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Analysis of Internal and External Factors Affecting Liquid Chemical Cargo Port Efficiency

Sıvı Kimyasal Liman Verimliliğini Etkileyen İç ve Dış Faktörlerin Analizi

Türk Denizcilik ve Deniz Bilimleri Dergisi

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ABSTRACT

The measurement of port efficiency is a crucial requirement in the maritime sector and has been the subject of numerous studies due to its direct impact on international trade. The methods used to determine port efficiency vary depending on the characteristics of the operations under investigation. Depending on which port operations are assessed, port adequacy can be measured in various ways. In the literature, it is evident that port efficiencies are mostly determined using numerical methods. However, when analyzing port efficiency, measuring it solely through numerical processes can lead to misleading results in some cases. To avoid this, it is necessary to analyze non-numerical internal and external factors that affect port efficiency. In this study, non-numerical internal and external factors influencing port efficiency in liquid chemical cargo ports were identified through a literature review and by experts. The identified factors were evaluated through surveys conducted with experts specializing in liquid chemical cargo ports. The survey results were analyzed using SPSS 21.0 statistical software. According to the results obtained from the surveys, factors such as the location and dimensions of the port area, the adequacy of hinterland connections and logistic facilities, well-organized physical surroundings of the port, the use of technological innovations, and the proper functioning of the quality control system were identified as significant factors affecting port efficiency. In addition to these factors, accurate job analysis in the port, satisfactory wages, sufficient education levels, and morale of port personnel were also found to be crucial factors influencing port efficiency.

Keywords: Port efficiency, Liquid chemical cargo ports, Port analysis, Efficiency analysis

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ÖZET

Liman verimliliği ölçümü, denizcilik sektöründe önemli bir gereksinimdir ve uluslararası ticareti doğrudan etkilediği için birçok çalışmanın konusu olmuştur. Liman verimliliğini belirlemek için kullanılacak yöntemler, limanın incelenecek operasyonel özelliklerine göre değişiklik göstermektedir. Hangi liman işlemlerinin değerlendirildiğine bağlı olarak, liman yeterliliği birçok şekilde ölçülebilir. Literatürde liman verimliliklerinin daha çok sayısal yöntemler kullanılarak belirlendiği görülmektedir. Ancak liman verimliliğini analiz ederken, verimliliği sadece sayısal işlemlerle ölçmek bazı durumlarda yanıltıcı sonuçlara yol açabilir. Bu durumdan sakınmak için liman verimliliğini etkileyen ancak sayısallaştırılamayan iç ve dış faktörlerin analiz edilmesi gereklidir. Bu çalışmada sıvı kimyasal yük limanlarında, liman verimliliğini etkileyen ancak sayısallaştırılamayan iç ve dış faktörler literatür taraması ve uzmanlar tarafından belirlenmiştir. Belirlenen faktörler sıvı kimyasal yük limanları konusunda uzmanlaşmış kişilerle yapılan anketler yoluyla değerlendirilmiştir. Anket sonuçları SPSS 21.0 istatistiksel yazılımı kullanılarak değerlendirilmiş olup değişkenlerin ortalamaları ile standart sapmaları belirlenmiştir. Anketlerden elde edilen sonuçlara göre liman sahasının yeri ve boyutları, arka saha bağlantılarının ve lojistik tesislerin iyi düzeyde olması, limanın fiziksel çevresinin iyi düzenlenmiş olması, teknolojik yeniliklerin kullanılması ve kalite kontrol sisteminin düzgün işlemesi liman verimliliği açısından önemli faktörler olarak tespit edilmiştir. Bu faktörlerin yanı sıra limanda iş analizinin doğru yapılması, limanda çalışan personelin aldığı ücretin, eğitim düzeyinin ve moral seviyesinin yeterli olması da liman verimliliğini etkileyen önemli faktörler olarak bulunmuştur.

Anahtar sözcükler: Liman verimliliği, Sıvı kimyasal yük limanları, Liman analizi, Verimlilik analizi

1. INTRODUCTION

Ports are natural or artificial coastal structures protected from wind and sea effects, equipped with adequate water depth, technical and social infrastructure facilities, management, support, maintenance, and storage units, allowing ships to embark and disembark passengers and cargo, load and unload, berth, and await (Ministry of Maritime Affairs, 2010).

Ports are recognized as critical components of international transportation. Due to their role as the most critical nodes in transportation, ports play a vital role in global trade, forming a crucial link within the world trade (Wang, 2011).

