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The Effects of Packaging, Digital Information, and Crowd Logistics on Last-Mile Delivery through Distribution Performance among Food and Beverage SMEs in Bandung

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Abstract: This study examines the effects of packaging, digital information, and crowd logistics on distribution performance and their implications for last-mile delivery among food and beverage SMEs utilizing online transportation services in Bandung, Indonesia. The rapid growth of digital-based delivery services has increased operational complexity in urban logistics, particularly regarding delivery accuracy, timeliness, and distribution effectiveness. A quantitative explanatory approach was employed using survey data collected from 131 SMEs selected through probability sampling. Data were analyzed using Structural Equation Modeling–Partial Least Squares (SEM-PLS) with SmartPLS. The findings reveal that packaging, digital information, and crowd logistics positively and significantly affect both distribution and last-mile delivery. In addition, distribution has a positive and significant effect on last-mile delivery performance. Mediation analysis further confirms that distribution partially mediates the relationships between packaging, digital information, crowd logistics, and last-mile delivery. These findings indicate that effective distribution systems strengthen the influence of operational, physical, and digital factors on final delivery performance. This study contributes to the logistics and supply chain literature by proposing an integrative framework that simultaneously combines packaging, digital information, and crowd-based logistics dimensions within a unified last-mile delivery model for online transportation-based SMEs.

Keyword: Packaging, Digital Information, Crowd Logistics, Distribution, Last-Mile Delivery, SMEs

INTRODUCTION

The rapid growth of e-commerce and online transportation services has significantly transformed logistics and distribution systems, particularly in the food and beverage sector. The increasing demand for fast, accurate, and reliable delivery services has intensified the importance of last-mile delivery, which represents the final stage of the logistics process connecting products with end consumers. Despite technological advancements, last-mile delivery remains one of the most challenging and costly activities in logistics operations due to issues related to delivery timeliness, product condition, information accuracy, and operational efficiency.

In Indonesia, food and beverage micro, small, and medium enterprises (SMEs) increasingly rely on online transportation platforms such as GoSend, GrabExpress, and Shopee Express to support their distribution activities. These platforms provide opportunities for SMEs to expand market reach and improve service responsiveness. However, the success of last-mile delivery depends not only on transportation availability but also on supporting factors such as packaging quality, digital information accuracy, crowd logistics utilization, and distribution effectiveness.

Packaging plays a critical role in protecting products from physical damage during transportation while maintaining product quality and customer satisfaction. In food and beverage distribution, inadequate packaging may result in product deterioration, delivery complaints, and customer dissatisfaction. At the same time, digital information has become an essential resource for enhancing visibility, communication, and coordination throughout the logistics process. Accurate and timely information enables businesses to monitor shipments, improve decision-making, and reduce distribution uncertainties.

Furthermore, the emergence of crowd logistics has introduced a more flexible and scalable logistics model by utilizing independent couriers and platform-based delivery networks. Crowd logistics allows SMEs to respond more efficiently to fluctuating customer demand while reducing operational constraints associated with conventional delivery systems. Previous studies have reported that crowd logistics contributes to delivery flexibility, operational efficiency, and improved logistics performance. Nevertheless, the effectiveness of crowd logistics is often influenced by the quality of distribution processes that coordinate the movement of products from suppliers to customers.

Although previous studies have investigated the individual effects of packaging, digital information, and crowd logistics on logistics performance, limited research has examined their simultaneous influence on distribution and last-mile delivery within the context of food and beverage SMEs utilizing online transportation services. Moreover, the mediating role of distribution in explaining the relationship between these operational and technological factors and last-mile delivery performance remains underexplored, particularly in developing economies.

To address this gap, this study examines the effects of Packaging, Digital Information, and Crowd Logistics on Distribution and their implications for Last-Mile Delivery among food and beverage SMEs in Bandung City. In addition, Distribution is incorporated as a mediating variable to explain the indirect effects of Packaging, Digital Information, and Crowd Logistics on Last-Mile Delivery performance. The findings are expected to contribute to the logistics and supply chain management literature while providing managerial insights for SMEs seeking to improve delivery effectiveness and customer service performance in the digital logistics environment.

Previous studies have extensively examined the role of packaging, digital technologies, and crowd logistics in improving logistics performance. Studies by Bortolini et al. (2022), Fatehi and Wagner (2022), and Liang et al. (2024) demonstrated that crowd logistics enhances delivery flexibility and operational efficiency. Similarly, research on digital information emphasized the importance of information visibility and data integration in supporting logistics and supply chain performance (Atieh et al., 2025; Iftikhar et al., 2024). Other studies highlighted the contribution of packaging to product protection, delivery quality, and customer satisfaction (Ganguly, 2025; Hellström, 2025).

However, several research gaps remain. First, previous studies generally examined packaging, digital information, and crowd logistics separately, whereas limited studies have integrated these variables within a single framework. Second, empirical evidence regarding the mediating role of distribution in linking operational and technological capabilities to last-mile delivery performance remains limited. Third, most prior studies focused on large logistics organizations, e-commerce platforms, or developed countries, while research involving food and beverage SMEs in emerging economies remains scarce.

