



DOI: <https://doi.org/10.38035/hrm.v1i2>
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Received: 10 February 2026 | Revised: 20 February 2026 | Accepted: 27 February 2026

Analysis of Material Handling and Distribution System in Less Container Load (LCL) Cargo Shipment on Delivery on Time at a Sea Freight Forwarder: Using Structural Equation Modeling

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Abstract: Timely delivery is a central performance measure for freight forwarding companies, yet less-than-container-load shipments, in which cargo from several customers is consolidated in one container, are vulnerable to delays caused by cargo handling and long distribution chains. Previous studies on shipment delays have mostly described the causes of delay or examined customer satisfaction, and few have tested material handling and the distribution system together with consolidated container shipments as a mechanism that leads to on-time delivery. This study aims to analyze the effect of material handling and the distribution system on on-time delivery, directly and through less-than-container-load cargo shipment, at a sea freight forwarder in Bekasi. This study used a descriptive quantitative approach, with a questionnaire completed by 100 sea division workers, and analyzed the data using partial least squares structural equation modeling in SmartPLS 3.3.9. The results show that material handling and the distribution system significantly and positively affect cargo shipment and on-time delivery, that shipment affects on-time delivery, and that it significantly mediates both relationships. This study's novelty is the empirical evidence that consolidated shipment performance transmits the effect of handling and distribution practices to delivery punctuality.

Keywords: Material Handling, Distribution System, Delivery on Time, Less Container Load, Structural Equation Modeling

INTRODUCTION

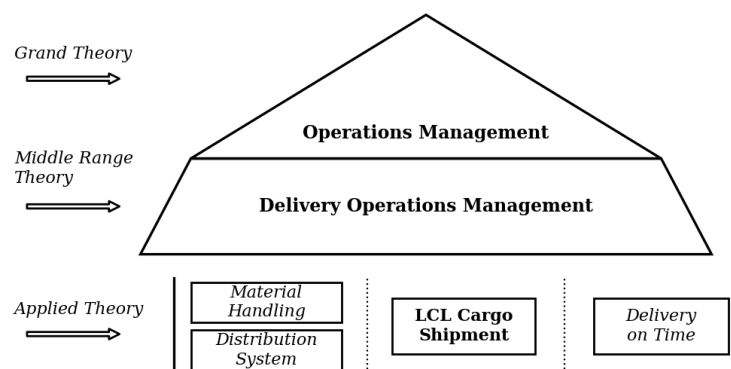
Urban infrastructure development increases business activity in Indonesia, including cargo logistics services. Because Indonesia is an archipelago, delivering goods to every region is difficult, and large shipments are therefore moved in containers between cities, provinces, and countries. Cargo forwarding companies are thus required to optimize the delivery process in order to achieve on-time delivery.

At the sea cargo forwarder studied, delays mainly arise from material handling and distribution. The checklist of goods prepared by the transit checker at the inbound station is error-prone because of the large volume of sea shipments, so goods may be lost or exchanged with those of other divisions, and grouping is inefficient because the grouping area adjoins that of another division. In addition, sea cargo can only be shipped from the head office, so goods from branch offices must first be distributed to the head office, which lengthens the distribution process.

Sea shipments are handled as less container load (LCL) cargo, in which the goods of several customers are stuffed into the same container at the central warehouse, sealed, and sent to the container yard of the port of shipment. On-time delivery has therefore become the main problem that must be resolved by eliminating the causes of delay.

Logistics is the process of planning, implementing, and controlling the efficient and effective flow and storage of goods, services, and related information to meet customer requirements (Bowersox, 2011). Beyond moving products and materials, logistics is regarded as a source of competitive advantage, and competitive logistics services are essential for national and international connectivity (Chapman et al., 2001; Salim, 2015).

The research model was developed from a hierarchy of theories (Figure 1). Operations management serves as the grand theory, delivery operations management as the middle-range theory, and material handling, distribution system, LCL cargo shipment, and delivery on time as the applied theories.



