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Article

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Why is demurrage important for logistics companies using container terminals? An analysis of the determinants of demurrage and its impact on firm performance[☆]

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ABSTRACT

During the COVID-19 pandemic, severe demurrage in shipping and container terminals has led to a global logistics crisis and supply chain disruptions. Although the situation is gradually stabilizing, discussions persist on strategies to reduce volatility in container freight transportation. Demurrage imposes unnecessary costs, delays deliveries, and impedes the efficiency of container terminals. This study analyzes the factors influencing demurrage from the perspective of logistics companies, specifically, based on the characteristics of logistics companies and the attributes of the cargo owners they serve. Additionally, it explores the impact of demurrage levels on firm performance and investigates how this relationship may be moderated by container terminal characteristics. The empirical findings indicate that advancements in information systems within logistics companies, along with improved collaboration and contract compliance among cargo owners, can significantly reduce demurrage. This reduction in demurrage can enhance firm performance. Furthermore, credibility management and digitization of shipping documents also play a crucial role in minimizing demurrage. Building on previous research and empirical insights, this study emphasizes the importance of sustained long-term investment and policy support from the government for the digital transformation of logistics processes, complementing the efforts of both logistics companies and cargo owners.

1. Introduction

Maritime transportation accounts for approximately 80 % of international trade.¹ In 2022, Korea's trade dependency reached 84.56 %, with most imports and exports managed through ports and container terminals. A demurrage in shipping hampers port efficiency, whereas a demurrage in container terminals reduces operational efficiency, ultimately affecting the entire logistics process.

Before and after the COVID-19 pandemic, many container terminals experienced difficulties in handling cargo. Severe demurrage in shipping and container terminals led to global logistics crises and supply chain disruptions. In particular, U.S. container terminals faced significant

delays in loading and unloading owing to cargo handling overloads for an extended period.³ As a result, significant demurrage occurred, causing financial difficulties for logistics stakeholders, such as logistics companies, ship owners, and cargo owners. Although the situation is gradually stabilizing, discussions persist on strategies to reduce volatility in container freight transportation. Demurrage imposes unnecessary costs, delays deliveries, and impedes the efficiency of container terminals. Therefore, this study begins with the following research question: "Why is demurrage important for logistics companies that use container terminals?"

If logistics companies fail to reduce demurrage, unnecessary fees will accumulate, leading to increased overall logistics costs. Although the

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¹ Review of Maritime Transport, (2020) (UNCTAD Resilient Maritime Logistics), available from <https://resilientmaritimelogistics.unctad.org/page/test-book-page>

² KOSIS National Statistical Portal, Trade dependency (the ratio of exports and imports to GDP) (OECD member countries), available from https://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT_2KAA806_OECD

³ Marketplace News (2021), "L.A.'s latest traffic jam: Dozens of container ships waiting to be unloaded", available from <https://www.marketplace.org/2021/03/08/dozens-container-ships-waiting-unloaded-port-los-angeles>

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Table 1
Classification of logistics companies^a.

Classification	Description
1PL: First-party logistics	The shipper company directly performs logistics operations using its own assets, such as personnel, equipment, and facilities.
2PL: Second-party logistics	The shipper company entrusts logistics operations to a subsidiary or an affiliated company to handle the logistics tasks.
3PL: Third-party logistics	The shipper company outsources some or all of its logistics operations to a logistics company that has no specific relationship with the shipper, allowing the logistics provider to manage tasks such as transportation, warehousing, and distribution.
4PL: Fourth-party logistics	The logistics company forms a partnership with the shipper, integrating services such as IT and consulting to provide comprehensive, end-to-end logistics solutions, including the management of the entire supply chain.

^a Korea Ministry of Land, Infrastructure, and Transport Logistics, Concept of Logistics (2024), retrieved August 25 from https://www.molit.go.kr/USR/policyData/m_34681/dtl.jsp?search=&srch_dept_nm=&srch_dept_id=&srch_usr_nm=&srch_usr_titl=Y&srch_usr_cntt=&search_regdate_s=&search_regdate_e=&psize=10-&s_category=p_sec_5&p_category=&lcmspage=5&id=73 (in Korean)

cost of demurrage at container terminals is relatively low compared with that of shipping demurrage (Storm, 2011), extended stays of container cargo at terminals can cause delivery delays, negatively affecting customer satisfaction. These additional costs and delays pose risks to long-term customer relationships. Furthermore, as demurrage at container terminals increases and terminal operational efficiency declines, disruptions in transportation planning and operations for logistics companies using these terminals also occur.

