility and potentially increasing response rates. Second, online surveys have the potential to reduce bias. By using standardized question formats, this approach minimizes the influence of interviewer bias and reduces the risk of social desirability bias. Lastly, online surveys improve privacy protection; they can be designed to ensure participant anonymity.

To administer the survey, Google Forms was selected as the platform due to its user-friendly interface and broad accessibility. The questionnaire primarily featured a five-point Likert scale, ranging from “strongly disagree” to “strongly agree,” to capture participants' responses to statements aligned with the study's objectives. Table III presents a comprehensive list of the latent variables and their corresponding indicators analyzed in this study.

TABLE III. QUESTIONNAIRE ITEMS AND SOURCE

Constructs	Codes	Questionnaire Items	Ref
Environmental Insight (EI)	EI1	I am aware of the environmental impacts associated with the use of plastic packaging	[22]
	EI2	I understand the detrimental effects of plastic packaging disposal on local ecosystems and wildlife.	[22]
	EI3	I am knowledgeable about the advantages of using environmentally friendly alternatives, such as paper packaging.	[22]
	EI4	I know that the purchase method of ordering food can reduce traffic jams and the mass of motorized vehicles on the streets, which positively impacts the environment.	[23]
	EI5	I am sure that by using the online food delivery service application, I can reduce pollution from vehicle emissions.	[23]
Environmental Risk Perception (ERP)	ERP1	I believe that plastic packaging presents a substantial threat to environmental health.	[24]
	ERP2	I view plastic packaging as a serious hazard to both wildlife and marine ecosystems in our region.	[24]
	ERP3	I feel that pollution from plastic packaging significantly impacts the quality of water resources and soil.	[24]

	ERP4	I am concerned that excessive use of motor vehicles contributes heavily to pollution.	[25]
	ERP5	I think that reducing motor vehicle use by utilizing online food ordering applications offers an easy and practical solution to help mitigate pollution.	[25]
Governmental Support & Regulations (GSR)	GSR1	I think regulations should be enacted to restrict the use of plastic packaging and encourage the adoption of paper alternatives.	[26]
	GSR2	I think the government should reduce taxes on paper packaging and increase taxes on plastic packaging.	[26]
	GSR3	I feel the government should actively engage in promoting and facilitating the transition to paper-based packaging solutions.	[27]
	GSR4	I believe that the government should implement policies to ease regulations for the existence of online food delivery service apps.	[28]
	GSR5	I support the government's efforts to support the ecosystem by implementing food delivery services.	[28]
Intention (IN)	IN1	I plan to actively seek out restaurants that use paper-based food packaging.	[29]
	IN2	I am committed to switching from my usual restaurant, which uses plastic packaging, to one that uses paper packaging once I find right place.	[29]
	IN3	I am motivated to make plastic waste reduction a key part of my sustainable lifestyle.	[29]
	IN4	I choose to order food online with a strong intention to help reduce pollution.	[28]
	IN5	I am committed to minimizing personal vehicle use for non-urgent activities, such as buying food.	[30]
Self-Awareness of Behavior (SAB)	SAB1	I consciously feel more comfortable eating food wrapped in paper packaging.	[31]
	SAB2	I frequently and independently choose to order from restaurants that use paper packaging.	[31]
	SAB3	I recognize that restaurants using paper packaging are more environmentally friendly than those using plastic.	[31]
	SAB4	I am aware that ordering food online through an app can reduce the need to use a personal vehicle.	[32]
	SAB5	I realize that frequently using a private motor vehicle to purchase food contributes to environmental pollution.	[32]
Sociological Perspective (SP)	SP1	I believe that people important to me regard the use of paper packaging as essential.	[29]
	SP2	I think that The perspectives of others in my community have positively influenced my choice to select restaurants that use paper packaging.	[29]
	SP3	I feel a social responsibility to follow the trend of using cotton bags among my peers.	[29]
	SP4	I notice that many people around me use food delivery services to avoid traffic congestion and reduce fuel consumption.	[30]
	SP5	I think those close to me prefer ordering food online rather than opting for takeaway or dine-in, as it is more efficient in terms of resources, energy, and time.	[30]
Trust (TR)	TR1	I believe that using paper packaging aligns with sustainability and environmental conservation values.	[29]
	TR2	I am obsessed with paper food packaging because I am motivated by its environment positive impact.	[31]
	TR3	I consider the use of paper packaging as a proactive measure for environmental protection.	[31]
	TR4	I regard using food delivery services as a responsible approach to conserving natural resources.	[32]
	TR5	I believe that transitioning from takeaway to food delivery can contribute to reducing environmental pollution.	[32]
Sustainable Consumer Behaviour (SCB)	SCB1	I consciously strive to reduce my dependence on plastic packaging by opting for paper packaging as a sustainable action.	[33]
	SCB2	I consistently choose restaurants that use paper packaging and bags over plastic packaging and bags.	[34]
	SCB3	I actively encourage others to adopt paper packaging as an environmentally sustainable food choice.	[34]
	SCB4	I consistently choose to order food through food delivery apps rather than takeaway.	[32]

