

Jeong, Seok-Hwan; Choi, Young-Seo; Listan Bernal, Maria; Yeo, Gi-Tae

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Analysis of obstacles to lowering demurrage at grain terminals in South Korea

Seok-Hwan Jeong, Young-Seo Choi, Maria Listan Bernal, Gi-Tae Yeo ^{*}

Graduate School of Logistics, Incheon National University, Incheon 22012, South Korea

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ABSTRACT

This study aimed to analyze the obstacles to lowering demurrage at a grain terminal. After conducting in-depth interviews with working-level staff in grain terminal, 12 factors were selected to derive key factors for reducing demurrage. The Consistent Fuzzy Preference Relations methodology, which can extract experts' knowledge and experiences, was employed to rank the obstacles in lowering demurrage. The analysis showed that the number one factor was "inventory requirements of grain shippers" (with an importance of 0.097), followed by "capacity of storage facilities" and "port congestion" as the second and third factors, respectively. As for sub-factors, "climate (e.g., typhoon, rain, etc.)" and "ship size" were ranked 11th and 12th, respectively. The analysis indicates that experts recognized factors that can be changed by shippers and that are difficult to control as more important obstacles than cost-related factors. The findings of this study provide the working-staff of ports, grain terminals, and the government implications for reducing demurrage.

1. Introduction

Grains refer to agricultural products, such as rice, corn, beans, and soybeans that are used for human consumption. The United States and Canada in North America and Argentina and Brazil in South America are the main producers of grains (Han, 2023). Ukraine and Russia are globally famous as producers of wheat; however, the recent war between these countries has adversely affected them and all the sectors related to wheat worldwide (Rose et al., 2022).

A grain terminal is a dock specializing in logistics processes (e.g., loading and unloading, storage, and release). It uses a continuous ship unloader for loading and unloading grains and a grain storage silo to treat grain freight. Grain terminals in Korea are located in Incheon, Pyeongtaek, Gunsan, Busan, and Ulsan. Such terminals are a capital-intensive business. They require a huge initial investment and operating costs, and are mainly operated by large companies, including major integrated logistics companies.

In 2022, South Korea recorded a food self-sufficiency rate of 21.8%. Therefore, it relied heavily on imports of major grains such as wheat and corn, including feed grains. The country reported a grain loading and unloading volume of 17.7 million tons in 2022, an increase of 1.1% from 17.5 million tons in 2021. The growth in harbor traffic volumes is expected to continue owing to expectations of a global economic recovery

after COVID-19 and the subsequent revitalization of imports and exports. Besides, an increase in domestic meat consumption and a higher purchasing power of grains are expected to contribute to the growth. Therefore, the demand for hub ports that can adequately handle grain volumes is expected to increase.

Demurrage is one of the several obstacles in improving productivity and profit and loss management while operating a terminal. It is a type of compensation paid to shipping companies in the case of a failure to load or discharge a ship within the agreed time. When loading/unloading grains in Korea, shippers and operators (grain terminals) frequently share demurrage if it occurs. It is customary to exclude Sundays, Saturdays, and public holidays in the calculation of laytime (Wilson et al., 2004). Demurrage is a crucial factor in profit and loss management because it is directly related to the lost revenue for a grain terminal. For example, a demurrage of approximately 12–15 million KRW per day (24 h) is incurred in loading/unloading a 50,000 DWT grain carrier, which is equivalent to a Panamax class vessel. Demurrage is estimated to contribute 4–5% to the volatility of the total annual operating profits of a grain terminal. Such volatility is significant in the logistics industry, which is categorized as a "service industry." Owing to this volatility, grain terminals continue to implement various improvement measures to lower demurrage. As such, reducing demurrage is indispensable for operating grain terminals; however, many grain

^{*} Corresponding author.

E-mail address: kyeo@inu.ac.kr (G.-T. Yeo).

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terminal operators incur losses owing to their annual expenditure on account of demurrage.