Therefore, logistics companies must manage demurrage effectively. However, despite regular discussions by regulatory bodies such as the Federal Maritime Commission and industry associations such as the International Federation of Freight Forwarders Associations (FIATA), the European Association for Forwarding, Transport, Logistics, and Customs Services (CLECAT), and the European Shippers' Council (ESC), there is a notable lack of research on this topic (Storms et al., 2023).

This study analyzes the factors influencing demurrage from the perspective of logistics companies, specifically, based on the characteristics of logistics companies and the attributes of the cargo owners they serve. Additionally, it explores the impact of demurrage levels on firm performance and investigates how this relationship may be moderated by container terminal characteristics. The findings are expected to offer solutions and insights to enhance the competitiveness of container terminals and logistics entities.

2. Logistics companies and demurrage

Logistics is the physical connection between domestic and international production and consumption through transportation, handling, storage, and economic activity. It creates added value through packaging, assembly, and information management processes. Logistics companies also perform these functions. Depending on their relationship with shippers, logistics companies are classified into 1PL (first-party logistics), 2PL (second-party logistics), 3PL (third-party logistics), and 4PL (fourth-party logistics), as shown in Table 1. Logistics companies face various expenses in their business activities, with demurrage being a significant concern. Effective demurrage management is particularly challenging, leading to considerable uncertainty and potentially unpredictable costs for these companies.

Demurrage refers to charges incurred when operations are delayed beyond a specified period and encompasses demurrages in both shipping and container terminals. Demurrage in container terminals occurs when the cargo's stay exceeds the free storage period (free time, typically 1–2 weeks) after it has entered the terminal but before it is released. Demurrage in shipping occurs when a vessel arrives at the port but cannot dock within 12 hours. Detention charges occur when empty containers released from the terminal do not return within the allocated timeframe.

Several studies have examined demurrage. For instance, Fazi and Roodbergen (2018) explored the impacts of demurrage and detention (D&D) on the efficiency of inland container transportation. Storms et al. (2023) investigated solutions for D&D through interviews and professional experience. Moini et al. (2012) analyzed the determinants of container dwell time (CDT), focusing on terminal facilities and efficiency, using data-mining algorithms. While most of these studies emphasized the relationship between demurrage and operational efficiency of container terminals, this study uniquely aims to analyze the factors influencing demurrage from the perspective of logistics companies.

An increase in the demand for container terminals decreases terminal efficiency, whereas increasing demurrage in shipping reduces port efficiency. As delays increase, the container turnover rate decreases. Demurrage in container terminals is designed to prevent prolonged container stays at the terminal, whereas demurrage in shipping fees prevents vessels from remaining in ports for extended periods. Detention fees have been introduced to increase the turnover rate of empty containers. These fees are calculated based on the number of days the vessel or container is delayed and serve as a control mechanism.

The cost of demurrage at container terminals, which is paid to the shipping company when demurrage occurs, varies slightly depending on the shipping company. The method for calculating demurrage periods