Recent years have witnessed a significant increase in global economic developments, trends towards liberalization in world trade, and the proliferation of the international division of labour. Consequently, the port sector has become one of the fastest-growing sectors. Reduction in tariff barriers is particularly boosting port trade, especially in many parts of the world. This makes the port sector a driving force for economic development (Reel and Terzi, 2008).

Efficiency is a key competitive advantage for most ports worldwide (Ghiara and Tei, 2021). Efficiency is the optimal utilization of all available resources by businesses to gain a competitive advantage. Efficiency measurement involves systematically collecting and analyzing data, and then reporting the findings regularly. This process helps businesses or organizations keep track of the resources used, as well as the products, services, and outputs they generate (Ersoy, 2021).

Port efficiency has become a significant concern in the modern world, primarily due to the increase in international trade (Barros and Athanasious, 2004). Ports play a crucial role in the efficiency of a country's transportation network (Oliveira and Cariou, 2011). The proper execution of services in ports positively influences the entire transportation service, while inadequately met services can adversely affect the entire system.

Inefficiently operating ports have the potential to prolong the delivery times of goods, which, in turn, results in a reduction in competitiveness in international trade for national economies. Consequently, in today's world, the efficient and effective operation of ports has become an

imperative (Çağlar *et al*., 2010).

The methods used to determine port efficiency vary depending on the specific characteristics of the port operations under investigation. Depending on which port processes are being evaluated, port competency can be measured in various ways. Furthermore, since there are multiple port users with different and sometimes conflicting interests, ports can also be examined from various perspectives. For instance, a port may be deemed efficient for shipowners but may be considered inadequate according to the interests of cargo owners. Therefore, port competency cannot be determined based on a single criterion alone. A meaningful assessment of port competency will require a set of indicators relating to various aspects of port operations. These competency indicators can be classified as operational competency measures and customer-oriented measures. The former category pertains to the use of productive assets such as cranes, piers, labor, and vessels. The latter category covers issues such as port charges, shorter vessel turnaround times, reduced cargo handling times, and reliability (Bolat, 2010).

As with all businesses, the location and size of ports have a significant impact on efficiency. Therefore, the selection of a suitable location for a port must adhere to certain criteria. Ports should be placed in areas with ample hinterlands. This necessitates the selection of areas with favorable traffic demand and natural conditions for transportation. Additionally, having the capacity to accommodate suitable equipment, cargo, etc., to meet demand is a vital factor in terms of efficiency. From a marketing perspective, the hinterlands come into play once again. Furthermore, inter-port competition is considered. Factors such as pricing policy and the use of fast and modern equipment also expand the marketing dimensions. Another crucial factor for the efficiency of ports is technical aspects, encompassing technology, work studies, quality control, and ergonomic considerations. The stronger the technical infrastructure of a port, the more robust its capacity to meet demands. Ports that efficiently meet demands operate effectively. Inadequate technical infrastructure leads to decreased efficiency in ports.

In line with all other businesses, ports are influenced by psychological and social factors. Factors such as employee training, an efficient organizational structure that indicates clear delegation of authority, wages, and service fees significantly impact efficiency. Moreover, employee morale and motivation can bring about significant changes. Additionally, free market conditions, the financial resources of the port, and financial policies also have a substantial impact on efficiency (Bayar, 2005).

Due to its significant role in international trade, the determination of port efficiency has been the subject of many studies. Liu (1995) conducted a study in the United Kingdom, using data from 28 ports for the years 1983-1990, and attempted to determine the impact of ownership type on port performance through stochastic frontier analysis. Martinez-Budria *et al*. (1999) found that the highest level of efficiency is observed in ports with high complexity structures, while the lowest efficiency is observed in ports with low complexity structures.