Meanwhile, previous studies have examined grain terminals from several perspectives. For example, there are general studies on grain terminals (Goedhals-Gerber, 2016; Stankevych et al., 2019; Stankevych et al., 2021). Then, there are studies on loading/unloading at grain terminals (Veremeenko and Rogovenko, 2020; Jafari, 2013) and on improving loading/unloading at such terminals (Rudenko et al., 2022). Although it is important to identify and overcome obstacles in lowering demurrage at grain terminals, scholars have paid scant attention to this issue. Therefore, this study examines how to overcome obstacles in reducing demurrage at grain terminals. For the analysis, we employ the Consistent Fuzzy Preference Relations (CFPR) methodology, which can extract the knowledge and experience of experts.

2. Current status analysis

2.1. Current status of loading/unloading of grains

In Korea, grain terminals are located in Incheon, Pyeongtaek, Gunsan, Busan, and Ulsan. Approximately 60% of the demand for grains (e. g., mixed-feed factories) comes from the Seoul Metropolitan Area and Chungcheong Province. This is owing to the choice of ports of entry, considering the concentration of population in the metropolitan area and the logistics costs incurred by manufacturing companies. A grain terminal is a business with high entry barriers because it requires significant initial investments for securing dock facilities, constructing silos and additional facilities, and introducing ship unloaders. Besides, it is difficult to gain know-how on silo operations. Consequently, only eight operators are in operation as of 2023. These grain terminal operators handle more than 90% of imported grain volumes using silos. (Table 1).

The volume of grains handled has reached approximately 15 million tons per year, with a compound annual growth rate of approximately – 1.19%. Although grain production and supply have fluctuated in recent years owing to the Russian-Ukraine war and climate change, there are many positive factors in the market, such as higher feed purchasing power owing to a gradual increase in domestic meat consumption.

2.2. Current status of grain terminals

In Korea, eight companies currently operate grain terminals. Terminals with large-scale loading/unloading and storage facilities are concentrated in ports on the west coast of the country, such as Incheon, Pyeongtaek, and Gunsan. This is because most demand for grains comes from the Seoul metropolitan area and Chungcheong Province. Incheon Port handles the largest volume of grains within the country, with five operators operating grain terminals at this port. A grain terminal consists of storage facilities called silos, conveyors that transport cargo unloaded from a wharf to silos, ship unloaders that unload grain cargo, and stock and release facilities and systems for stored cargo. Unlike general docks that handle general bulk cargo, grain terminals are often built as dedicated docks because they require large-scale investments in facilities, such as silos and conveyor belts. Furthermore, as corn and wheat account for a significant portion of imported grains in Korea, only two-three types of cargo are handled at grain terminals in the country.

Table 1
Grain volumes handled per year port-wise (units: thousand tons).

	2020	2021	2022	Total
Incheon Port	5523	5697	5745	16,967
Pyeongtaek Port	3003	2453	2328	7787
Gunsan Port	4284	4544	4361	13,190
Ulsan Port	1561	1687	1532	4780
Busan Port	1327	1222	1176	3725
Total	15,698	15,603	15,142	46,449

Source: Korea Port Logistics Association

Table 2

Current status of the grain terminal at Incheon Port.

	Hanjin Logistics	Sun Kwang	CJ Logistics	Korea Silo	TBT Korea
Scale	200,000 tons	270,000 tons	110,000 tons	300,000 tons	150,000 tons
Year of completion	1987	1985	1988	1975	1982
Belt length	2000 m	1500 m	554 m	1000 m	271 m
Loading and unloading equipment (tons/H)	800 × 1	800 × 1 200 × 1	800 × 1	750 × 1 400 × 2	750 × 2 360 × 1
Length of berth	225 m × 1	280 m × 1	225 m × 1	300 m × 2	300 m × 2

Source: The website of grain terminal operators

Table 3

Current status of grain terminals at other ports.