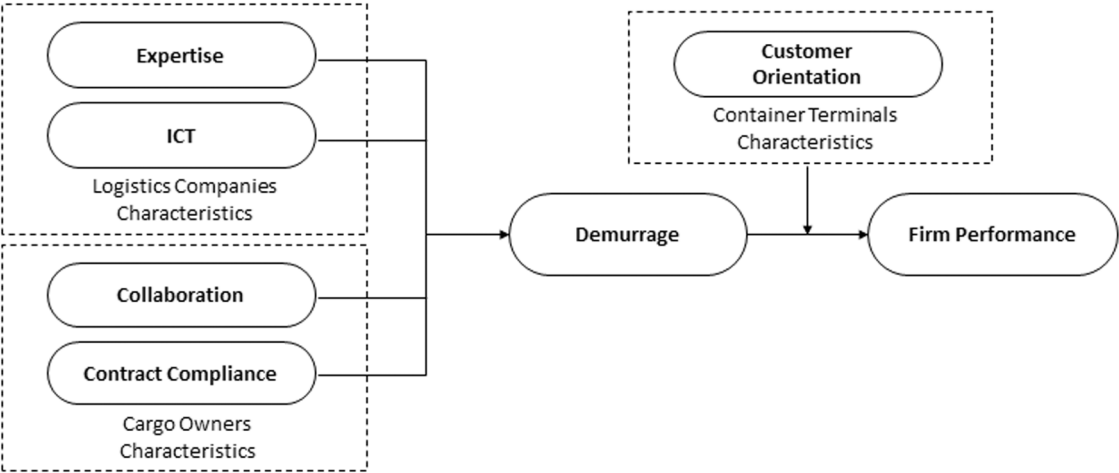


Fig. 1. Conceptual model of this study.

differs for exports and imports. For exports, the demurrage period is calculated from the time the container enters the terminal gate until it is loaded onto the vessel. This is influenced by the efficiency of the container terminal and port, which occurs when the vessel's waiting time is prolonged. For imports, the demurrage period is calculated from when the container is unloaded from the vessel and enters the terminal gate until it is cleared through customs and collected by the consignee. Delays in container release from the terminal can be caused by a decline in terminal efficiency, lack of information sharing and communication between logistics and supply chain stakeholders, issues with trade payment settlements, and customs clearance delays.

3. Literature and hypotheses

3.1. Research model

Most previous studies focused on the efficiency of container terminals. By contrast, this study primarily investigates the idea that the characteristics of logistics and supply chain stakeholders, such as shippers and logistics companies involved in imports and exports, are the key determinants of container cargo demurrage at container terminals. This study empirically analyzes both the determinants and outcomes of demurrage and examines the moderating effects of external variables. The overall research model used to achieve this objective is shown in Fig. 1.

The determinants of demurrage in container terminals are categorized into logistics company characteristics, such as expertise and use of information and communication technology (ICT), and cargo owner characteristics, including collaboration and contract compliance. This study also explores the relationship between demurrage and firm performance by focusing on how the customer orientation of container terminals moderates this relationship. The relationships among these variables were empirically analyzed using structural equation modeling (SEM).

3.2. Demurrage and firm performance

Firm performance refers to logistics activity indicators that improve efficiency through logistics management, thereby reducing costs and increasing customer satisfaction (Lambert et al., 1998). It is typically summarized by logistics cost reduction and on-time delivery, with factors such as communication, trust, culture, operational system compliance, standardization, and the level of collaboration acting as influencing elements (Jazairy et al., 2017). Demurrage in container terminals indicates an extension of logistics lead times, which leads to delivery delays. Demurrage fees at container terminals directly contribute to increased logistics costs, thereby negatively impacting logistics performance.

Logistics performance can be divided into financial and operational performance (Kim & Song, 2012). From a financial perspective, the scale of demurrage in container terminal fees is smaller than that for shipping fees (Storm, 2011). However, from an operational perspective, partial logistics delays caused by demurrage in container terminals hinder the optimization of overall logistics and thus deteriorates operational performance. Kim et al. (2018) explained that direct and indirect logistics performance can be assessed through logistics cost reduction, lead-time reduction, and improved customer responsiveness. Na and Kwon (2018) identified the critical elements of logistics performance as expanding logistics services, improving customer satisfaction, and enhancing flexible operations and agility. Based on these previous studies, we hypothesize the following:

H1. There is a negative relationship between demurrage at container terminals and the performance of logistics companies using these terminals.

3.3. Expertise and demurrage

Logistic competitiveness is a critical factor in global markets. According to Hunt and Morgan (1995), logistics personnel's knowledge and expertise are critical determinants of a company's logistics performance. A company cannot achieve performance through advanced technology and systems alone without human resources and the knowledge, skills, and competencies required for the job (Sweeney, 2013). While most previous research on logistics supply chain management focused on the technical aspects, the importance of human factors has become increasingly significant. The expertise of logistics personnel plays a decisive role in achieving supply chain performance (Van Hoek et al., 2002).

According to the resource-based view, unique resources that are valuable, rare, inimitable, and non-substitutable provide a firm with a sustainable competitive advantage (Wright et al., 1994). Progoulaki and Theotokas (2010) classified a firm's resources into physical, organizational, and human capital resources. Human capital resources include employee skills, judgment, and intelligence. Expertise is a part of human capital resources. Wong and Karia (2010) classified the logistics resources of LSPs (logistics service providers) into physical resources, information resources, human resources, and knowledge resources. Expertise is a unique knowledge resource that is difficult to imitate or substitute.