Notteboom *et al*. (2000) determined that container ports located in the north of Europe are more efficient compared to those in the south, while centrally located ports are more efficient than feeder ports. Coto-Millan *et al*. (2000) and Cullinane *et al*. (2006) have stated that ports with high handling volumes have high technical efficiency but lower scale efficiency, resulting in lower overall efficiency. Tongzon (2001) and Cullinane *et al*. (2004), in their studies, concluded that there is no relationship between efficiency and port size, and cargo handling volume. Oliveira and Cariou (2011) examined 122 ports in multiple countries and found a significant relationship between the output variable they used, which is the volume of cargo handled, and the efficiency value. In a study comparing the relative efficiency of North American and European ports, Port Klang, Johor, and Charleston ports were found to be efficient (Valentine and Gray, 2000). In a study conducted to examine the efficiency of Japan's 8 major container ports, the efficiency of the ports between 1990 and 1999 was calculated. As a result of the study, it was determined that the Yokohama, Osaka, and Kobe ports had low efficiency, while the Tokyo and Nagoya ports

had high efficiency (Itoh, 2002). Estache *et al*. (2002) conducted a study to determine the efficiency of 11 ports in Mexico between 1996 and 1999. Cullinane *et al*. (2002) aimed to determine whether there was a relationship between the efficiency of ports and their ownership and administrative structures. They found that port efficiency was closely related to port size, and private ports were more efficient compared to public ports.

Ateş (2010) conducted a study on the efficiency of container terminals in Turkey, using data from the years 2005 to 2009. In research aimed at determining the efficiency of container ports in the Mediterranean and Black Sea regions, including some ports from Turkey, the efficiency values of a total of 30 ports were measured using Data Envelopment Analysis (DEA) (Niavis and Tsekeris, 2012). In a study conducted by Çağlar (2012) to measure the efficiency of container, general cargo, and dry cargo ports in Turkey, 9 out of 13 container ports were found to be efficient. He identified eighteen non-quantifiable factors that affect efficiency in Turkish dry cargo and container ports. He conducted interviews with expert port workers using an interview form prepared based on these factors. He argued that relative analysis methods alone were not sufficient to determine the potential of port operations. In the study conducted by Bayar in 2005, it was determined that the Haydarpaşa and Derince ports, which share the same catchment area for container handling in Turkey, operate with lower efficiency.

It is observed that studies on port efficiency in the world and Turkey are predominantly focused on container terminals. In addition, a limited number of studies have investigated the efficiency of ports handling bulk cargoes. However, in the literature, it is evident that there are very few studies conducted on the efficiency of ports handling liquid chemical cargoes. Therefore, it is understood that this study on the efficiency of liquid chemical cargo ports in Turkey is of great importance.

2. MATERIALS AND METHODS

When analyzing port efficiency, measuring it solely through quantitative processes can lead to misleading results in some cases. To avoid this situation, it is necessary to analyze the non-digitizable internal and external factors that influence port efficiency. One of the most effective ways to do this is through surveys and interviews conducted with experts in the field. In this study, non-numerical internal and external factors influencing port efficiency in liquid chemical cargo ports were identified through a literature review and by experts. The identified factors were evaluated through surveys conducted with experts specializing in liquid chemical cargo ports. SPSS 21.0 statistical software was used for the evaluation of the survey results, and the means and standard deviations of variables were determined.

To qualitatively assess the efficiency of liquid chemical cargo ports, factors influencing port efficiency that cannot be measured quantitatively were identified. A structured interview form was prepared to facilitate the assessment of these factors by experts in the field. The expressions used in the interview were based on Frankel's (1987) work identifying factors influencing port efficiency. In this study, factors affecting port efficiency were categorized into five groups, namely, general factors, technical factors, social factors, psychological factors, and institutional factors (Table 1). The statements in the interview were prepared to align with these factors.

Table 1. Factors influencing port efficiency (Frankel, 1987)

General Factors	Technical Factors	Social Factors	Psychological Factors	Institutional Factors
Port location and dimensions	Technology	Education	Moral	Free market
Dimensions of marketing	Quality control	Organization	Motivation	Financial opportunities
	Work analysis	Fees		Financial policies
	Ergonomics			

The Likert-type questionnaire method was chosen as the data collection tool. The Likert scale is one of the most useful question formats (Likert, 1932). In the most used format of this scale, respondents are directed to indicate their level of agreement with each statement. In short, an individual is presented with a statement and asked to express their level of agreement using a scale with three, five, or seven options (Tezbaşaran, 1997). In this study, a five-point Likert scale was chosen (Table 2). Since the Likert scale in the interview had five options, it was evaluated as follows: strongly agree=5, agree=4, neutral=3, disagree=2, and strongly disagree=1.

Therefore, it is possible to categorize the responses to interview questions into three groups. The "strongly agree" and "agree" options indicate a positive view, the "disagree" and "strongly disagree" options represent a negative view, and the "neutral" option signifies neutrality. Therefore, values with an average of 4.00 or above were considered to reflect a positive view, values below 2.00 were considered to reflect a negative view, and others were categorized as items indicating a neutral view.