Source: Developed by the authors from various sources

Figure 1. Grand Theory, Middle Range Theory, and Applied Theory

Material handling is broadly defined as the handling of materials in a manufacturing environment (Meyers & Stephens, 2005). It provides the 9R (right amount, material, condition, place, time, position, sequence, cost, and method) that minimize production costs (Tompkins et al., 2003). Its main objective is to reduce the unit production cost, supported by maintaining product quality, improving safety, increasing productivity, and controlling inventory (Meyers & Stephens, 2005).

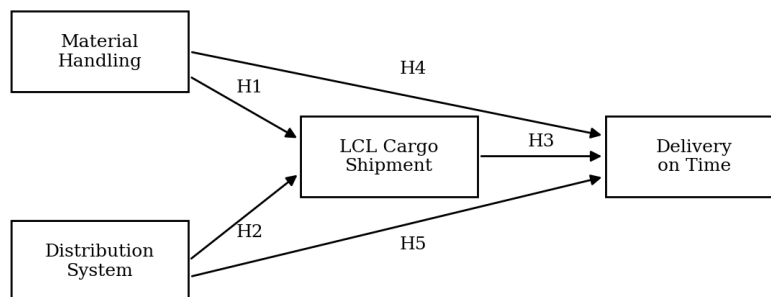
Distribution is the movement of goods or services from the original source to the end consumer through distribution channels (Subagyo & Handoko, 2018) and a marketing activity that smooths the delivery of goods from producers to consumers (Fakhrudin, 2021). Its dimensions are location, time, form, and information (Keegan, 2006, as cited in Koesworodjati).

LCL shipment refers to containers that are not fully loaded and are therefore consolidated with other goods at the next loading port (Amir, 2005). The cargo of several shippers is received in breakbulk condition, stuffed at a container freight station (CFS), unstuffed at the CFS of the discharge port, and handed over to the consignees, with the shipping company responsible for damage and loss (Suyono, 2005). Its dimensions are timeliness, cost, type of service, and guarantee.

On-time delivery means that a shipment is made on the specified date and day so that customers have no reason to complain. Timeliness is defined as the supplier's ability to deliver on time in minimum batches (Aminah, 2017).

Previous studies have addressed related outcomes using quantitative methods, such as customer satisfaction with an express delivery service (Tania, 2021; Tania & Reymond, 2021), dock productivity (Siahaan, 2016), the operational performance of shipping companies (Apriyani et al., 2018), and supply chain performance (Arifudin et al., 2020). However, none of these studies examined material handling and the distribution system jointly, with LCL cargo shipment as a mediating variable, as determinants of on-time delivery using structural equation modeling. This is the **research gap** addressed in this study. The **novelty** of this study lies in testing, in a single structural model, the direct effects of material handling and the distribution system on on-time delivery and their indirect effects through LCL cargo shipment at a sea freight forwarder.

Material handling covers all handling of materials in a delivery company (Meyers & Stephens, 2005), and good handling supports a smooth shipment process that ultimately produces on-time delivery. An effective and efficient distribution system (Subagyo et al., 2018) is likewise expected to affect on-time delivery. Because LCL shipment merges the goods of various customers into one container (Amir, 2005), effective handling is required, and the distribution system must facilitate delivery to consumers (Arif, 2018). The conceptual framework (Figure 2) therefore assumes that material handling and the distribution system affect LCL cargo shipment, which in turn affects on-time delivery.



Source: Research framework

Figure 2. Conceptual Framework

A hypothesis is a predictive statement about the relationship between variables (Jogiyanto & Abdillah, 2009). Material handling and the distribution system were hypothesized to affect LCL cargo shipment positively (H1 and H2, respectively); LCL cargo shipment was hypothesized to affect on-time delivery positively (H3); material handling and the distribution system were hypothesized to affect on-time delivery positively (H4 and H5); and both were hypothesized to affect on-time delivery positively through LCL cargo shipment (H6 and H7). Accordingly, this study aims to determine these direct and indirect effects at a sea freight forwarding company.

METHODS

Research Design and Object

A descriptive quantitative approach was applied, using data from field observation and questionnaires. The research was conducted between June and August 2022 at a freight forwarding and logistics company in Bekasi whose sea division handles LCL cargo shipment. Questionnaires were distributed from 21 July to 5 August 2022.

Population and Sample

The population comprised all 138 workers of the company, particularly in operations. The sample consisted of 100 sea division workers, selected using saturated sampling (Sugiyono, 2017).