Thus, expertise can be a type of firm resource that enhances a firm's competitive advantage. For instance, it reduces unnecessary costs related to business operations and increases efficiency, thereby achieving a competitive advantage. Therefore, the expertise of human resources in logistics firms plays a crucial role in reducing unnecessary costs, such as demurrage fees. Based on these previous studies, this study proposes the following hypothesis:

H2-1. A negative relationship exists between logistics companies' expertise and the demurrage they incur.

3.4. ICT and demurrage

ICT refers to the convergence of communication and computer technologies that store, process, and transmit information over long distances. Logistics companies can use ICT to directly provide information and communication to customers, thereby enhancing delivery speed and reducing information transmission costs (Choy et al., 2014). Thus, ICT is essential for efficient supply chain management. Logistics service providers (LSPs) aim to provide high-level logistics services and improve logistics performance by utilizing various forms of ICT, such as transport management systems (TMS), warehouse management systems (WMS), tracking management systems, radio frequency identification, electronic data interchange, and the Internet (Vieira et al., 2015).

According to Chung (2011), integrating logistics and internal information technology across supply chain stakeholders can lead to shorter lead times, reduced inventory, and improved company performance. Logistics information systems streamline logistics operations and facilitate just-in-time (JIT) production by enabling seamless information connectivity (No et al., 2003).

From a resource-based view (RBV), ICT has become a type of corporate resource. Wong and Karia (2010) classified ICT as an information resource among LSPs' logistics resources. LSPs seek to enhance their information resource capabilities by developing information systems. Kamasak (2017) showed that intangible resources (IRs) and tangible resources (TRs) significantly contribute to a company's profits and performance. Additionally, this study reveals a positive relationship between technological resources, customer service, and cost advantage. This suggests that logistics companies' tangible and intangible resources enhance their competitiveness and reduce unnecessary costs, such as demurrage charges. Based on these prior studies, this study hypothesizes the following:

H2-2. A negative relationship exists between the information system of logistics companies and the demurrage they incur.

3.5. Collaboration and demurrage

When information regarding a container ship’s time of arrival (ETA/ATA) or time of departure (ETD/ATD) is not promptly shared with the relevant stakeholders, containers may not be picked up, leading to delays in the container terminal. This lack of information sharing between supply chain stakeholders increases the dwell time at container terminals, resulting in demurrage in container terminals (Storms et al., 2023).

In this study, we define communication and information sharing as collaborative performances. Communication and trust are components of partnerships, a form of inter-company cooperation, and a type of strategic alliance (Anderson & Narus, 1990). To measure the variables of communication, Kim and Song (2012) used indicators such as speed of communication, level of formal procedures, extent of communication barriers, and timeliness of information sharing.

Yigitbasioglu (2010) emphasized the importance of information sharing from the transaction cost theory (TCT) perspective. Information sharing between buyers and key suppliers improves buyer performance in terms of resource usage, output, and flexibility. According to Um and Kim (2019), supply chain collaboration enhances firm performance and transaction cost advantages. Hill (1990) highlighted the risks of opportunistic behavior inherent in transactions through TCT and suggested that cooperative behavior creates long-term value. In this context, collaboration between firms leads to increased trust between the parties, and improved trust reduces the opportunistic behavior of the counterpart, resulting in cost reduction. High levels of collaboration between logistics companies and shippers ultimately enhance mutual trust; as a result, a reduction in demurrage costs related to the transaction is expected. Based on these previous studies, we hypothesize the following:

H3-1. A negative relationship exists between logistics companies’ collaboration with cargo owners and the demurrage incurred by logistics companies.

3.6. Contract compliance and demurrage

The core of international trade is fulfilling agreed-upon contract terms within the stipulated period, and failure to do so can cause significant harm to both parties (Woo, 2023). In cases where the importer abandons customs clearance because of a lack of funds or fails to meet the domestic legal requirements for importation and cannot fulfill the contract, demurrage in container terminals occurs.⁵ This can also be influenced by the issuance of shipping documents, export and import permits, and certifications provided by public and private institutions (Woo, 2023). If shipping documents are not prepared and executed according to contracts, problems arise during customs clearance, leading to demurrage in container terminals.