Therefore, this study contributes to the logistics and transportation literature in three ways. First, it develops an integrated model linking Packaging, Digital Information, and Crowd Logistics to Distribution and Last-Mile Delivery. Second, it investigates the mediating role of Distribution in explaining how operational and technological resources influence delivery performance. Third, it provides empirical evidence from food and beverage SMEs utilizing online transportation services in Bandung City, Indonesia, thereby extending the application of logistics and supply chain theories in the SME context.

Based on the theoretical foundations and research gaps identified above, this study proposes a conceptual model that explains the relationships among Packaging, Digital Information, Crowd Logistics, Distribution, and Last-Mile Delivery. Packaging, Digital Information, and Crowd Logistics are positioned as exogenous variables influencing Distribution and Last-Mile Delivery. Distribution is incorporated as a mediating variable that transmits the effects of these factors to Last-Mile Delivery performance.

The proposed model assumes that effective packaging improves product protection and handling during transportation, digital information enhances coordination and visibility throughout logistics activities, and crowd logistics increases flexibility and responsiveness in delivery operations. These factors are expected to improve distribution effectiveness, which subsequently contributes to better last-mile delivery performance.

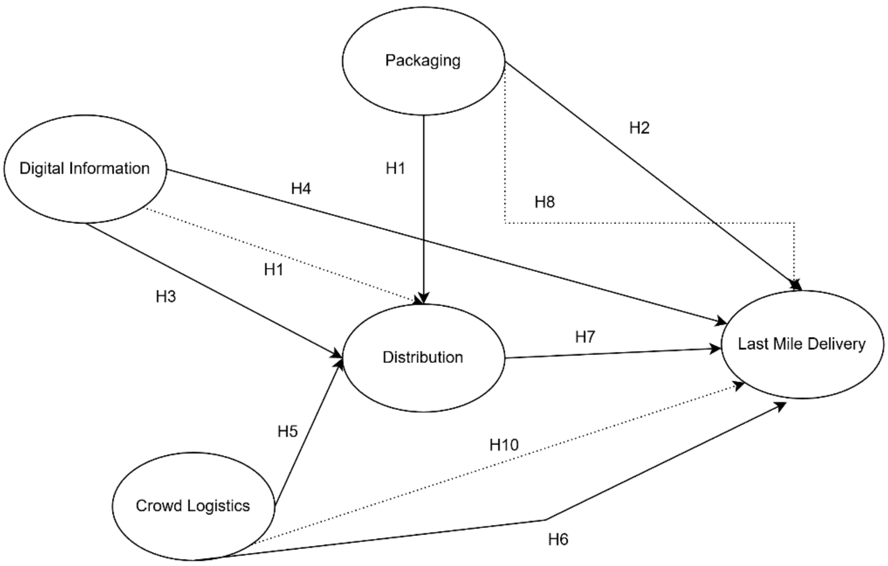


Figure 1. Conceptual Model

Based on the proposed conceptual model, the following hypotheses are formulated:
H1: Packaging positively affects Distribution.
H2: Packaging positively affects Last-Mile Delivery.
H3: Digital Information positively affects Distribution.
H4: Digital Information positively affects Last-Mile Delivery.
H5: Crowd Logistics positively affects Distribution.

H6: Crowd Logistics positively affects Last-Mile Delivery.
H7: Distribution positively affects Last-Mile Delivery.
H8: Distribution mediates the relationship between Packaging and Last-Mile Delivery.
H9: Distribution mediates the relationship between Digital Information and Last-Mile Delivery.
H10: Distribution mediates the relationship between Crowd Logistics and Last-Mile Delivery.

METHOD

In order to examine the causal links between the variables in the research model, this study uses a quantitative technique using an explanatory design. Because it can empirically explain both direct and indirect effects between independent variables, mediating variables, and dependent variables, this method was selected.

The population in this study consists of all micro, small, and medium-sized enterprises (SMEs) in the food and beverage sector in Bandung City that use online transportation services in their product distribution process. The population data were obtained from the Bandung City Cooperative and SME Office (Dinas Koperasi dan UMKM Kota Bandung), supplemented by the directory of registered food and beverage businesses available through the Bandung City One-Stop Integrated Service (DPMPTSP), and confirmed through field verification. Businesses were included in the population list if they (1) were legally registered as food and beverage SMEs, (2) were domiciled in Bandung City, and (3) actively used online transportation platforms such as GoSend, GrabExpress, or Shopee Express as part of their distribution activities. Based on these criteria, the total population identified was 190 businesses. The sampling technique used in this study was purposive sampling, in which each business unit in the population list had an equal probability of selection. Questionnaires were distributed directly to business owners or managing proprietors, as they are the primary decision-makers responsible for distribution and logistics activities in SMEs. Respondents who did not own or manage the business operations were excluded to ensure relevance and data quality. The sample size consisted of 131 respondents, which met the minimum sample requirement for SEM-PLS analysis based on the ten-times rule proposed by Hair et al. (2021). According to this guideline, the minimum sample size should be at least ten times the maximum number of structural paths in the research model that are aimed at a latent construct. Last-Mile Delivery is the construct in this study with the most pathways (five incoming paths), resulting in a minimum sample size of 50. This criteria is significantly exceeded by the final sample of 131 responders, guaranteeing analytical adequacy.