Data Collection and Research Instrument

Primary data were collected directly from the respondents using a questionnaire, and secondary data were obtained from books, journals, and internet sources (Abdillah & Jogiyanto, 2015). Responses were measured on a five-point Likert scale (Noor, 2014), from 1 (strongly disagree) to 5 (strongly agree).

Variables and Operationalization

The 20 indicators in Table 2 operationalize material handling (Meyers & Stephens, 2005), the distribution system (Subagyo & Handoko, 2018), (Arif, 2018), LCL cargo shipment (Amir, 2005), and delivery on time (Aminah, 2017); an operational variable is an attribute or value of an object or activity with a certain variation that is determined for study (Sugiyono, 2017).

Table 2. Operationalization of Variables

Variable	Dimension	Code	Questionnaire statement
Material handling (MH)	Right amount	MH1	Grouping of goods in material handling operations is appropriate
	Right material	MH2	The goods handled in operations are appropriate for the sea division
	Right condition	MH3	The goods handled in material handling are in good condition
	Right place	MH4	Material handling operations use the right place
	Right time	MH5	The timing of material handling operations is appropriate
	Right position	MH6	The placement of goods resulting from material handling operations is appropriate
	Right sequence	MH7	The sequence of material handling operations is efficient and effective
	Right cost	MH8	The cost incurred in material handling operations is relatively low
	Right methods	MH9	The method used in material handling operations is efficient and effective
Distribution system (DS)	Location	DS1	The place where goods distribution operations are carried out is appropriate
	Time	DS2	The goods distribution operation takes a short time
	Form	DS3	Goods distribution uses an appropriate model
	Information	DS4	Every worker understands the distribution information used
LCL cargo shipment (LCL)	Timeliness	LCL1	LCL cargo shipment is carried out on time

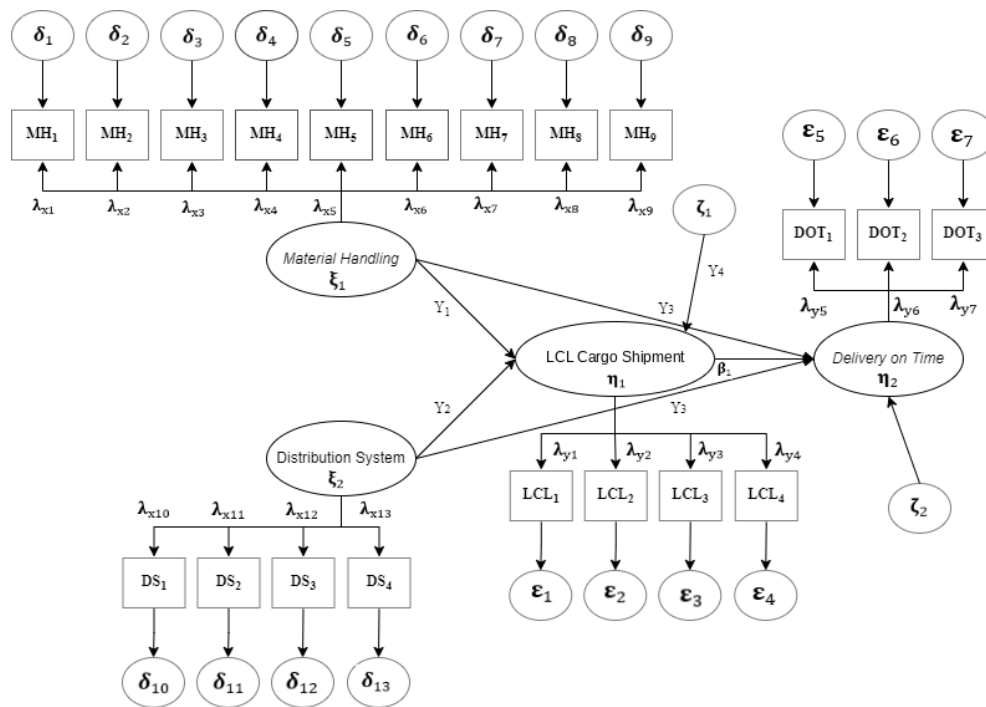
Variable	Dimension	Code	Questionnaire statement
Delivery on time (DOT)	Cost	LCL2	The cost incurred in the LCL cargo shipment process is relatively low
	Type of service	LCL3	In practice, the company provides various types of service
	Guarantee	LCL4	A guarantee is provided in LCL cargo shipment as security for the goods
	Accuracy of delivery service	DOT1	The type of service provided in delivery is appropriate and efficient
	Accuracy of price provisions	DOT2	The price charged for the delivery service is appropriate
	Timeliness provisions	DOT3	In the delivery process, the time required is appropriate