According to the institutional theory, Cho (2008) suggested that conformity to normative institutions between companies reduces uncertainty in business activities, leading to cost reduction. When conformity is effectively achieved, organizations can avoid unnecessary conflicts or legal issues, resulting in cost savings. Zamir (1991) proposed the concept of conformity in contract performance to reduce disputes and enhance contract reliability. The contractual terms between logistics companies and shippers can be considered a normative institution between the two parties, and faithful contract compliance by shippers

Table 2
Construct operationalization.

Latent variable	Operational definition	References
Expertise	Logistics personnel’s specialized knowledge, work experience, and technical skills	Koo (2005), Hunt and Morgan (1995)
ICT	Positioning technology, tracking technology, communication technology infrastructure, WMS, TMS, etc.	No et al. (2003), Kim and Bae (2008), Bae and Lee (2014)
Collaboration	Timeliness of information sharing and speed of communication between supply chain entities	Storms et al. (2023) Kim and Song (2012)
Contract compliance	Issuance of shipping documents, export/import permits, certification by public and private institutions, payment, and fulfillment of legal requirements	Woo (2023) Korea Customs Logistics Association (2017)
Customer orientation	Flexibility in operations, information provision capability, one-stop service capability, and customer relationship management	Oh and Koo (2008), Kotler (1996)
Firm performance	Reduction in logistics costs, shorter lead times, improved customer responsiveness, and enhanced customer satisfaction	Lambert et al. (1998), Kim et al. (2018), Na and Kwon (2018)

can contribute to reducing costs such as demurrage fees. Based on previous research, this study seeks to establish the following hypothesis:

H3-2. There is a negative relationship between cargo owners’ contract compliance and demurrage incurred by logistics companies.

3.7. Customer orientation of container terminals and demurrage

As competition in container ports and terminals intensifies, equipment and facilities are standardized at a higher level, leading to efforts to improve service quality to gain a competitive advantage (Kim, 2006). According to Shin (2006), container terminal services are a core strategy for securing and enhancing the competitiveness of container ports and for conducting research to measure the service quality of container terminals. Kim and Choi (2013) argued that, to achieve differentiated competitive advantages, it is necessary to improve job satisfaction and organizational commitment among container terminal employees and enhance customer orientation.

Oh and Koo (2008) defined the service attributes of container terminals. They identified operational flexibility, information provision capabilities, one-stop service capabilities, and customer relationship management as elements of customer orientation (convenience). Customer orientation plays a vital role in achieving an organization’s goals and refers to effectively satisfying customer needs and desires (Kotler, 1996). Previous studies have suggested that customer orientation is a key factor in determining the competitiveness of container terminals, which can, in turn, indirectly improve the performance of various stakeholders, including logistics companies that utilize these terminals. Building on this research, the following hypothesis is proposed:

H4. Customer orientation at container terminals positively moderates the relationship between demurrage at container terminals and the performance of the logistics companies that use them.

4. Research methods

4.1. Sample and methodology

Based on previous research, this study identifies the determinants of demurrage in container terminals from the perspective of logistics companies. Additionally, it explores the impact of demurrage levels on

⁵ Korea Customs Logistics Association (2017), Export and Import Logistics Report, Vol.7, No.4, pp.1–117, retrieved August 25, 2024, from https://www.kclca.kr/Jsourc/Jboard/content.asp?ji_num=45&jb_idx=20752&jb_ref=20752&gotopage=3&folder_name=Jboard&screen_width=1600 (in Korean)

Table 3
General information of survey respondents.

Category	Percentage (No. of respondents)
Job type	
Import	40.6 % (41)
Export	28.7 % (29)
Combined	30.7 % (31)
Total	100.0 % (101)
Company type	
1PL	15.8 % (16)
2PL	47.5 % (48)
3PL	32.7 % (33)
4PL	3.0 % (3)
Shipping company	1.0 % (1)
Total	100.0 % (101)
Company size	
Small and medium-sized	54.5 % (55)
Mid-sized	39.6 % (40)
Conglomerate	5.9 % (6)
Total	100.0 % (101)
Years of experience	
Less than 1 year	4.0 % (4)
1–3 years	37.6 % (38)
3–5 years	30.7 % (31)
5–10 years	17.8 % (18)
More than 10 years	9.9 % (10)
Total	100.0 % (101)

firm performance and investigates how this relationship may be moderated by the characteristics of container terminals. The survey questions were constructed based on the operational definitions of the latent variables, as shown in Table 2. Measurements were taken using a 5-point Likert scale (1: strongly disagree to 5: strongly agree), with import/export managers from logistics companies providing subjective evaluations compared to competitive firms or industry averages.