Questionnaires were distributed to respondents in order to collect data. The research instrument was designed based on variable indicators adapted from relevant literature and tailored to the research context. Each statement in the questionnaire was measured using a five-point Likert scale, ranging from strongly disagree to strongly agree, to assess respondents' perceptions of each variable.

Last-mile delivery is the dependent variable in this study, whereas packaging, digital information, and crowd logistics are the independent variables. Distribution is the mediating variable. Each variable was measured using a number of indicators that represented the real circumstances in MSMEs' online transportation-based distribution operations.

The measurement indicators used in this study were adapted from previous logistics and supply chain studies related to packaging quality, digital information systems, crowd logistics, distribution effectiveness, and last-mile delivery performance. All indicators were modified to fit the context of food and beverage SMEs utilizing online transportation services.

Table 1. Research Variable Indicators

Variable	Code	Indicator Statement	Source
Packaging	PACK1	Product packaging adequately protects items from physical damage during delivery.	Ganguly (2025)
	PACK2	The packaging material used maintains product freshness and quality during transportation.	Hellstrom (2025)
	PACK3	Packaging design is appropriate for delivery via online transportation platforms.	Hellstrom (2025)
	PACK4	The labeling on packaging provides clear product information for couriers.	Ganguly (2025)
	PACK5	Packaging quality reduces the risk of product returns due to damage.	Ganguly (2025)
	PACK6	The packaging used is cost-effective and suitable for SME operations.	Hellstrom (2025)
Digital Information	DIGI1	Real-time shipment tracking is available and accurate through the delivery platform.	Atieh et al. (2025)
	DIGI2	Digital information systems support effective communication between SMEs and couriers.	Iftikhar et al. (2024)
	DIGI3	Order and delivery status information is updated automatically and promptly.	Atieh et al. (2025)
	DIGI4	Digital tools help reduce errors in delivery address and recipient data.	Iftikhar et al. (2024)
	DIGI5	Integration between order systems and delivery platforms improves coordination.	Atieh et al. (2025)
	DIGI6	Digital information improves decision-making in the distribution process.	Iftikhar et al. (2024)
Crowd Logistics	CL1	Platform-based couriers are readily available during peak demand periods.	Bortolini et al. (2022)
	CL2	Crowd logistics provides flexible delivery options that match SME operating schedules.	Samad et al. (2023)
	CL3	Using crowd couriers reduces delivery costs compared to conventional logistics.	Pourrahmani & Jaller (2021)
	CL4	Crowd logistics enables faster response to fluctuating customer orders.	Kim et al. (2023)
	CL5	The availability of crowd couriers supports delivery to diverse urban locations.	Haron et al. (2023)
	CL6	Crowd logistics platforms are easy to use and integrate into SME distribution activities.	Bortolini et al. (2022)
Distribution	DIST1	Products are distributed to customers accurately according to the correct address.	Wang & Wong (2023)
	DIST2	Delivery is completed within the promised timeframe.	Wang & Wong (2023)
	DIST3	The distribution process minimizes product losses or errors during transit.	Budiyanto et al. (2024)
	DIST4	Distribution activities are carried out consistently and reliably.	Wang & Wong (2023)
	DIST5	The distribution system can accommodate varying order volumes effectively.	Budiyanto et al. (2024)
	DIST6	Distribution performance is monitored and evaluated regularly.	Wang & Wong (2023)
Last-Mile Delivery	LMD1	Products reach customers in good condition without damage.	Ji (2023)
	LMD2	Last-mile delivery is completed within the expected delivery window.	Karli (2025)
	LMD3	Customers receive accurate delivery notifications throughout the process.	Ji (2023)
	LMD4	The last-mile delivery process is responsive to customer requests and complaints.	Karli (2025)
	LMD5	Delivery success rates are consistently high across different locations in Bandung.	Ji (2023)
	LMD6	Overall customer satisfaction with last-mile delivery performance is high.	Karli (2025)

Source: Adapted from various sources (2021-2025)

With the aid of SmartPLS, the Partial Least Squares-based Structural Equation Modeling (SEM-PLS) method was used to analyze the data. This approach was used because it does not require rigorous data distribution and may evaluate intricate correlations between latent variables. Measurement model assessment was used to test construct validity and reliability, whereas structural model evaluation was used to test research hypotheses and examine correlations between variables.