Source: Research instrument (2022)

Data Analysis

Respondents' answers were described for each indicator using descriptive analysis (Suliyanto, 2018). Hypotheses were tested using partial least squares structural equation modeling (PLS-SEM) in SmartPLS 3.3.9, which allows multiple independent, dependent, and intervening latent variables measured by several indicators to be analyzed simultaneously (Abdillah & Jogiyanto, 2015a). PLS-SEM is a variance-based method that does not depend on strict distributional assumptions, suits relatively small samples, and accommodates reflective and formative constructs (M Tenenhaus et al., 2005), and it is robust to multicollinearity and non-normal data (Abdillah & Jogiyanto, 2015a).

The measurement (outer) model was evaluated through convergent validity (outer loading > 0.7 and AVE > 0.5), discriminant validity (the cross loading of each indicator being highest on its own construct), and reliability (Cronbach's alpha and composite reliability of at least 0.7, with 0.6 still acceptable) (Abdillah & Jogiyanto, 2015; Sarwono & Narimawati, 2015). The structural (inner) model was evaluated through R^2 , interpreted as substantial, moderate, or weak at 0.67, 0.33, and 0.19, and through path coefficients whose significance was tested by bootstrapping with a t-statistic above 1.96 and $p \leq 0.05$ (Abdillah & Jogiyanto, 2015). In the path model (Figure 3), material handling (X1) and the distribution system (X2) are exogenous variables, LCL cargo shipment (Z) is the intervening variable, and delivery on time (Y) is the dependent variable.



Source: Research model

Figure 3. Path Diagram Construction

RESULTS AND DISCUSSION

Results

Respondent Profile

Of the 103 questionnaires distributed, 100 complete questionnaires from sea division workers were analyzed. Most respondents were male (72%), aged 20-29 years (42%), senior high school graduates (65%), and had worked for 3-4 years (34%) (Table 3).

Table 3. Respondent Profile (n = 100)

Characteristic	Total	Percentage
Gender		
Male	72	72%
Female	28	28%
Age		
< 20 years	18	18%
20-29 years	42	42%
30-39 years	25	25%
40-49 years	11	11%
> 50 years	4	4%
Education		
Junior high school	12	12%
Senior high school	65	65%
Bachelor's degree	23	23%
Length of service		

Characteristic	Total	Percentage
< 1 year	9	9%
1-2 years	11	11%
2-3 years	20	20%
3-4 years	34	34%
> 4 years	26	26%

Source: Research data (2022)

Descriptive Statistics

The mean scores of the 20 indicators ranged from 3.860 (MH1) to 4.190 (DS4), with standard deviations of 0.637-0.768 (Table 4), indicating generally high agreement with the statements on all four variables.