	Sun Kwang (Gunsan Port)	Taeyoung Grain Terminal (Pyeongtaek Port)	Taeyoung Industry (Ulsan Port)	KCTC Silo (Busan Port)
Scale	700,000 tons	420,000 tons	190,000 tons	130,000 tons
Year of completion	2019	2011	1986	1975
Belt length	1400 m	1500 m	554 m	1000 m
Loading and unloading equipment (tons/H)	700 × 3 600 × 1	800 × 2 400 × 2	750 × 2 700 × 1	800 × 1
Length of berth	225 m × 2	230 m × 2	230 × 1	270 m × 1

Source: The websites of these grain terminal operators

(Tables 2 and 3).

Statistics indicate that South Korea's grain self-sufficiency rate is 21.8%, which is remarkably lower than that of the major advanced countries (e.g., United States, Canada, Australia, etc). their grain self-sufficiency rate is 45% on average. Approximately 12 million tons of feed grain are imported annually in Korea. Given the extremely low rate of self-sufficiency in grains, grain terminals are the only hubs where stockpiles can be brought. As seen in the Russia-Ukraine war, a war, epidemic, or economic sanctions can directly affect South Korea in terms of its grain self-sufficiency. In this regard, it has been reported that the Korean government is currently considering the security of additional grain hubs in the Seoul metropolitan area, and major Korean companies are also actively engaged in grain terminal M&A and the security of shares in Ukraine and the United States.

2.3. Demurrage expenditure status at grain terminals

Demurrage is a type of compensation paid to shipping companies in the case of a failure to load or discharge a ship within the agreed time. When loading/unloading grains in Korea, it is common for shippers and operators (grain terminals) to share demurrage if it occurs. As demurrage is an operating loss for a grain terminal and a burden on shippers, finding ways to reduce demurrage is crucial.

Various factors affect the occurrence of demurrage, such as an unexpected bulk purchase of raw materials owing to lower international grain prices by a shipper, a mother ship waiting at outer ports owing to a surge in import volumes, a port's berth availability, the storage capacity of a grain terminal, and the frequency and volume of the release of stored inventory. As many obstacles that can trigger demurrage cannot be managed by a grain terminal, demurrage is considered an operational risk.

As shown in Table 4, there were more demurrage occurrences in some ports. At Pyeongtaek Port, approximately KRW 6.4 billion worth of demurrage has occurred in the last five years as of 2022, which

Table 4

Occurrence of and expenditures related to demurrage year-wise (Unit: USD 1000).

Year	Incheon Port		Pyeongtaek Port		Ulsan Port		Busan Port		Gunsan Port	
	No. of cases	Amount	No. of cases	Amount	No. of cases	Amount	No. of cases	Amount	No. of cases	Amount
2022	-	-	7	968	-	-	7	757	-	-
2021	-	-	1	49	-	-	2	84	-	-
2020	-	-	15	1987	-	-	5	200	-	-
2019	-	-	10	615	-	-	1	14	-	-
2018	2	25	13	1208	1	1	2	103	2	69
Total	2	25	46	4827	1	1	17	1158	2	69

Source: The Korea Feed Association

negatively affected the finances of grain terminal operators. Further, it deteriorated shippers' trust in the port and resulted in a loss of business opportunities for the port. This also suggests that studies should be conducted on whether the frequency of demurrage is dramatically different for each port, despite similar berth sizes and storage facilities.

3. Literature review

The grain shipping industry has witnessed a notable upswing over the decades. Therefore, the aspects pertaining to logistics, management, and structure of grain terminals have motivated numerous studies regarding grain terminals impact on the overall supply chain.