A survey was conducted with import and export managers from logistics companies in South Korea and yielded 128 responses. After excluding 27 responses owing to insincerity or high rates of missing data, 101 valid responses (78.9 %) were retained for analysis (Table 3).

4.2. Result

This study proposes various hypotheses related to the determinants of container cargo demurrage in container terminals and their impact on

logistics performance. Using statistical programs such as SPSS and Smart PLS, this study conducted reliability, validity, and correlation analyses as well as an analysis of the causal relationships between variables. The structural equation modeling (SEM) method was empirically tested.

SEM can be divided into covariance-based SEM (CB-SEM) and partial least squares SEM (PLS-SEM). This study uses the PLS-SEM method, which is based on the least-squares approach. Smart PLS is a flexible and less demanding method in terms of sample size and is a practical option when a small dataset is available. Smart PLS is a variance-based SEM method that uses bootstrapping to estimate confidence intervals. This method works well with a small sample and relies on resampling the available data rather than requesting a large sample. Fig. 2. is the graphical output of Smart PLS.

According to the results from SPSS, the model demonstrated strong reliability, with a Cronbach's alpha coefficient of 0.870, exceeding the threshold of 0.7. Average extracted variance (AVE) values for all variables were above 0.5. Table 4 presents the construct reliability and validity results from the Smart PLS.

The factor loadings of the latent variables from the Smart PLS, as shown in Table 5, were mostly above 0.7, confirming the validity of the model.

Table 6 presents the heterotrait-monotrait ratio (HTMT) values, showing discriminant validity in structural equation modeling. As all HTMT values were below the threshold of 0.85, discriminant validity

Table 4
Construct reliability and validity.

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Customer orientation	0.770	0.775	0.867	0.708
Demurrage	0.637	0.643	0.804	0.578
Expertise	0.842	0.842	0.905	0.761
ICT	0.809	0.834	0.886	0.722
Firm performance	0.745	0.749	0.839	0.562
Collaboration	0.815	0.817	0.890	0.730
Contract compliance	0.790	0.790	0.877	0.704

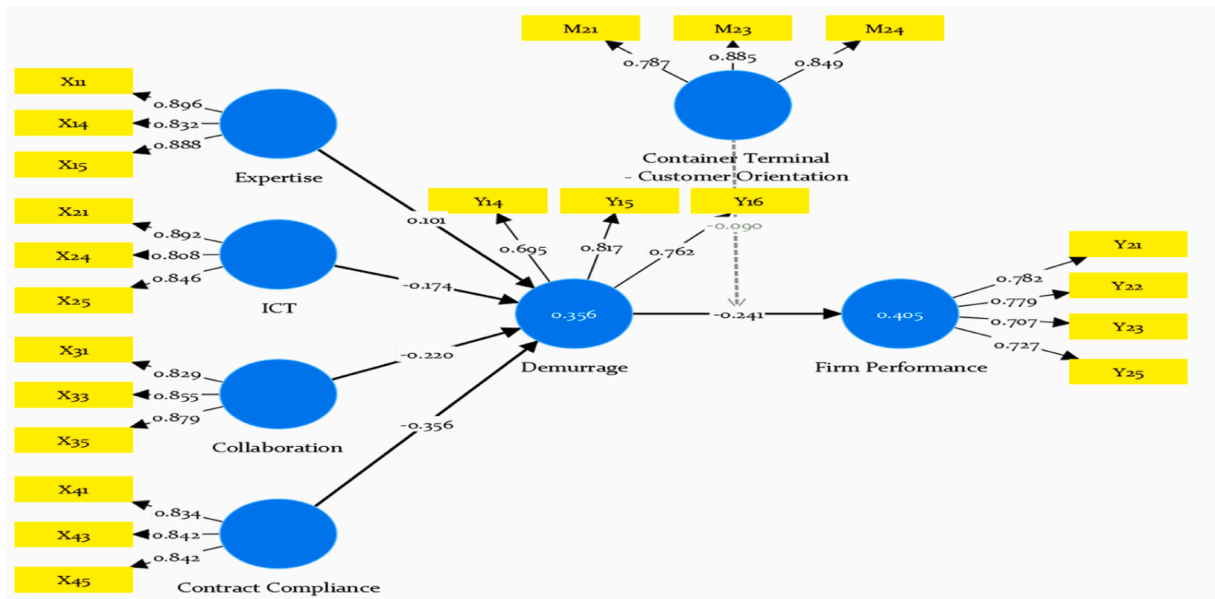


Fig. 2. Graphical output.