RESULTS AND DISCUSSION

Results

To make sure each indicator could accurately and consistently reflect the hidden concept, this study first assessed the measurement model. Each indicator's outside loadings were tested in order to assess the measurement model. The degree of correlation between the indicators and the latent variables created is measured using outer loading values. Although a number above 0.60 is still acceptable in exploratory research, an indicator is deemed to achieve convergent validity in SEM-PLS analysis if its outer loading value is more than 0.70. Table 1 displays the findings from the outside loading tests used in this investigation.

Table 2. Outer Loadings

	Crowd Logistics	Digital Information	Distribution	Last Mile Delivery	Packaging
CL1	0.704				
CL2	0.857				
CL3	0.830				
CL4	0.840				
CL5	0.851				
CL6	0.820				
DIGI1		0.708			
DIGI2		0.835			
DIGI3		0.857			
DIGI4		0.852			
DIGI5		0.848			
DIGI6		0.850			
DIST1			0.849		
DIST2			0.848		
DIST3			0.880		
DIST4			0.865		
DIST5			0.877		
DIST6			0.888		
LMD1				0.832	
LMD2				0.790	
LMD3				0.827	
LMD4				0.777	
LMD5				0.760	
LMD6				0.766	
PACK1					0.762
PACK2					0.842
PACK3					0.848
PACK4					0.828

Source: Research data

Table 2 shows that all indicators have outer loading values between 0.704 and 0.888 that are higher than the suggested cutoff of 0.70. These findings show that all measurement indicators meet the criteria for convergent validity and accurately reflect their corresponding latent variables.

The findings confirm that the constructs of Packaging, Digital Information, Crowd Logistics, Distribution, and Last-Mile Delivery are measured reliably and consistently. Therefore, all indicators were retained for further analysis, and the measurement model was considered suitable for subsequent validity, reliability, and structural model evaluations.

Convergent validity requirements alone, however, are insufficient to guarantee the measurement model's overall quality. To make sure that each construct is different and does not overlap with other constructs, additional discriminant validity testing is necessary. The Fornell-Larcker criterion, which contrasts the square root of the Average Variance Extracted (AVE) with the inter-construct correlations, was used to assess discriminant validity in this investigation. A construct is said to have good discriminant validity if its square root of the AVE is higher than the correlation values between other constructs. The following table displays the findings of the Fornell-Larcker test used in this investigation.

Table 3. Fornell Larcker

Fornell-Larcker	Crowd Logistics	Digital Information	Distribution	Last Mile Delivery	Packaging
Crowd Logistics	0.819				
Digital Information	0.704	0.827			
Distribution	0.740	0.720	0.868		
Last Mile Delivery	0.750	0.754	0.793	0.793	
Packaging	0.756	0.759	0.758	0.783	0.826

Source: Research data

By comparing the square root of AVE for each construct with its correlations with other constructs, the Fornell-Larcker criterion was employed to evaluate discriminant validity. Each construct shares more variation with its own indicators than with other constructs, as seen by Table 3's diagonal values, which are typically greater than the inter-construct correlations.

Although the correlation between Distribution and Last-Mile Delivery is relatively high, the discriminant validity assessment was further confirmed using the Heterotrait-Monotrait Ratio (HTMT). According to Hair et al. (2022), the HTMT approach is considered more sensitive in detecting issues of discriminant validity than conventional methods. Thus, the HTMT criterion is used in this work to further assess discriminant validity. When the HTMT value is less than the suggested cutoff of 0.90, a construct is deemed to have sufficient discriminant validity. Table 3 displays the HTMT analysis's findings.

Table 4. HTMT Result

	Crowd Logistics	Digital Information	Distribution	Last Mile Delivery	Packaging
Crowd Logistics					
Digital Information	0.734				
Distribution	0,763	0.737			
Last Mile Delivery	0.795	0.798	0.825		
Packaging	0.795	0.796	0.793	0.835	

Source: Research data

All HTMT values are below the suggested cutoff of 0.90, as shown in Table 4. These findings show that there are no problems with discriminant validity in the measurement model and that each construct is empirically different from the others.

The HTMT results further confirm the findings obtained from the Fornell-Larcker criterion, demonstrating that Packaging, Digital Information, Crowd Logistics, Distribution, and Last-Mile Delivery measure different conceptual domains. Therefore, the measurement model satisfies the discriminant validity requirements and can be considered suitable for subsequent reliability and structural model evaluations.

The measuring model's reliability and convergent validity must be assessed after discriminant validity has been established. As shown in Table 4, Cronbach's Alpha, Composite Reliability (CR), and Average Variance Extracted (AVE) are used in this evaluation.