Adequate handling and storage capacity are essential for operational efficiency, minimizing delays and demurrage, and successfully manage seasonal fluctuations. Goedhals-Gerber (2016) approached the issue of expansion or upgrade of the Port of Cape Town by considering its current and forecasted capacity to handle the volumes of imported grains using the Box-Jenkins method. Meanwhile, the specification level of a terminal's unloading equipment remains a key issue in a grain terminal's design. Rudenko et al. (2022) compared the Pareto-optimal options for building a terminal with different equipment configurations and concluded that increasing the equipment capacity reduced the average cargo processing time for requests in the queue, thereby increasing the cargo unit transshipment cost. Stankevych et al. (2020) explored the quantitative and qualitative characteristics of the technological process of receiving grain from a railway at an Ukrainian LLC grain terminal to improve its efficiency. Managerial risk, particularly risk related to a terminal's grain loading and unloading processes, has also been addressed by different authors. Veremeenko and Rogovenko (2020) assessed the failures of ground equipment at grain terminals using servicing vehicle process simulation modeling. Jafari (2013) identified and prioritized 22 potential risks linked to the process of discharging grain from a ship at the grain terminal of the Persian Gulf. Santos et al. (2018) evaluated the operational efficiency of 24 Brazilian intermodal grain terminals using Data Envelopment Analysis. The authors retrieved and later classified groups of large-scale terminals into terminals that implemented transshipment processes with a leadership strategy, and horizontally diversified small-scale terminals with a differentiation strategy. The regulatory aspects of grain terminal operations have also been addressed in literature. Stankevich et al. (2020) examined the formation of wheat shipload lots at Ukrlevatorprom's grain terminal and identified discrepancies between the contract-required quality parameters and the actual quality of wheat grain in some silos using a linear programming model.

Recent literature on detention and demurrage (D&D) mostly comprises efficiency studies; it predominantly examines port congestion through different perspectives. Demurrage issues are often encountered in managerial studies. Yu et al. (2018) addressed an ocean carrier's decision about free detention time for containers and a hinterland container operator's decision on when to dispatch empty containers back to a sea terminal from an inland terminal. The findings demonstrated that higher profits were not assured by higher detention fee rates; the findings also explained the impact of slow hinterland

transportation on the ocean carrier's profit. Storms et al. (2023) addressed the organizational challenges faced by intermodal transportation that arise from a reduction in free time as opposed to an increase in demurrage fees. Ribeiro et al. (2016) examined a berth allocation problem that arose at a Brazil Ore Port terminal. The authors considered berth maintenance activities, demurrage, and dispatch values when managing vessels. Legislative research on issues related to demurrage is not so rare. Puti Diamar and An Chandrawulan (2020) presented the limitations of demurrage liability terms included in bills of lading and exception clauses related to laytime in Indonesia. Fazi and Roodbergen (2018) analyzed various D&D policies regarding the planning of intermodal transportation involving maritime containers at seaports and a final inland destination. The authors suggested combining a single free period for both demurrage and detention to relieve congestion at ports. With regard to studies tackling sustainability, Padayachee and Naude (2021) conducted a comparative analysis of implications for charter parties regarding laytime and demurrage provisions. The authors advised a collective redesign of a charter party's clauses by a global group of stakeholders.

By focusing on the general operation of grain terminals, previous studies mainly investigated these topics: grain throughput prediction at a grain terminal (Goedhals-Gerber, 2016) and efficient operations of a grain terminal (Wilson et al., 2020; Santos et al., 2018; Stankevich et al., 2020). However, no study has identified and focused on the obstacles to lowering demurrage at grain terminals. The findings of this study can be used as a reference by the staff at ports, terminals, and governments to reduce demurrage.

4. Research methodology

This study conducted an analysis using the CFPR methodology to identify obstacles in lowering demurrage at domestic grain terminals. First proposed by Herrera-Viedma et al. (2004), the consistent fuzzy preference relation (CFPR) method establishes pairwise-comparison preference decision matrices to determine the priority of selected factors. This method was applied to reduce wavering and inconclusiveness in preference evaluation, as it offers consistency in the decision-making process and a higher response rate owing to a short questionnaire.

This study followed the key definitions and propositions previously introduced by Chao and Chen (2009), Wang and Lin (2009), and Chang et al. (2013) by utilizing multiplicative and fuzzy preference relations.