In this study, expert opinion was used for the selection of the research sample. Interview forms were completed by 25 experts. Face-to-face interviews were conducted with experts from Evyap, Aksa, Aktaş, Altıntel, Koruma Klor, Poliport, Solventaş, Yılport, Martaş, and Akport ports, while data from 15 experts working in other ports were obtained via email. Care was taken to select experts with a minimum of ten years of experience in their respective fields, with a focus on general managers, assistant general managers, and operations managers during the phase of filling out the interview forms. The summary table for the experts who participated in the survey is presented in Table 3.

Table 2. Likert scale interview form example (Likert, 1932)

No	Statements	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	Statement 1			X		
2	Statement 2				X	
3	Statement 3		X			
4	Statement 4					X
5	Statement 5	X				

Table 3. Detailed information of experts

Expert	Title	Background	Experience
Exp-1	General manager	Bachelor's	22 years
Exp-2	General manager	Bachelor's	25 years
Exp-3	General manager	MSc	20 years
Exp-4	General manager	Bachelor's	24 years
Exp-5	General manager	MSc	20 years
Exp-6	General manager	Bachelor's	23 years
Exp-7	General manager	Bachelor's	22 years
Exp-8	Assistant general managers	Bachelor's	15 years
Exp-9	Assistant general managers	Bachelor's	18 years
Exp-10	Assistant general managers	Bachelor's	18 years
Exp-11	Assistant general managers	MSc	15 years
Exp-12	Assistant general managers	Bachelor's	14 years
Exp-13	Assistant general managers	Bachelor's	12 years
Exp-14	Assistant general managers	Bachelor's	19 years
Exp-15	Assistant general managers	Bachelor's	15 years
Exp-16	Operations manager	Bachelor's	10 years
Exp-17	Operations manager	Bachelor's	11 years
Exp-18	Operations manager	MSc	11 years
Exp-19	Operations manager	Bachelor's	13 years
Exp-20	Operations manager	Bachelor's	15 years
Exp-21	Operations manager	Bachelor's	15 years
Exp-22	Operations manager	MSc	14 years
Exp-23	Operations manager	Bachelor's	13 years
Exp-24	Operations manager	Bachelor's	12 years
Exp-25	Operations manager	Bachelor's	12 years

3. RESULTS AND DISCUSSIONS

A group of 25 experts were interviewed, and the average and standard deviation values of their responses to the interview questions are presented in Table 4. Based on the interview results, an analysis of the factors affecting the efficiency of ports handling liquid chemical cargo was conducted.

Statement 1: The average response to the first question in the interview form, which is "The location and size of the port area positively affect port efficiency," is 5, with a standard deviation of 0. Therefore, the statement is strongly supported by the experts. During the interviews, the experts emphasized that the location and size of the port area are one of the most significant factors affecting port efficiency. They highlighted that if the places where ships will berth are not constructed appropriately, there is insufficient manoeuvring space within the port, and intra-port transportation services are inadequate due to structural reasons, port efficiency will be negatively affected. The impact of port area and size on port efficiency is a consensus among the experts, and it applies not only to liquid chemical cargo handling ports but to all types of ports. Furthermore, it was mentioned that the location and size of the port area are crucial factors in the establishment phase of ports and in the selection of port locations.

Statement 2: The average response to the second question in the interview form, which is "Good marketing strategies of port operations positively affect port efficiency," is 4.56, with a standard deviation of 0.51. The responses indicate that experts support this statement. It was emphasized by the experts that in a competitive market, brand recognition is highly important. They stated that having adequate distribution channels and the ability to respond promptly to customer needs are directly related to port efficiency.