Table 5. Construct Reliability and Validity

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Crowd Logistics	0.902	0.913	0.924	0.670
Digital Information	0.908	0.919	0.928	0.683
Distribution	0.935	0.937	0.948	0.754
Last Mile Delivery	0.883	0.891	0.910	0.628
Packaging	0.907	0.917	0.928	0.682

Source: Research data

Based on Table 5, the Cronbach's alpha values for all variables are above 0.70, ranging from 0.883 to 0.935, indicating that each construct has a good level of internal consistency. The distribution variable has the highest value of 0.935, indicating that the indicators within that variable are highly consistent in measuring the construct. Furthermore, the composite reliability values also show excellent results, with all values above 0.70, even approaching 0.90. The highest composite reliability value is found in the distribution variable at 0.948, followed by the digital information and packaging variables at 0.928 each. This indicates that the constructs in this study have very high reliability in explaining the latent variables. In terms of convergent validity, all variables had AVE values above 0.50, ranging from 0.628 to 0.754. The distribution variable again showed the highest value of 0.754, meaning that most of the variance in the indicators can be explained by that construct. Meanwhile, the "last-mile delivery" variable has an AVE value of 0.628, which remains within the valid and acceptable range.

After confirming the adequacy of the measurement model, the next step is to evaluate the structural model. Structural model evaluation aims to examine the relationships among latent constructs and assess the predictive capability of the proposed model. Following the recommendations of Hair et al. (2022), the evaluation begins with a collinearity assessment using Variance Inflation Factor (VIF) values to ensure that multicollinearity does not exist among predictor constructs. The results of the VIF analysis are presented in Table 3.

To illustrate the relationships among the variables in this study, the structural model (inner model) is shown in Figure 1. This model depicts the causal relationships between the variables of packaging, digital information, and crowd logistics and their effects on distribution, as well as their implications for last-mile delivery as the primary endogenous variable.

Table 6. Collinearity Statistics (VIF)

	Distribution	Last Mile Delivery
Crowd Logistics	**1.788**	**1.987**
Digital Information	**1.816**	**1.912**
Distribution		**1.977**
Last Mile Delivery		
Packaging	**1.959**	**2.115**

Source: Research data

The collinearity assessment results show that all VIF values range from 1.788 to 2.115, which are substantially below the recommended threshold of 5.00. For the Distribution construct, the VIF values of Crowd Logistics, Digital Information, and Packaging were 1.788, 1.816, and 1.959, respectively. Similarly, for the Last-Mile Delivery construct, the VIF values ranged from 1.912 to 2.115.

These findings indicate that no multicollinearity issues exist among the predictor constructs. In other words, Packaging, Digital Information, Crowd Logistics, and Distribution provide unique explanatory contributions to the model without excessive overlap. Therefore, the structural model satisfies the collinearity assumption and can be further evaluated through coefficient of determination (R^2), effect size (f^2), predictive relevance (Q^2), and hypothesis testing analyses.

Having confirmed the absence of multicollinearity among the predictor constructs, the next step is to assess the explanatory power of the structural model using the coefficient of determination (R^2). The R^2 values indicate the extent to which the endogenous constructs can be explained by their respective predictor variables.

Table 7. R .Square

	R-square	R-square adjusted
Distribution	0,663	0,655
Last Mile Delivery	0,740	0,732

Source: Research data

The suggested structural model's explanatory capacity was evaluated using the coefficient of determination (R^2). As indicated in Table 6, the R^2 value for Distribution was 0.663, while the corrected R^2 value was 0.655. These results indicate that Packaging, Digital Information, and Crowd Logistics collectively explain 66.3% of the variance in Distribution. The remaining 33.7% is attributable to other factors not included in the present model.

Furthermore, the R^2 value for Last-Mile Delivery was 0.740, with an adjusted R^2 value of 0.732. This finding suggests that Packaging, Digital Information, Crowd Logistics, and Distribution explain 74.0% of the variance in Last-Mile Delivery, while the remaining 26.0% is explained by external factors beyond the scope of this study.

Hair et al. (2022) state that moderate to substantial explanatory power is indicated by R2 values greater than 0.50. Consequently, the findings show that the suggested model has a significant predictive capacity in explaining the distribution and last-mile delivery performance of food and beverage SMEs in Bandung City that use online transportation services.

It's crucial to evaluate each predictor construct's unique contribution even though the R2 values show the model's overall explanatory strength. In order to ascertain the extent to which each exogenous variable affected the endogenous constructs, the effect size (f^2) analysis was used.

Table 8. Effect Size (f-Square)

	f-square
Crowd Logistics -> Distribution	0.111
Crowd Logistics -> Last Mile Delivery	0.058
Digital Information -> Distribution	0.053
Digital Information -> Last Mile Delivery	0.058
Distribution -> Last Mile Delivery	0.020
Packaging -> Distribution	0.079
Packaging -> Last Mile Delivery	0.043

Source: Research data

Each exogenous construct's contribution to the endogenous variables in the structural model was evaluated using the effect size (f2) analysis. Hair et al. (2022) state that tiny, medium, and large effect sizes are indicated by f^2 values of 0.02, 0.15, and 0.35, respectively.