A determined number of experts ($E = \{e_1, e_2, \dots, e_m, m \geq 2\}$) in the multiplicative preference relation, Eq. (1), indicates their choices for a finite set of alternatives (X).

($X = \{x_1, x_2, \dots, x_n, n \geq 2\}$) is denoted by a preference relation matrix $AX \times X, A = (a_{ij}), \forall i, j \in \{1, \dots, n\}, a_{ij} \in [\frac{1}{5}, 5]$. a_{ij} refers to the preference ratio of the alternative x_i to the alternative x_j . In this Equation, $a_{ij} = 1$ indicates the equivalence of x_i and x_j , and $a_{ij} = 5$ indicates that x_i is preferred over x_j . Therefore, A is a multiplicative reciprocal.

$$a_{ij} \times a_{ji} = 1 \forall i, j \in \{1, \dots, n\} \quad (1)$$

Meanwhile, the fuzzy preference relation, Eq. (2), shows the preference ratio of alternative x_i over x_j , and X is indicated by a positive

relation matrix $P \in X \times X$ with a membership function $\mu_p(x_i, x_j) = p_{ij}$ with the membership function. Furthermore, $p_{ij} = \frac{1}{2}$ indicates that indiscrimination exists between x_i and x_j ($x_i \sim x_j$), while $p_{ij} = 1$ indicates that x_i is preferred over x_j . In addition, $p_{ij} = 0$ indicates that x_j is absolutely preferred over x_i ; $p_{ij} \geq \frac{1}{2}$ indicates that x_i is preferred over x_j . P is an additive reciprocal.

$$p_{ij} + p_{ji} = 1 \forall i, j \in \{1, \dots, n\} \quad (2)$$

The decision matrix of CFPR is constructed based on the following propositions.

Proposition 1. Assume a set of alternatives $X = \{x_1, x_2, \dots, x_n\}$ related to $A = (a_{ij})$, which is a multiplicative preference relation, with $a_{ij} \in [\frac{1}{5}, 5]$. The reciprocal additive preference is expressed in Eq. (3).

$$p_{ij} = g(a_{ij}) = \frac{1}{2}(1 + \log_5 a_{ij}) \quad (3)$$

In Eq. (3), g stands for a transformation function, and $\log_5 a_{ij}$ corresponds to the use of $a_{ij} \in [\frac{1}{5}, 5]$.

Proposition 2. In this reciprocal fuzzy preference relation, $P = g(A)$, $P = p_{ij}$ is equal to the following.

$$p_{ij} + p_{jk} + p_{ki} = \frac{3}{2} \forall i, j, k \quad (4)$$

$$p_{ij} + p_{jk} + p_{ki} = \frac{3}{2} \forall i, j, k \quad (5)$$

Proposition 3. Reciprocal Additive Fuzzy Relation. $P = (p_{ij})$ corresponds to Eq. (6).

$$p_{ij} + p_{jk} + p_{ki} = \frac{3}{2} \forall i, j, k$$

$$p_{i(i+1)} + p_{i(i+1)(i+2)} + \dots + p_{j(i-1)} + p_{ji} = \frac{j-i+1}{2} \forall i, j \quad (6)$$

However, according to Herrera-Viedma et al. (2004), a linear transformation $f: [-a, 1+a] \rightarrow [0, 1]$ is essential when the preference matrix includes values present in the interval $[-a, 1+a]$, but not contained within the interval $[0, 1]$. The transformation function is expressed as:

$$f(p_{ij}^k) = (p_{ij}^k + a) / (1 + 2a) \quad (7)$$

where a is the absolute minimum negative value in the preference mix.

5. Empirical analysis

5.1. Factor selection

We conducted a literature review, applied data from the websites of grain terminal operators and company introduction materials, and collected related factors to derive a total of sixteen core factors assumed to be necessary for reducing demurrage. Then, we determined a total of 12 factors after interviewing the working-level staff of these companies: five companies (CJ Logistics, HANJIN Logistics, SUN KWANG, TBT Korea, and KOREA SILO) at Incheon Port, two companies (Taeyoung Grain Terminal and PYEONG TEAK SILO) at Pyeongtaek Port, one company (TAE YOUNG INDUSTRY) at Ulsan Port, one company (SUN KWANG) at Gunsan Port, and one company (KCTC SILO) at Busan Port. (Table 5).