Table 4. Statistical information regarding responses to interview questions

No	Statements	Average	Standard deviation
Statement 1	The location and size of the port area positively affect port efficiency	5.00	0.00
Statement 2	Good marketing strategies of port operations positively affect port efficiency	4.56	0.51
Statement 3	Adequate education of port personnel positively affects port efficiency	4.52	0.59
Statement 4	A well-organized structure of the port operation positively affects port efficiency	4.64	0.64
Statement 5	Satisfactory wages for port personnel positively affect port efficiency	4.68	0.48
Statement 6	The use of technological innovations in ports positively affects port efficiency	4.72	0.46
Statement 7	Procedures related to ships by local authorities positively affect port efficiency	2.96	0.93
Statement 8	Proper job analysis in ports positively affects port efficiency	4.76	0.52
Statement 9	A well-organized physical environment of the port positively affects port efficiency (lighting, ventilation, sound, and noise)	4.72	0.68
Statement 10	Having a variety of cargo types positively affects port efficiency	2.92	0.99
Statement 11	Operating in a free-market economy positively affects port efficiency	4.24	0.97
Statement 12	Good hinterland connections (road, railway, etc.) positively affect port efficiency	5.00	0.00
Statement 13	The economic policies pursued by the port operation positively affect port efficiency	4.24	0.93
Statement 14	Delays caused by ships negatively affect port efficiency	3.64	0.86
Statement 15	The morale of port employees positively affects port efficiency	4.76	0.44
Statement 16	Slow and incomplete information sent by agents negatively affects port efficiency	4.52	0.65
Statement 17	The proper functioning of the quality control system in the port positively affects port efficiency	4.56	0.65
Statement 18	High port tariffs negatively affect port efficiency	2.68	0.99
Statement 19	The financial resources of the port operation positively affect port efficiency	4.08	0.95
Statement 20	Logistics facilities in the port hinterland providing a high level of service positively affect port efficiency	4.84	0.37
Statement 21	Adequate safety and security systems in the port positively affect port efficiency	4.44	0.65
Statement 22	Implementing day and night shifts at the port positively affects port efficiency	4.24	0.78
Statement 23	Government support for ports positively affects port efficiency	4.04	0.89
Statement 24	Global economic crises negatively affect port efficiency	4.60	0.71
Statement 25	The distance between the terminal and storage tanks affects port efficiency negatively	4.40	0.96

Statement 3: The average response to the third question in the interview form, which is "Adequate education of port personnel positively affects port efficiency," is 4.52, with a standard deviation of 0.59. The responses show that experts support this statement. The experts highlighted the need for personnel working in liquid chemical cargo ports to have special skills. They mentioned that special precautions are necessary due to the often-hazardous nature of the handled cargo. All the experts consulted emphasized the need for specialization in handling liquid cargo and noted that it takes a long time. They explained that the complexity of the handling processes in liquid chemical cargo ports is the reason for this. They also pointed out that personnel working in liquid cargo ports typically rise through the ranks and eventually reach the operator level over time. They mentioned that there could be a shortage of personnel, particularly at the operator level in the future. To address this, they suggested the opening of courses or departments related to liquid chemical cargo handling in educational institutions and the necessity of collaborative efforts between ports and schools to overcome this challenge.

Statement 4: The average response to the fourth question in the interview form, which is "A well-organized structure of the port operation positively affects port efficiency," is 4.64, with a standard deviation of 0.64. Based on the obtained data, it is understood that experts support this statement. Considering the complexity of port operations, it was argued that the decision-making structure should be well-defined. It was mentioned that the proper execution of tasks with a well-organized structure would positively affect port efficiency, preventing delays.

Statement 5: The average response to the fifth question in the interview form, which is "Satisfactory wages for port personnel positively affect port efficiency," is 4.68, with a standard deviation of 0.48. The responses indicate that experts support this statement. During the interviews, it was emphasized that a suitable wage policy should be followed to increase workforce efficiency and to motivate employees for the sake of work and the operation. It was suggested that the satisfactory wages received by port personnel and the recognition of their efforts would make them feel more secure and increase their commitment to the operation, which, in turn, enhances port efficiency.

Statement 6: The average response to the sixth question in the interview form, which is "The use of technological innovations in ports positively affects port efficiency," is 4.72, with a standard deviation of 0.46. Based on the data obtained, it is understood that experts support this statement. It was stated that the automation system is an essential element in ports handling liquid chemical cargo. Particularly, it was emphasized that, in most ports, operations are carried out more quickly and safely thanks to software containing unique features during cargo handling. It was highlighted that access to cargo movements and information is easy through special sensors in tanks, which is crucial for operators. It was also suggested that in technologically advanced ports, less labour can achieve more work compared to others, making technological innovations positively impact efficiency.