Table 4. Descriptive Statistics

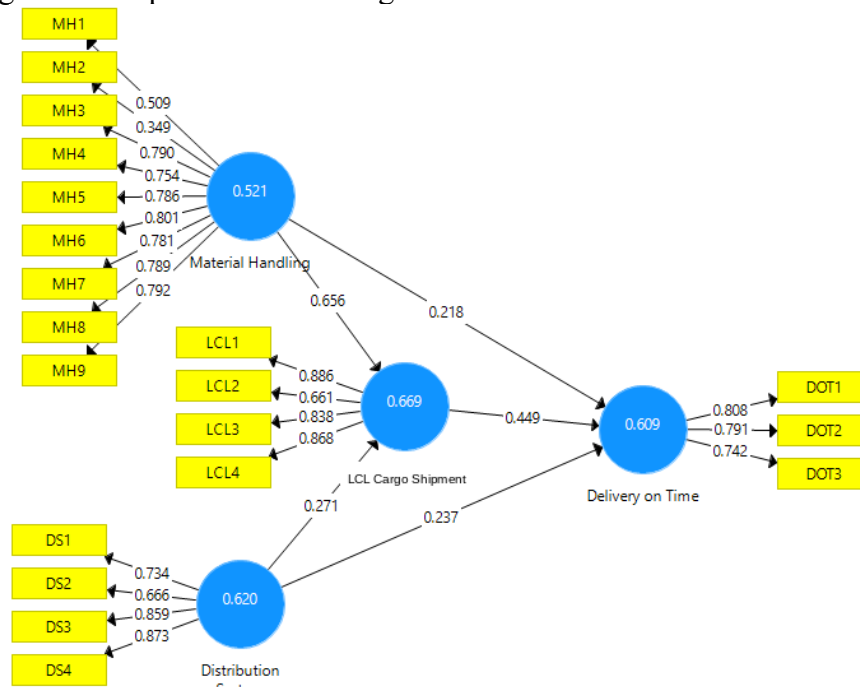
Variable	Indicator	N	Min	Max	Mean	Std. deviation
Material handling	MH1	100	3.000	5.000	3.860	0.721
	MH2	100	3.000	5.000	3.990	0.714
	MH3	100	3.000	5.000	4.130	0.688
	MH4	100	3.000	5.000	4.060	0.719
	MH5	100	3.000	5.000	4.100	0.728
	MH6	100	3.000	5.000	4.040	0.734
	MH7	100	3.000	5.000	4.030	0.714
	MH8	100	3.000	5.000	4.070	0.682
	MH9	100	3.000	5.000	4.130	0.730
Distribution system	DS1	100	3.000	5.000	4.130	0.637
	DS2	100	3.000	5.000	4.060	0.676
	DS3	100	3.000	5.000	4.130	0.716
	DS4	100	3.000	5.000	4.190	0.643
LCL cargo shipment	LCL1	100	3.000	5.000	4.100	0.768
	LCL2	100	3.000	5.000	4.150	0.638
	LCL3	100	3.000	5.000	4.100	0.742
	LCL4	100	3.000	5.000	4.080	0.730
Delivery on time	DOT1	100	3.000	5.000	4.060	0.705
	DOT2	100	3.000	5.000	4.000	0.707

Variable	Indicator	N	Min	Max	Mean	Std. deviation
	DOT3	100	3.000	5.000	4.140	0.693

Source: Data processed (SmartPLS 3.3.9), 2022

Evaluation of the Measurement Model (Outer Model)

The algorithm output is shown in Figure 4.



Source: Data processed (SmartPLS 3.3.9), 2022

Figure 4. Results of the Structural Algorithm Measurement

Sixteen of the 20 outer loadings ranged from 0.742 to 0.886, whereas MH1 (0.509), MH2 (0.349), DS2 (0.666), and LCL2 (0.661) were below 0.7. These indicators were retained because the AVE of every construct exceeded 0.5 (Table 6). Discriminant validity was supported by the cross loadings in Table 5, in which each indicator loaded highest on its own construct (Noor, 2014), except MH2, which loaded slightly higher on LCL cargo shipment (0.370) than on material handling (0.349). Cronbach's alpha ranged from 0.791 to 0.877 for three constructs and was 0.679 for delivery on time, which is still acceptable (Abdillah & Jogiyanto, 2015b), and composite reliability ranged from 0.824 to 0.904 for all constructs (Table 6).

Table 5. Outer Loadings (Bold) and Cross Loadings of Indicators

Indicator	Material handling	Distribution system	LCL cargo shipment	Delivery on time
MH1	0.509	0.400	0.283	0.140
MH2	0.349	0.243	0.370	0.049
MH3	0.790	0.271	0.442	-0.030
MH4	0.754	0.183	0.385	0.014
MH5	0.786	0.385	0.312	0.350
MH6	0.801	0.147	0.197	0.158