The survey targets were selected based on the following criteria. First, we selected one company to represent each port based on the volumes treated by eight companies in the grain terminal business. At

Table 5
Obstacles to reducing demurrage at grain terminals.

No.	Factor	Definition of factors
1	Climate (typhoon, rain, etc.)	The climate (precipitation frequency) of a port significantly impacts the calculation of demurrage. (According to the contract for loading and unloading, rain and snowfall are also counted in laytime)
2	(Planning) water depth	Depending on the water depth of a port, the size of a ship to be berthed varies, and this size affects congestion at a port, as it is related to the port time and work time.
3	Ship size	The port time varies in a port based on the size of a ship.
4	Port congestion	When ships arriving at a port bring goods in a volume greater than a port's capacity to handle, waiting at outer ports becomes severe, which causes demurrage.
5	Specification of loading/unloading equipment	As for cranes and unloaders, loading/unloading has a great influence on unit productivity (e.g., 800 tonnage unloading/Hour).
6	Capacity of storage facilities	The capacity of grain storage silos and open-air storage yards affect the continuity of loading/unloading work.
7	International situation and seasonality	International situation (decline in grain prices) and seasonality (winter season) affect the volatility in grain imports by shippers.
8	Free time (Status of charging a storage fee)	If free time is not applied to stored cargo, storage fees are incurred, and at this time, a customer's shipping frequency will increase. When shipping frequency increases, the turnover rate of storage facilities increases, and the continuity of loading/unloading work increases.
9	Loading/unloading subtasks	Time required for maintaining an unloader, cleaning equipment (excavator), etc. (factors related to manpower)
10	Contract structure and types	Depending on the loading/unloading contract with a customer, the occurrence of demurrage and number of days vary (laytime conditions are different per contract).
11	Management/operation capacities of companies for loading and unloading	There is a difference in productivity depending on the know-how of equipment operators and loading/unloading supervisors who direct/control the overall loading/unloading work.
12	Inventory requirements of grain shippers	The delivery schedule for stored cargo is determined by a shipper's production schedule, which is a difficult factor for loading/unloading companies to control.

Incheon Port, five companies currently operate grain terminals. Among them, HANJIN Logistics was selected. HANJIN Logistics ranks second in terms of the volume of goods transported through Incheon Port. However, KOREA SILO, which ranks first in terms of volume, was not selected because it specializes in procuring and storing raw materials necessary for a parent company's milling business; therefore, it does not meet the purpose of a grain terminal as a logistics service provider.

As the second survey target group, we selected general companies involved in loading/unloading at general cargo wharves, rather than at a grain terminal. This is because the loading/unloading work is specialized at grain terminals, which is handled by unloaders and belt conveyors. Although loading and unloading companies work in a different manner, we tried to accommodate their opinions, as they also deal with laytime and demurrage.

We chose shipping companies engaged in the maritime transportation of grains as the third survey target. As the finance of shipping companies is directly affected by dispatch money and demurrage in loading and unloading, we assumed that it was possible to obtain significant results through questionnaires, considering that we attempted to examine the viewpoint of grain terminals toward demurrage, and shipping companies' viewpoint in demurrage.

A group of shippers was selected as the fourth survey target because they import grain and produce feed. When demurrage is incurred, this group is obligated to pay it together with loading and unloading companies. As demurrage is a sunk cost that occurs without any fault of a shipper, often shippers react sensitively to the occurrence of demurrage.

Finally, we selected a group representing the interests of shippers importing grains, such as the Korea Feed Association and Korea Corn Processing Industry Association. In fact, this group is similar to shippers in terms of its business.(Table 6).