	SCB5	I always appreciate people who order food through a delivery app instead of using their own vehicle for takeaway.	[32]
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III. RESULTS

The results of this study present data processing output consisting of sub-sections of data pre-processing, final model results and plot, result validation, and analysis of key findings.

A. Data Pre-Processing

Prior to conducting statistical analysis and applying machine learning techniques, the researchers meticulously preprocessed the collected data. IBM SPSS Statistics was employed to verify that no missing values existed within the dataset, which contained 28,400 data entries. To ensure data integrity, a correlation analysis was conducted, removing variables with high correlations, where Pearson's R exceeded 0.20 and p-values were below the 0.05 threshold. This data cleaning process minimized the impact of redundant information on subsequent analyses. The final Pearson correlation coefficients for all variables are presented in Table IV.

TABLE IV. PEARSON'S R CORRELATION

	EI	ERP	GSR	IN	SAB	SP	TR	SCB
EI	1							
ERP	0.811	1						
GSR	0.479	0.499	1					
IN	0.635	0.642	0.660	1				
SAB	0.655	0.682	0.776	0.822	1			
SP	0.643	0.675	0.523	0.766	0.843	1		
TR	0.745	0.792	0.539	0.719	0.775	0.796	1	
SCB	0.443	0.406	0.543	0.636	0.646	0.585	0.515	1

Artificial Neural Networks (ANNs) rely on specific data points for processing. In this study, the input layer serves as the starting point, feeding the ANN with seven key factors derived from the data: Environmental Insight (EI), Environmental Risk Perception (ERP), Governmental Support & Regulations (GSR), Intention (IN), Self-Awareness of Behavior (SAB), Sociological Perspective (SP), and Trust (TR). These factors were aggregated to form a consolidated representation. The ANN then processed this information to predict the factors influencing the output variable, namely Sustainable Consumer Behavior (SCB). This model to examine the relationship between the use of paper packaging and online food delivery apps and the broader tendency toward Sustainable Consumer Behavior. Additionally, as part of the ANN implementation, the data was cleaned and aggregated by calculating the mean of each construct per variable.

To prepare the data for analysis, the indicators for each variable were first averaged, resulting in a more compact representation. Data aggregation involves categorizing the sums of the means of the variables into discrete intervals, each corresponding to a specific numerical range. If the sum of a variable fell within the range of 1 to 5, it was assigned an aggregate value of 1; similarly, sums within the ranges of 6 to 10, 11 to 15, 16 to 20, and 21 to 25 were assigned aggregate values of 2, 3, 4, and 5, respectively. This grouping process transformed continuous data into discrete categories, enhancing interpretability without losing critical information. These sums were then categorized into distinct labels for easier interpretation. The

labeling scheme (1–5) simplifies the data, facilitating the identification of patterns and trends in the variables. These data preprocessing steps are important for ensuring the analysis of reliability and validity, as shown in Table V.

TABLE V. DATA AGGREGATION

Indicator					Sum	Label	Average
EI1	EI2	EI3	EI4	EI5			
2	5	4	5	3	19	4	3.8
ERP1	ERP2	ERP3	ERP4	ERP5			
2	1	1	4	5	13	3	2.6
GSR1	GSR2	GSR3	GSR4	GSR5			
1	2	3	2	1	9	2	1.8
TR1	TR2	TR3	TR4	TR5			
1	1	1	1	1	5	1	1
SP1	SP2	SP3	SP4	SP5			
5	5	3	3	5	21	5	4.2
SCB1	SCB2	SCB3	SCB4	SCB5			
5	4	1	4	3	17	4	3.4

B. Final Model Results and Plots

To determine the optimal architecture for the Artificial Neural Network (ANN), the training process was carried out for an adequate number of epochs to ensure the stability of the loss function across both the training and testing sets. This strategy helped mitigate overfitting and enabled the selection of a model that generalizes effectively to unseen data. Fig. 3 illustrates the selected ANN model, which incorporates multiple input factors, a hidden layer consisting of 70 nodes, and an output node representing Sustainable Consumer Behavior (SCB).