Indicator	Material handling	Distribution system	LCL cargo shipment	Delivery on time
MH7	0.781	0.393	0.370	0.172
MH8	0.789	0.258	0.132	0.213
MH9	0.792	0.195	0.370	0.127
DS1	0.216	0.734	0.011	0.213
DS2	0.256	0.666	0.011	0.213
DS3	0.402	0.859	0.231	0.127
DS4	0.320	0.873	-0.031	0.190
LCL1	0.336	0.047	0.886	0.334
LCL2	0.340	0.019	0.661	-0.018
LCL3	0.369	0.086	0.838	0.117
LCL4	0.331	0.058	0.868	0.132
DOT1	0.193	0.240	-0.025	0.808
DOT2	0.112	0.150	0.322	0.791
DOT3	0.098	0.177	0.025	0.742

Source: Data processed (SmartPLS 3.3.9), 2022

Table 6. Construct Reliability and Validity

Variable	Cronbach's alpha	Composite reliability	AVE
Material handling	0.877	0.904	0.521
Distribution system	0.791	0.866	0.620
LCL cargo shipment	0.831	0.889	0.669
Delivery on time	0.679	0.824	0.609

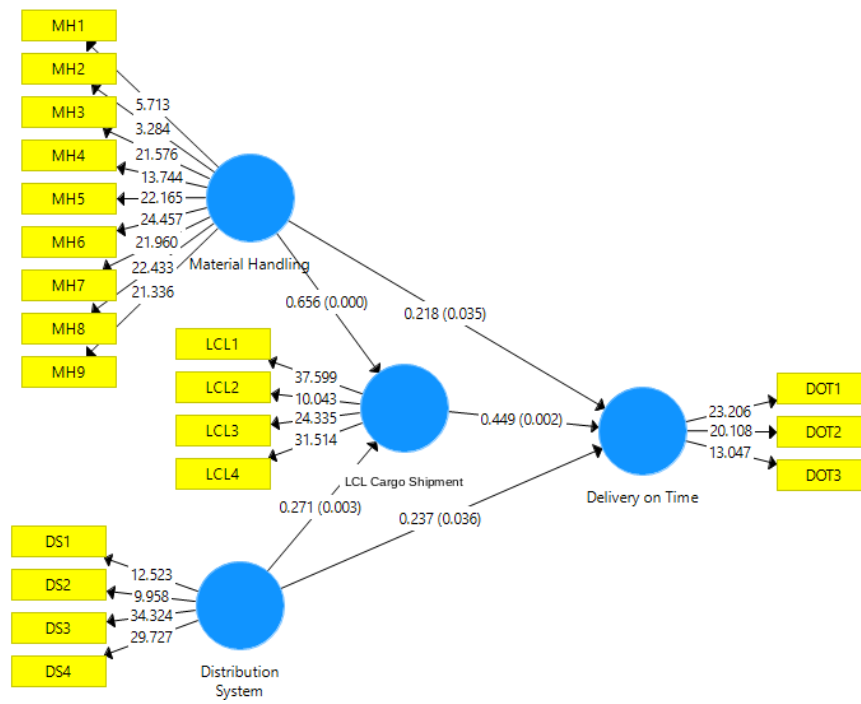
Source: Data processed (SmartPLS 3.3.9), 2022

Evaluation of the Structural Model (Inner Model)

The R^2 values were 0.724 for LCL cargo shipment and 0.675 for delivery on time (adjusted R^2 of 0.718 and 0.665), meaning that 72.4% and 67.5% of their variation were explained by their predictors; both values fall in the substantial range.

Hypothesis Testing

Hypotheses were tested by bootstrapping (Figure 5; Table 7). All path coefficients were positive, with t-statistics above 1.96 and p-values below 0.05; therefore, H1 to H7 were accepted.



Source: Data processed (SmartPLS 3.3.9), 2022

Figure 5. Structural Measurement Using Bootstrapping
Table 7. Path Coefficients (Direct and Indirect Effects)

Path	Hypothesis	Original sample (O)	Std. deviation	T-statistic	P-value	Decision
MH → LCL	H1	0.656	0.083	7.871	0.000	Accepted
DS → LCL	H2	0.271	0.100	2.715	0.003	Accepted
LCL → DOT	H3	0.449	0.157	2.854	0.002	Accepted
MH → DOT	H4	0.218	0.120	2.820	0.035	Accepted
DS → DOT	H5	0.237	0.131	2.804	0.036	Accepted
MH → LCL → DOT	H6	0.294	0.110	2.688	0.004	Accepted
DS → LCL → DOT	H7	0.122	0.116	2.020	0.022	Accepted