5.2. Factor analysis results

The questionnaires were distributed among companies targeted for the survey, and the responses from those companies were collected. Table 7 presents a summary of the survey responses.

Table 8 shows the ranking of the importance of obstacles in lowering demurrage at grain terminals in South Korea. The inventory requirements of grain shippers ranked first among the 12 obstacles, with an importance of 0.097. This is followed by the capacity of storage facilities (with an importance of 0.091) and port congestion (with an importance of 0.090), which ranked second and third, respectively.

The basic process of a grain terminal is to store grain stocks that have been imported and loaded/unloaded in grain silos and take them out frequently according to a shipper's inventory requirements. The implication of this process is that a shipper's inventory requirements (the frequency or scale of discharging from stored stocks) determine a silo's stocking rate, and the level of stocking rate directly affects the ability to attract new mother ships to load/unload and the port time of mother ships. For example, if a grain terminal with a capacity of 200,000 tons has a current stocking rate of 190,000 tons (95%), and a new 40,000-ton mother ship loads/unloads goods, the loading/unloading work can be

Table 6
Target companies of the survey.

No.	Classification	Name of companies	Details
1	Grain terminals (Silo Operators)	HANJIN Logistics Inc.	Inchon port's grain terminal operator
2		SUN KWANG Inc.	Gunsan port's grain terminal operator
3		Taeyoung Grain Terminal	Pyeongtaek port's grain terminal operator
4		KCTC SILO	Busan port's grain terminal operator
5	General companies for loading and unloading	TAE YOUNG INDUSTRY	Ulsan port's grain terminal operator
6		CJ Logistics	General companies for loading and unloading grains
7		SEBANG Inc.	
8		Dongwon LOEX	
9		Pan Ocean	Companies transporting grains/subsidiary materials for feed grains
10		HYUNDAI GLOVIS	
11		Korea Line Corporation	
12	Grain shippers	Nonghyup Feed	Shippers importing grains/subsidiary materials for feed grains
13		CJ CheilJedang	
14		DAEHANFEED	(Mixed feed manufacturers)
15	Others	Korea Feed Association	Grain shipper interest groups
16		Korea Corn Processing Industry Association	Grain shipper interest groups

Table 7
Summary of survey and survey targets.

Survey period	Year of work experience of the 7 targets	Number of forwarded questionnaires	Number of collected questionnaires	Collection rate (%)
Jun 1, 2023	More than 15 years	10	9	90
-	10 to 15 years	10	3	30
Jun 30, 2023	Less than 10 years	10	7	70

Table 8
Ranking of the importance of obstacles.

Factor	Importance	Ranking
Inventory requirements of grain shippers	0.097	1
Capacity of storage facilities	0.091	2
Port congestion	0.090	3
International situation and seasonality	0.090	4
Status of charging a storage fee (Free Time)	0.089	5
Contract structure and types	0.086	6
Management/operation capacities of companies for loading and unloading	0.082	7
Water depth	0.080	8
Specification of loading/unloading equipment	0.080	9
Work of loading/unloading units	0.077	10
Climate (typhoons, rain, etc.)	0.074	11
Ship size	0.064	12

completed when 30,000 tons of inventory is discharged. Under these circumstances, if there is a shortage of inventory discharge, loading and unloading process may have to be suspended, and there is a direct causal relationship between laytime and the occurrence of demurrage. Some grain terminals charge storage fees to encourage shippers to quickly deplete their inventory. However, this study's analysis indicates that a shipper's inventory depletion is a crucial factor in lowering demurrage, as shown in Table 8. This is because the depletion of stored inventory depends on the will of a shipper and it is difficult to manage directly at a grain terminal. This is why it was found to be highly important.

The second priority is the capacity of storage facilities. Unlike general bulk cargo wharves, grain terminals have a limited storage capacity. In general bulk cargo wharves, it is possible to rent wharves temporarily in the case of loading/unloading that exceeds the storage capacity and flexibly respond to accommodating loading/unloading volumes through (on-site) transportation to backyard storage. However, as most grain terminals show loading/unloading patterns through unloaders and conveyors, the capacity of the storage facility is strongly linked to loading/unloading productivity. In other words, the capacity of a storage facility determines the ordinary stocking and turnover ratios, and these two factors also affect the loading/unloading productivity per unit of time.