As shown in Table 7, all relationships exhibit f^2 values above 0.02, indicating that each predictor construct contributes to the explanatory power of the model. However, all f^2 values remain below 0.15, suggesting that the effects can be classified as small. Among the relationships influencing Distribution, Crowd Logistics demonstrates the highest effect size ($f^2 = 0.111$), followed by Packaging ($f^2 = 0.079$) and Digital Information ($f^2 = 0.053$). This finding indicates that Crowd Logistics provides the greatest relative contribution to improving Distribution performance among the predictor variables, although the magnitude of the effect remains within the small category.

For the Last-Mile Delivery construct, Crowd Logistics and Digital Information each show an effect size of 0.058, while Packaging has an effect size of 0.043. In addition, Distribution exhibits an effect size of 0.020 on Last-Mile Delivery. Although these values are relatively small, they indicate that each construct contributes to explaining variations in last-mile delivery performance.

Overall, the f^2 results suggest that the explanatory power of the model is derived from the combined influence of Packaging, Digital Information, Crowd Logistics, and Distribution rather than from a single dominant predictor. This finding highlights the importance of integrating operational, informational, and logistics capabilities to improve distribution effectiveness and last-mile delivery performance among food and beverage SMEs.

In addition to evaluating the explanatory power and effect sizes of the structural model, it is also necessary to assess its predictive capability. Therefore, predictive relevance analysis (Q^2 Predict) was performed to determine the model's ability to predict the endogenous constructs.

Table 9. Hasil Predictive Relevance

	Q^2predict	RMSE	MAE
Distribution	0.432	0.768	0.440
Last Mile Delivery	0.419	0.775	0.417

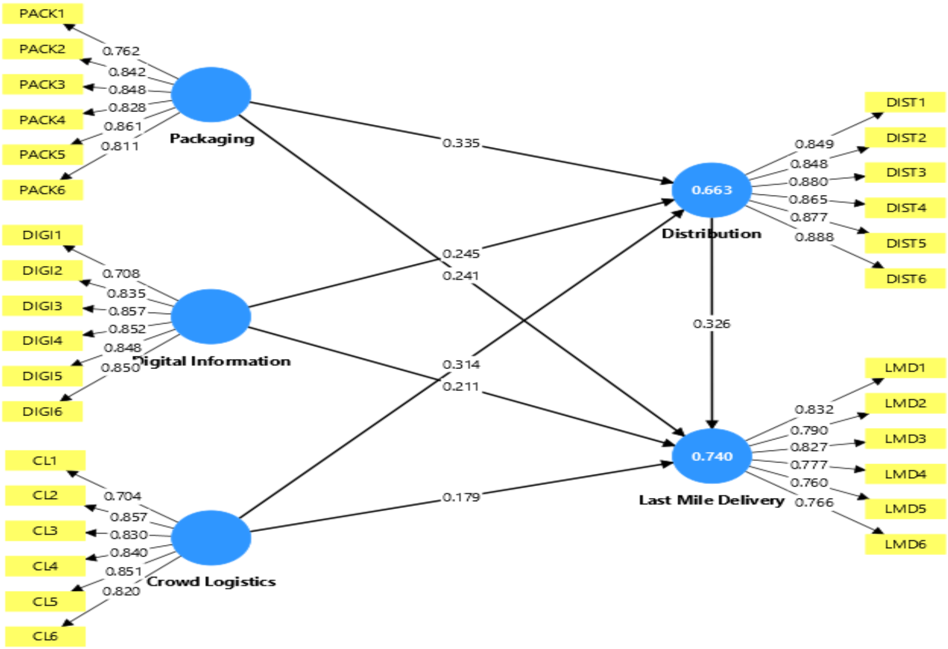
Source: Research data

The model's ability to predict the endogenous constructs was assessed using the predictive relevance (Q^2 Predict) methodology. The Q^2 Predict value for distribution was 0.432, and the Q^2 Predict value for last-mile delivery was 0.419, as shown in Table 8. Since both values are higher than zero, the suggested model has sufficient predictive relevance.

Additionally, both endogenous constructs' RMSE and MAE values were comparatively low, indicating that the model produced reasonable prediction errors. These results show that the structural model performs satisfactorily in predicting distribution and last-mile delivery outcomes in addition to explaining the relationships between the constructs. As a result, the model can be regarded as reliable and appropriate for additional hypothesis testing.

Following the assessment of predictive relevance, the structural model was evaluated to examine the relationships among the latent constructs. The structural model provides a visual representation of the path coefficients and the explanatory power of the endogenous variables. The path coefficients indicate the direction and magnitude of the relationships among the constructs, whereas the coefficient of determination (R^2) reflects the proportion of variance explained by the predictor variables.

As shown in Figure 2, the model illustrates the direct effects of Packaging, Digital Information, and Crowd Logistics on Distribution and Last-Mile Delivery, as well as the effect of Distribution on Last-Mile Delivery. The figure also presents the R^2 values for the endogenous constructs, where Distribution achieved an R^2 value of 0.663 and Last-Mile Delivery achieved an R^2 value of 0.740. These results indicate that the proposed model possesses substantial explanatory power in predicting distribution effectiveness and last-mile delivery performance.