Source: Data processed (SmartPLS 3.3.9), 2022. MH = material handling; DS = distribution system; LCL = LCL cargo shipment; DOT = delivery on time

Discussion

Material handling had the strongest effect on LCL cargo shipment ($\beta = 0.656$, $t = 7.871$, $p = 0.000$), followed by the distribution system ($\beta = 0.271$, $t = 2.715$, $p = 0.003$), which supports H1 and H2. Because LCL shipment merges the goods of several customers in one container (Amir, 2005), handling in the right amount, condition, place, time, and sequence is essential, which is consistent with the checking errors and inefficient grouping observed at the company. A well-functioning distribution system, in turn, smooths the delivery of goods to consumers (Arif, 2018), although its coefficient was smaller than that of material handling.

LCL cargo shipment affected delivery on time ($\beta = 0.449$, $t = 2.854$, $p = 0.002$), so on-time delivery is realized when LCL shipment follows proper procedures (H3). Material handling ($\beta = 0.218$, $t = 2.820$, $p = 0.035$) and the distribution system ($\beta = 0.237$, $t = 2.804$, $p = 0.036$) also affected delivery on time.

= 0.036) also affected delivery on time directly (H4 and H5), in line with the view that on-time delivery is the end result of material handling (Meyers & Stephens, 2005) and of an effective distribution system (Subagyo et al., 2018). The direct effect of material handling was much smaller than its effect on LCL shipment, indicating that handling works mainly through the shipment process.

LCL cargo shipment significantly mediated the effects of material handling ($\beta = 0.294$, $t = 2.688$, $p = 0.004$) and the distribution system ($\beta = 0.122$, $t = 2.020$, $p = 0.022$) on delivery on time (H6 and H7). Because the direct effects were also significant, the mediation was partial. When direct and indirect coefficients are added, material handling (0.512) has a larger total effect than the distribution system (0.359).

Novelty: LCL cargo shipment was shown to be a significant mediating mechanism through which both material handling and the distribution system reach delivery on time, in addition to their direct effects. Improving delivery punctuality at a sea freight forwarder therefore requires attention both to the handling of goods and to the quality of the consolidated shipment process.

CONCLUSIONS AND RECOMMENDATIONS

Conclusion

Material handling and the distribution system positively and significantly affected LCL cargo shipment ($\beta = 0.656$ and 0.271), which in turn positively and significantly affected delivery on time ($\beta = 0.449$). Both variables also affected delivery on time directly ($\beta = 0.218$ and 0.237) and indirectly through LCL cargo shipment ($\beta = 0.294$ and 0.122); thus, all seven hypotheses were accepted. These findings provide empirical evidence that consolidated shipment performance is the channel through which handling and distribution practices improve delivery punctuality in LCL freight forwarding.

Limitations

This study was limited to one company and one type of service (LCL cargo shipment), used a sample of 100 sea division workers, and examined only two determinants of delivery on time, so the findings cannot be generalized to other companies or other causes of delay. In addition, four indicators (MH1, MH2, DS2, and LCL2) had outer loadings below 0.7, and MH2 did not meet the cross-loading criterion.

Recommendations

The company is advised to improve the handling of goods and the distribution system, particularly in LCL cargo shipment, to achieve timely delivery. Future studies should use larger samples, include other causes of delay, and compare other types of delivery service.

Author Contributions

All authors made significant contributions to this study. These contributions included research conceptualization, development of the theoretical framework, data collection, data analysis, interpretation of results, manuscript preparation, scholarly revision, and final approval of the manuscript for publication. All authors confirm that they have read and approved the final version of the article.

AI Disclosure Statement

During the preparation of this manuscript, the authors used Claude (Anthropic) to translate the text of the original Indonesian-language thesis into English, to restructure and condense it into the journal template, and to edit its language. The data, statistical analyses, and findings derive from the original research and were not generated by AI. The authors reviewed

and edited all AI-assisted content, verified the data, citations, and references, and take full responsibility for the entire publication.

Acknowledgment

The authors would like to thank all workers of the sea division of the company studied who took part in this study, and Institut Transportasi dan Logistik Trisakti for its support.

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