The third priority is port congestion, which should be interpreted from a port's location perspective rather than from the loading/unloading capacity and storage facilities of grain terminals. For example, Inchon Port has five grain-terminal operators. Therefore, even in situations when there is a concern about a temporary increase in loading/unloading time and oversupply, it is possible to solve the problem at a practical level by adjusting the berthing schedule through consultation between shippers, suppliers, and grain terminals and by changing the order of motherships among operators. However, Pyeongtaek Port has only one grain terminal, while the demand for domestic grain is concentrated in ports in the Seoul metropolitan area and on the west coast of Korea. Therefore, there is a constant demand for large motherships to load/unload goods throughout the year. This naturally leads to an intensified phenomenon in which ships scheduled to load/unload must wait at outer ports. No matter how excellent a

terminal's loading/unloading capacity, storage facilities, and inventory turnover ratio are, the number of ships that can be simultaneously berthed at the terminal is limited because of the limited number of berths, resulting in the inevitable situation of port congestion. Therefore, port congestion is an obstacle in reducing demurrage.

In addition, the ranking of importance was derived in this order: international situations and seasonality, status of charging a storage fee, and contract structure and types. As a result, the individual importance of these factors may be relatively significant, but a combination of these factors contributed to incurring demurrage. However, climate and ship size were the lowest-ranked factors. A common feature of these factors is that they are exogenous variables that cannot be managed by grain terminal operators and shippers. In the overwhelming majority of loading/unloading contracts in Korea, it is customary to include a clause indicating that laytime is not counted during periods of sudden rain and snowfall, in case work is suspended owing to these reasons. Therefore, these perceptions were reflected in the survey results. Finally, ship size was ranked the lowest, which can be owing to the differential application of laytime based on ship size. In other words, as for the ship size, laytime is determined by loading/unloading volume (Bill of lading volume); the smaller the ship loading and unloading goods, the shorter the laytime. There may be differences in the equipment and manpower required depending on the ship size; however, this is assumed to have little significant impact on reducing demurrage from an operator's perspective.

6. Conclusion

In contrast to container terminals, grain terminals are hubs for loading and unloading imported and exported cargo, along with storing inventory for long periods through silos, which is important from a logistics viewpoint. The occurrence of demurrage is a negative factor not only for grain terminal operators but also for shipping companies in terms of the loss of business opportunities. This is because, in addition to grain terminal operators, shippers are also exposed to the risk of unnecessary cost increases. Therefore, continuous reductions in demurrage is important.

Against this backdrop, this study focused on analyzing obstacles in reducing demurrage at grain terminals in Korea. Our literature review showed that several studies have identified factors influencing demurrage and time-saving measures. However, no study has identified factors functioning as obstacles in reducing demurrage at grain terminals. Therefore, this study identified obstacles through in-depth interviews with stakeholders and clarified the rankings of the obstacles based on a survey of experts in the field.

The findings of this study can be summarized as follows. First, among the 12 extracted factors, "inventory requirements of grain shippers" was found to be the first factor with an importance of 0.097, followed by "capacity of storage facilities" and "port congestion" as the second and third factors, respectively. Second, "climate (typhoon, rain, etc.)" and "ship size" were found to rank 11th and 12th; as these are exogenous factors that are difficult to control at grain terminals by shippers and operators, they ranked low. Third, the factors that are variable or difficult for shippers to control were recognized as important obstacles in demurrage reduction at grain terminals, rather than factors that are directly related to cost.

This study was conducted as a basic research, as relevant previous studies on demurrage reduction at grain terminals are still insufficient. Therefore, it could not include the responses of a wide range of practitioners in the analysis. Future studies should consider the opinions of stakeholders from diverse groups to extend this research.

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