Table 5
Factor loadings of observed constructs.

Components	1	2	3	4	5	6	7
X11	0.896	0.528	0.603	0.515	0.394	−0.327	0.47
X14	0.832	0.565	0.543	0.552	0.312	−0.333	0.366
X15	0.888	0.546	0.62	0.54	0.337	−0.322	0.438
X21	0.634	0.892	0.634	0.579	0.482	−0.484	0.485
X24	0.502	0.808	0.552	0.548	0.485	−0.338	0.489
X25	0.445	0.846	0.549	0.511	0.5	−0.406	0.586
X31	0.551	0.423	0.829	0.545	0.453	−0.428	0.466
X33	0.524	0.619	0.855	0.54	0.412	−0.464	0.507
X35	0.663	0.711	0.879	0.63	0.481	−0.405	0.487
X41	0.48	0.521	0.499	0.834	0.526	−0.467	0.52
X43	0.47	0.535	0.6	0.842	0.433	−0.461	0.364
X45	0.598	0.559	0.581	0.842	0.393	−0.462	0.434
M21	0.325	0.424	0.401	0.401	0.787	−0.24	0.355
M23	0.375	0.517	0.452	0.532	0.885	−0.31	0.585
M24	0.304	0.494	0.468	0.402	0.849	−0.154	0.468
Y14	−0.323	−0.344	−0.331	−0.432	−0.073	0.695	−0.188
Y15	−0.278	−0.331	−0.383	−0.421	−0.129	0.817	−0.322
Y16	−0.266	−0.431	−0.433	−0.412	−0.397	0.762	−0.399
Y21	0.353	0.35	0.424	0.317	0.474	−0.461	0.782
Y22	0.384	0.568	0.436	0.41	0.502	−0.257	0.779
Y23	0.357	0.476	0.448	0.491	0.364	−0.253	0.707
Y25	0.377	0.459	0.414	0.394	0.353	−0.215	0.727
Variables	Expertise	ICT	Collaboration	Contract compliance	Customer orientation	Demurrage	Firm performance
AVE	0.761	0.722	0.730	0.704	0.708	0.578	0.562

Table 6
Discriminant validity-HTMT.

	1	2	3	4	5	6	7
1. Collaboration	1.000						
2. Customer orientation	0.649	1.000					
3. Contract compliance	0.834	0.663	1.000				
4. Demurrage	0.694	0.378	0.782	1.000			
5. Expertise	0.819	0.483	0.753	0.518	1.000		
6. Firm performance	0.733	0.705	0.697	0.555	0.617	1.000	
7. ICT	0.839	0.708	0.803	0.663	0.75	0.798	1.000

Table 7
Structural equation modeling (SEM) results.

Hypotheses	Relationships	Standardized coefficients	Results
1	Demurrage > Firm performance	−0.241**	Accept
2-1	Expertise > Demurrage	0.101	Reject
2-2	ICT > Demurrage	−0.174*	Accept
3-1	Collaboration > Demurrage	−0.220**	Accept
3-2	Contract compliance > Demurrage	−0.356***	Accept
4	Demurrage x Customer orientation > Firm performance	−0.090	Reject
Model fit verification		Recommending criterion	Model fit verification
CMIN/DF		≤ 2.0	1.521
IFI		≥ 0.9	0.920
GFI		≥ 0.9	0.795
TLI		≥ 0.9	0.887
CFI		≥ 0.9	0.908
PGFI		≥ 0.5	0.591
RMSEA		0.05–0.08	0.072
RMR		Close to 0	0.071

* p<0.10, **p<0.05, ***p<0.01

was successfully established. Based on these results, we conclude that there are no significant issues concerning reliability and validity.