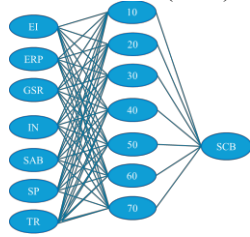


Fig. 3. Optimum ANN Model

C. Result Validation

With optimized parameters, the model achieves a high accuracy of 97.75% in capturing the relationship between Trust (TR) to Sustainable Consumer Behavior (SCB). Notably, the final model's training loss plot demonstrates an absence of overfitting or modeling issues. The training loss consistently decreases across epochs, with the validation loss following a parallel trend and showing minimal deviation—indicating a well-fitted model. This observation is further supported by Fig. 4, which visually corroborates the model's performance and alignment with the described statement.

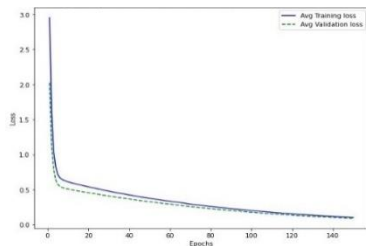


Fig. 4. Average Training and Validation Loss of ANN for Trust (TR)

Fig. 4 offers a detailed overview of the optimization runs performed for the Artificial Neural Network (ANN), highlighting the optimal parameters identified for each

feature. Informed by a range of studies, these parameters were systematically evaluated and ranked based on their average testing performance, providing insight into the relative importance of each feature with respect to the dependent variable. The ANN model demonstrating the lowest standard deviation alongside the highest accuracy was selected as the most representative of each feature's impact on the dependent variable [35]. With an accuracy of 97.75%, the factor TR emerged as the most influential among the components. Additionally, factors such as SAB, IN, GSR, EI, ERP, and SP were found to hold significant importance, each achieving accuracy rates above 95%, as detailed in Table VI.

TABLE VI. ANN SUMMARY OF RESULTS

Feature	Average Train	Train–StDev	Average Test	Test–StDev
TR	0.0989	0.0228	97.75%	0.0089
SAB	0.1081	0.0186	97.50%	0.0072
IN	0.1254	0.0220	96.98%	0.0129
GSR	0.1299	0.0180	96.67%	0.0068
EI	0.1334	0.0211	96.40%	0.0112
ERP	0.1456	0.0165	95.89%	0.0047
SP	0.1652	0.0345	95.30%	0.0073

The ANN model robustly validates the hypothesized relationships between various factors and Sustainable Consumer Behavior (SCB). Table VII presents the testing accuracy for each hypothesis, demonstrating consistently high accuracy levels with low standard deviations. These findings indicate statistically significant results, thereby substantiating each hypothesized relationship through the ANN methodology.

TABLE VII. VALIDATION OF HYPOTHESIS FOR ANN

No	Relationship	Average Test	Test–StDev	Result	Hypothesis
1	TR → SCB	97.75%	0.0089	Positive	Accepted
2	SAB → SCB	97.50%	0.0072	Positive	Accepted
3	IN → SCB	96.98%	0.0129	Positive	Accepted
4	GSR → SCB	96.67%	0.0068	Positive	Accepted
5	EI → SCB	96.40%	0.0112	Positive	Accepted
6	ERP → SCB	95.89%	0.0047	Positive	Accepted
7	SP → SCB	95.30%	0.0073	Positive	Accepted

D. Analysis of Key Findings

There is the strongest and highest significant relationship between Trust (TR) and Sustainable Consumer Behavior (SCB) among other factors, with a 97.75% significance level in ANN model. This underscores the critical role of individual trust toward paper packaging and online food delivery apps in predicting actual engagement in sustainable practices. The findings indicate that individuals with greater trust in paper packaging and food delivery services are more inclined to convert these positive beliefs into tangible, sustainable consumer behaviors.

IV. CONCLUSION

This study highlights the significant impact of sustainable consumer behavior (SCB) on advancing circular economy principles within Indonesia. Through quantitative analysis involving 710 participants, findings show a strong preference for paper packaging and online food delivery services over plastic-based and traditional takeaway options, with 97.86% accuracy in predicting sustainable consumer behavior using Trust as a critical influencing factor. Respondents, predominantly young and environmentally conscious, demonstrated a willingness to

adopt alternatives that mitigate environmental impact. The transition to paper packaging and the use of online delivery platforms indicates positive strides toward reducing plastic waste, pollution, and vehicle emissions, aligning with circular economy goals by encouraging resource optimization and waste minimization. These findings underscore the importance of fostering sustainable consumer choices and governmental support to enhance eco-friendly practices.

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