Statement 7: The average response to the seventh question in the interview form, which is "Procedures related to ships by local authorities positively affect port efficiency," is 2.96, with a standard deviation of 0.93. The responses indicate that experts hold a neutral view on this statement. During the interviews, it was stated that problems often arise between ports and local authorities. Generally, it was mentioned that procedures determined by local authorities, especially when evaluated in terms of environmental impact, slow down workflow in ports, which has a negative impact on port efficiency.

Statement 8: The average response to the eighth question in the interview form, which is "Proper job analysis in ports positively affects port efficiency," is 4.76, with a standard deviation of 0.52. The data obtained show that experts support this statement. The experts consulted emphasized the necessity of job analysis before any type of operation in liquid chemical cargo ports to ensure that tasks are carried out regularly and correctly. It was stressed that job analysis may vary for different cargo types due to the distinct characteristics of the handled cargo.

Statement 9: The average response to the ninth question in the interview form, which is "A well-organized physical environment of the port positively affects port efficiency," is 4.72, with a standard deviation of 0.68. Based on the data obtained, it is understood that experts support this statement. According to the experts, one of the most critical factors for ports to operate efficiently is the physical environment. It was stated that factors such as lighting, ventilation, noise, and sound may lead to stress levels for port employees, resulting in early fatigue. It was argued that physically and mentally tired personnel would work less efficiently in port operations, which would directly affect port efficiency. Additionally, it was noted that effective port lighting systems are crucial for safety, especially during nighttime operations.

Statement 10: The average response to the tenth question in the interview form, which is "Having a variety of cargo types positively affects port efficiency," is 2.92, with a standard deviation of 0.99. The responses indicate that experts hold a neutral view on this statement. In liquid chemical cargo ports, specific loading lines should be used for each cargo group. It was stressed that the most important issue during the handling of liquid chemical cargo is to avoid mixing cargo. Having a variety of cargo types and the absence of a dedicated loading line for each cargo would require handling from the same loading line. In this case, it is important to ensure that there are no residues from the previous cargo on the loading line, and the loading lines need to be thoroughly cleaned using special methods. Every part of the line, including valves, needs to be meticulously cleaned. It was pointed out that these procedures cause both time loss and excess labour.

Statement 11: The average response to the eleventh question in the interview form, which is "Operating in a free-market economy positively affects port efficiency," is 4.24, with a standard deviation of 0.97. The responses indicate that experts support this statement. Given that world trade and transportation activities are highly competitive, all ports are at the forefront of international competition. To overcome such a competitive environment, free-market economy policies that ports will adopt are crucial. The opinions of the experts consulted align with these statements.

Statement 12: The average response to the twelfth question in the interview form, which is "Good hinterland connections (road, railway, etc.) positively affect port efficiency," is 5, with a standard deviation of 0. The data obtained show that experts strongly support this statement. In today's port management, ports have become not only the places where cargoes are unloaded and loaded but also a hub where all modes of transport converge. To send cargoes to their destination quickly, it is crucial that the hinterland connections of the port are in good condition. Therefore, for cargo transport through ports, the hinterland connections must be well-maintained. All experts consulted during the interviews addressed these issues and expressed their full agreement with this statement.

Statement 13: The average response to the thirteenth question in the interview form, which is "The economic policies pursued by the port operation positively affect port efficiency," is 4.24, with a standard deviation of 0.93. Based on the data obtained, it is understood that experts support this statement.

Statement 14: The average response to the fourteenth question in the interview form, which is "Delays caused by ships negatively affect port efficiency," is 3.64, with a standard deviation of 0.86. The responses indicate that experts hold a neutral view on this statement. Experts mentioned that if a ship arrives late at the port, they replace it with another ship that is ready. The delayed ship is given a suitable date for a later time. In case of any delays at the port, they take the ships outside the port and wait at a suitable location. According to experts, delays caused by ships would affect the ship experiencing the delay rather than the port.

Statement 15: The average response to the fifteenth question in the interview form, which is "The morale of port employees positively affects port efficiency," is 4.76, with a standard deviation of 0.44. The responses indicate that experts support this statement. The experts consulted emphasized that the high morale of employees enhances efficiency, not only for liquid chemical cargo ports but for all businesses. They pointed out that in a task that requires

extreme attention, like handling liquid chemical cargo, any decrease in morale could lead to distraction and even irreversible damage from making mistakes without giving the necessary importance to the job.