Table 7 presents the regression analysis results for the latent variables. This study classifies the factors influencing demurrage into two

categories: logistics companies and cargo owners. It also investigates the impact of demurrage on the performance of logistics companies. Six hypotheses were formulated for each variable, grounded in prior research, and tested empirically using structural equation modeling (SEM). Table 7 presents the SEM outcomes, including the standardized regression coefficients and model fit indices.

Among the model fit indices, the absolute fit index (CMIN/DF) is 1.521, which is below the recommended threshold of 2.0, indicating a good fit. The incremental fit index (IFI) is 0.920, and the comparative fit index (CFI) is 0.908, both of which are within acceptable ranges. Although the goodness-of-fit index (GFI) and the Tucker-Lewis index (TLI) are slightly below the recommended value of 0.9, the overall fit of the model is deemed acceptable. Additionally, the root mean square error of approximation (RMSEA), which measures model fit, is 0.072. Based on these results, the model fit is considered good.

For the first hypothesis, which examines the relationship between demurrage and logistics performance, the standardized regression coefficient is −0.241. This negative value supports our hypothesis, indicating that as demurrage increases, logistics performance decreases. Hypothesis H3-1 examines the relationship between cargo owner collaboration and demurrage. The standardized regression coefficient is −0.220, which is consistent with the hypothesis, and statistical significance is verified. Hypothesis H3-2 addresses the relationship between cargo owners' contract compliance and demurrage, with a standardized regression coefficient of −0.356. This relationship shows the highest correlation and is statistically significant.

Hypothesis H2-1 is rejected because the coefficient is not statistically significant. Hypothesis H2-2 discusses the relationship between logistics

companies' information systems and demurrage, with a standardized regression coefficient of -0.174 . Statistical significance is confirmed, leading to the acceptance of this hypothesis. Hypothesis H4 suggests that container terminals' customer orientation has a moderating effect. However, this does not achieve statistical significance and is therefore rejected. This summary highlights the key findings, showing that most of the hypotheses are supported, except for those related to logistics company expertise and container terminals' customer orientation. The rejected results for Hypotheses H2-1 and H4 may be attributed to an insufficient sample size.

5. Conclusion and implications

During the COVID-19 pandemic, severe demurrage in shipping and container terminals led to a global logistics crisis and supply chain disruptions. Although the situation is gradually stabilizing, discussions persist on strategies to reduce volatility in container freight transportation. Demurrage imposes unnecessary costs, delays deliveries, and impedes the efficiency of container terminals.

This study examines the determinants of demurrage from the perspective of logistics companies. We explored these determinants by considering both the characteristics of logistics companies and the attributes of the cargo owners they serve. The empirical findings indicate that the level of contract compliance, including timely payments by cargo owners and the preparation of export and import shipping documents, has the most significant impact on the occurrence of demurrage in container terminals. Improving the accuracy and speed of preparing such documents reduces the risk of demurrage. Therefore, reducing human errors and digitizing shipping documents can enhance the efficiency of container terminals and improve logistics performance.

In line with the current trend toward paperless operations, the logistics industry is also attempting to adopt this approach. However, complete digitization has yet to be achieved because of security and development issues. When there are errors in the content of a bill of lading or a certificate of origin that prevent customs clearance and only original paper documents are accepted, the current process requires returning the original document, making corrections, and resubmitting it, which takes a significant amount of time and cost. However, with future digitization of shipping documents, it will be possible to achieve significant reductions in time and cost.

Regarding payments, if a cargo owner's payment capacity and creditworthiness are low, there is a likelihood of prolonged demurrage, which is considered a chronic problem that deteriorates terminal efficiency. To reduce this problem, contract compliance rates can be improved through credit management and related relief policies. Information sharing and collaboration between logistics and supply chain entities can reduce demurrage and enhance terminal efficiency. Pre-awareness and education of stakeholders can improve collaboration. While the expertise of logistics companies does not have a significant impact on demurrage, the level of ICT does. Thus, logistics companies can shorten lead times, improve productivity, and reduce demurrage by developing ICT. Along with the efforts of cargo owners and logistics companies, continuous and long-term investment and support from the government in policy development and digital transformation of logistics processes are necessary.

Conflicts of interest

The author declares that he/she has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Hyoseon Kim: Writing – original draft. **Hyuksoo Cho:** Writing – original draft, Writing – review & editing.

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