Source: Processed by the Author

Figure 2. Structural Model

The structural model presented in Figure 2 demonstrates that all proposed direct relationships exhibit positive path coefficients. Packaging showed positive effects on Distribution (β = 0.335) and Last-Mile Delivery (β = 0.241). Digital Information positively influenced Distribution (β = 0.245) and Last-Mile Delivery (β = 0.211), while Crowd Logistics positively affected Distribution (β = 0.314) and Last-Mile Delivery (β = 0.179). In addition, Distribution exerted a positive effect on Last-Mile Delivery (β = 0.326).

The bootstrapping approach was used for hypothesis testing in order to ascertain the statistical significance of these associations. Table 9 displays the outcomes of the hypothesis test.

After evaluating the structural model, the next step was to test the proposed hypotheses using the bootstrapping procedure in SmartPLS. Hypothesis testing was conducted by examining the path coefficients, t-statistics, and p-values for each relationship in the model. Following the recommendations of Hair et al. (2022), a hypothesis is considered statistically significant when the t-statistic exceeds 1.96 and the p-value is below 0.05. Table 9 provides an overview of the direct and indirect consequences.

Table 10. Hypothesis Testing

Hypothesis	Path Coefficient	Sample Mean	STDEV	T-Statistic	P-Value	Decision
H1: Packaging → Distribution	0.335	0.332	0.123	2.730	0.006	Accepted
H2: Packaging → Last Mile Delivery	0.241	0.232	0.105	2.297	0.022	Accepted
H3: Digital Information → Distribution	0.245	0.243	0.087	2.822	0.005	Accepted
H4: Digital Information → Last Mile Delivery	0.211	0.219	0.098	2.144	0.032	Accepted
H5: Crowd Logistics → Distribution	0.314	0.321	0.117	2.975	0.007	Accepted
H6: Crowd Logistics → Last Mile Delivery	0.179	0.190	0.088	2.032	0.042	Accepted
H7: Distribution → Last Mile Delivery	0.326	0.314	0.084	3.897	< 0.001	Accepted
H8: Packaging → Distribution → Last Mile Delivery	0.109	0.106	0.049	2.207	0.027	Accepted
H9: Digital Information → Distribution → Last Mile Delivery	0.080	0.078	0.037	2.151	0.032	Accepted
H10: Crowd Logistics → Distribution → Last Mile Delivery	0.102	0.098	0.037	2.738	0.006	Accepted

Source: Processed by the Author

Based on the results of hypothesis testing using the Structural Equation Modeling–Partial Least Squares (SEM-PLS) method via the bootstrapping procedure, all research hypotheses yielded t-statistics greater than 1.96 and p-values less than 0.05. This indicates that all relationships between variables in the research model were found to be positive and significant, and thus all research hypotheses were accepted.

In the mediation analysis, the Distribution variable was found to mediate the relationship between Crowd Logistics, Digital Information, and Packaging and Last Mile Delivery. The test results showed p-values of 0.006, 0.032, and 0.027, respectively, indicating that all indirect effects were significant. These findings suggest that improving distribution quality can strengthen the influence of operational, digital, and physical factors on the success of last-mile delivery for food and beverage SMEs utilizing online transportation services in Bandung.

Table 11. Indirect Effect

	Crowd Logistics	Digital Information	Distribution	Last Mile Delivery	Packaging
Crowd Logistics				0.102	
Digital Information				0.080	
Distribution					
Last Mile Delivery					
Packaging				0.109	

Source: Processed by the Author

The indirect effect results indicate that Distribution significantly mediates the relationships between Packaging, Digital Information, Crowd Logistics, and Last-Mile Delivery. The strongest indirect effect was observed in the relationship between Packaging and Last-Mile Delivery through Distribution, with a path coefficient of 0.109. This finding suggests that effective packaging not only directly improves delivery performance but also enhances distribution effectiveness, which subsequently contributes to successful last-mile delivery.

Furthermore, Crowd Logistics demonstrated an indirect effect of 0.102 on Last-Mile Delivery through Distribution. This result indicates that the flexibility and responsiveness provided by crowd-based logistics networks improve distribution performance, which in turn supports better last-mile delivery outcomes.

Digital Information also exhibited a positive indirect effect on Last-Mile Delivery through Distribution, with a path coefficient of 0.080. This finding highlights the importance of information visibility, communication accuracy, and digital coordination in strengthening distribution processes and enhancing delivery performance.

Overall, the mediation analysis confirms the strategic role of Distribution as an intermediary construct linking operational and technological capabilities to Last-Mile Delivery performance. These findings suggest that improving Packaging, Digital Information, and Crowd Logistics can enhance delivery outcomes not only through direct effects but also through more effective distribution processes.

The results of both the direct and indirect effects provide empirical support for the proposed conceptual model. The following discussion elaborates on each hypothesis and relates the findings to existing theories and previous studies in logistics, distribution management, and last-mile delivery.