Statement 16: The average response to the sixteenth question in the interview form, which is "Slow and incomplete information sent by agents negatively affects port efficiency," is 4.52, with a standard deviation of 0.65. Based on the data obtained, it is understood that experts support this statement. During the interviews, it was mentioned that external delays are often caused by incorrect information and documents sent by agents. It was particularly emphasized that errors in cargo information on ships could lead to significant changes in the operational planning made by the port, which could result in time loss. It was stated that errors made by agents are an uncontrollable factor, but they can be minimized with good coordination.

Statement 17: The average response to the seventeenth question in the interview form, which is "The proper functioning of the quality control system in the port positively affects port efficiency," is 4.56, with a standard deviation of 0.65. The responses indicate that experts support this statement. Experts emphasized that in a port, the proper functioning of the quality control system involves having defined procedures for all types of operations and guidelines for who does what and how. A well-functioning quality control system minimizes errors and deficiencies, ensuring that port operations are performed correctly. Thus, a properly functioning quality control system contributes significantly to port efficiency.

Statement 18: The average response to the eighteenth question in the interview form, which is "High port tariffs negatively affect port efficiency," is 2.68, with a standard deviation of 0.99. The responses indicate that experts hold a neutral view on this statement. Many of the experts stated that this statement might be valid for other types of ports but not for liquid chemical cargo ports. They mentioned that almost all liquid chemical cargo ports operating in the country are established and managed by companies to transport raw materials to their industrial facilities. In such a structure where the port carries its own cargo through its own port, port tariffs are of little importance, according to the experts.

Statement 19: The average response to the nineteenth question in the interview form, which is "The financial resources of the port operation positively affect port efficiency," is 4.08, with a standard deviation of 0.95. The responses indicate that experts support this statement. Experts mentioned that financially strong port operations can swiftly address problems that affect efficiency and require financial expenditures. A financially strong port operation is expected to work more efficiently compared to other port operations.

Statement 20: The average response to the twentieth question in the interview form, which is "Logistics facilities in the port hinterland providing a high level of service positively affect port efficiency," is 4.84, with a standard deviation of 0.37. The data indicate that experts strongly support this statement. During the interviews, it was emphasized that logistics facilities that provide support to the port are necessary for the continuous operation of port activities. Furthermore, to maintain the relationship between logistics facilities and the port, good connections like road and railway systems need to be well-established.

Statement 21: The average response to the twenty-first question in the interview form, which is "Adequate safety and security systems in the port positively affect port efficiency," is 4.44, with a standard deviation of 0.65. The data indicate that experts support this statement. To be a safe and reliable port in global and international trade, ports are required to make investments and arrangements related to safety and security in line with international obligations. According to the experts, safety and security measures are crucial, and a port with adequate measures would have fewer issues, making it more efficient.

Statement 22: The average response to the twenty-second question in the interview form, which is "Implementing day and night shift at the port positively affects port efficiency," is 4.24, with a standard deviation of 0.78. The responses indicate that experts support this statement. Experts pointed out that in liquid chemical cargo ports, handling operations are difficult and time-

consuming. Therefore, the biggest disadvantage that employees might face is sleeplessness and fatigue. The implementation of a day and night shift system can alleviate this issue, reducing the possibility of human errors in handling operations. It was emphasized that in a port with fewer errors, efficiency would be higher.

Statement 23: The average response to the twenty-third question in the interview form, which is "Government support to ports positively affects port efficiency," is 4.04, with a standard deviation of 0.89. The data show that experts support this statement. In their responses, the experts highlighted the importance of the government's role in reducing pressures on ports and working to eliminate bureaucratic obstacles.

Statement 24: The average response to the twenty-fourth question in the interview form, which is "Global economic crises negatively affect port efficiency," is 4.60, with a standard deviation of 0.71. The responses indicate that experts support this statement. Like in many other industries, experts acknowledged that economic crises have significant effects on the port sector, and global developments directly impact ports.

Statement 25: The average response to the twenty-fifth question in the interview form, which is "The distance between the terminal and storage tanks affects port efficiency negatively," is 4.40, with a standard deviation of 0.96. The data indicate that experts support this statement. Experts mentioned that as the distance between storage tanks and the terminal increases, there will be higher counterpressure when handling from the ships to the terminal, leading to longer operations. Additionally, an increased distance between the terminal and tanks may create a security vulnerability, albeit rare, sometimes leading to smuggling incidents.