Discussion

H1 and H2 are supported, confirming that Packaging positively and significantly influences both Distribution and Last-Mile Delivery. This finding is consistent with Ganguly (2025), who demonstrated that packaging quality directly contributes to distribution efficiency by reducing handling errors and product damage during transit. Similarly, Hellström (2025) argued that sustainable and functional packaging is a competitive enabler in home-delivery contexts, supporting the reliability of the delivery process from the sender to the final recipient. In the context of food and beverage SMEs in Bandung utilizing online transportation services, proper packaging not only protects product integrity but also facilitates smoother handoffs between the SME, the crowd courier, and the end customer. These findings imply that SME operators should invest in standardized, delivery-compatible packaging materials as a foundational logistics strategy to reduce return rates and improve delivery success rates in last-mile operations.

H3 and H4 are supported, indicating that Digital Information positively affects both Distribution and Last-Mile Delivery. This result aligns with Atieh et al. (2025), who found that digital technology integration, including data automation and real-time tracking, significantly improves supply chain performance. Iftikhar et al. (2024) further demonstrated through a bibliometric analysis that digital innovation strengthens supply chain resilience, a construct closely related to distribution robustness. In the context of UMKM F&B in Bandung, where order volumes fluctuate and courier coordination relies heavily on platform-based communication, the accuracy of digital information reduces miscommunication, delivery errors, and delayed status updates. These findings suggest that SMEs should leverage available digital tools on platforms such as GoSend and GrabExpress to improve real-time visibility and coordination, ultimately contributing to more reliable last-mile delivery outcomes.

H5 and H6 are supported, confirming that Crowd Logistics positively and significantly affects both Distribution and Last-Mile Delivery. This finding is consistent with Bortolini et al. (2022), who demonstrated that crowd logistics enhances delivery flexibility and operational efficiency in northern Italy, a context comparable to Bandung as a dense urban agglomeration with high e-commerce activity. Pourrahmani and Jaller (2021) similarly identified crowdshipping as an operationally viable model for last-mile delivery, particularly in environments where demand is spatially dispersed and time-sensitive. Samad et al. (2023) further established that crowd logistics contributes to supply chain agility, which is a critical capability for F&B SMEs responding to fluctuating customer orders. The practical implication for SMEs in Bandung is that actively utilizing and managing crowd courier networks through platforms such as GoSend can substitute for conventional logistics infrastructure, enabling scalable and cost-efficient distribution without significant capital investment.

H7 is supported, demonstrating that Distribution has a positive and significant effect on Last-Mile Delivery ($t = 3.897$, $p < 0.001$). This result is consistent with Wang and Wong (2023), who concluded that distribution effectiveness is among the most critical determinants of last-mile delivery success in urban logistics settings. Budiyanto et al. (2024) further argued that the future of last-mile logistics in developing economies depends heavily on the reliability and scalability of distribution systems that support e-commerce operations. For F&B SMEs in Bandung, effective distribution encompasses not only the physical movement of products but also the coordination of order verification, route planning, and handover protocols with online transportation platforms. The significance of this path coefficient (beta = 0.326) suggests that even marginal improvements in distribution processes yield meaningful gains in delivery performance, reinforcing the importance of distribution as a core operational capability for SMEs seeking competitive advantage in the digital logistics environment.

The mediation analysis confirms that Distribution serves as an important intermediary mechanism linking Packaging, Digital Information, and Crowd Logistics with Last-Mile Delivery performance. These findings indicate that improvements in logistics resources and information capabilities enhance delivery outcomes not only directly but also indirectly through more effective distribution processes.

CONCLUSION

This study examined the effects of Packaging, Digital Information, and Crowd Logistics on Distribution and their implications for Last-Mile Delivery among food and beverage SMEs utilizing online transportation services in Bandung City. The findings demonstrate that Packaging, Digital Information, and Crowd Logistics significantly improve Distribution performance and directly enhance Last-Mile Delivery. These results indicate that operational readiness, information quality, and logistics flexibility are important determinants of delivery performance in digital logistics environments.

The study also confirms that Distribution plays a critical role in improving Last-Mile Delivery performance. Effective distribution processes contribute to delivery accuracy, timeliness, and service reliability, making Distribution a key operational mechanism that connects logistics capabilities with successful delivery outcomes.

Furthermore, the mediation analysis reveals that Distribution significantly mediates the relationships between Packaging, Digital Information, Crowd Logistics, and Last-Mile Delivery. This finding suggests that improvements in packaging quality, information management, and crowd-based logistics systems can strengthen delivery performance not only through direct effects but also through more effective distribution processes.

This study contributes to the logistics and supply chain management literature by providing an integrated model that links Packaging, Digital Information, Crowd Logistics, Distribution, and Last-Mile Delivery within the context of food and beverage SMEs. From a managerial perspective, the findings imply that SME operators should simultaneously improve packaging practices, digital information capabilities, and crowd logistics utilization while strengthening distribution effectiveness to achieve better last-mile delivery performance and maintain competitiveness in the digital economy.

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