When determining the efficiency of liquid chemical cargo ports, making decisions based solely on numerical data can sometimes lead to misleading results. In this study, through expert surveys conducted to evaluate non-quantifiable data, the location and dimensions of the port area were identified as one of the most important factors affecting port efficiency by experts. Furthermore, it was determined that the good condition of port hinterland connections and logistic facilities has a positive impact on port efficiency.

According to the expert interviews conducted, it was emphasized that the economic policies adopted by ports and the free-market economy also influence port efficiency. Ports are often complex facilities, and therefore, individuals working in such environments need to possess specific skills. It was supported by experts that individuals working in ports should have received adequate levels of education, and this would enhance port efficiency. It is predicted that in the coming years, there will be a shortage of personnel at the operator level in ports. Therefore, university-level programs need to be established to train a workforce capable of working at the operator level in liquid chemical cargo ports.

Results obtained from interviews with port experts indicate that the organizational structure of port operations is a crucial factor influencing efficiency. Additionally, it is of utmost importance that job analysis in ports is performed accurately to minimize errors that may occur in port operations. The expert opinions reveal that ports with fewer errors operate more efficiently. Furthermore, it was determined that having a workforce with sufficient capacity positively contributes to port efficiency, and that the morale, motivation, and financial satisfaction of employees also have a positive impact on efficiency.

Global economic crises lead to a reduction in cargo handling volume at ports, causing ports to operate well below their capacities. Consequently, port efficiency is adversely affected.

It has been established that an increase in the distance between the terminal and storage tanks in liquid chemical cargo ports has a negative impact on efficiency. This is due to the potential for increased counterpressure during cargo handling operations, leading to longer operation times and, consequently, time loss. Additionally, the diversity of cargo types handled in ports contributes to extended operation times, negatively affecting efficiency.

Local authorities' procedures negatively impact port efficiency, and the government's policies must reduce bureaucratic procedures at ports.

Furthermore, equipping ports with adequate safety and security systems is crucial to minimize complexity and job loss resulting from adverse incidents. Since the prevention of job loss directly affects port efficiency, necessary safety and security measures at ports should be organized according to international standards.

When the literature and previous studies are evaluated, there is no evidence of research specifically addressing the efficiency of liquid chemical cargo ports. Efficiency analyses in the literature have predominantly focused on container and dry cargo ports. The results obtained in this study appear to be quite like those found in the literature. Çağlar (2012) determined in their study that factors such as the location of the port area, well-established hinterland connections, and the utilization of technological innovations are crucial for port efficiency. Tovar and Wall (2022) asserted in their study that strong connections of ports with other ports and hinterlands are among the most significant factors influencing port efficiency. Görçün (2021) expressed that the location of ports and their proximity to transportation routes positively contribute to their efficiency. Additionally, studies conducted by Yuen *et al*. (2012), Nazemzadeh and Vanelslander (2015), Martinez Moya and Feo Valero (2017), Rezaei *et al*. (2019), and Fahim *et al*. (2022) have also indicated that the locations of ports, hinterland connections, and the adoption of technological innovations in ports contribute to increased port efficiency.

4. CONCLUSIONS

The location and dimensions of the port area, the good condition of hinterland connections and logistic facilities, the well-organized physical environment of the port, the utilization of technological innovations, and the proper functioning of the quality control system have been identified as significant factors affecting port efficiency by experts. In addition to these factors, conducting accurate job analysis in the port, and providing adequate wages, education levels, and morale of port personnel were found to be important factors influencing port efficiency.

Most ports in our country are operated by the private sector, with profit being the primary focus. While efforts are made to prioritize environmental impact, customer satisfaction, and service quality, these policies cannot be implemented at every port. Therefore, it is necessary for Turkey to establish a new port policy and make the required regulations to elevate the service quality of its ports to the level of European Union ports.

Many Turkish ports are positioned to serve the same catchment area, and most of these ports can handle different types of cargo. As the variety of cargo types handled in ports diversifies, the level of port efficiency decreases. Moreover, differences in efficiency emerge among ports handling the same type of cargo, resulting in the wastage of existing resources. To address this issue, ports serving the same catchment area should specialize in handling a specific type of cargo to enhance their efficiency.

Considering only ports that handle their own cargo, it is evident that these ports primarily serve their proprietary industrial facilities. Therefore, the structure of the ports and their hinterland facilities are designed accordingly. The cranes and other equipment used at the port are selected to serve the incoming and outgoing cargoes for this industrial facility. During times when ships are not in port, the docks remain idle. To prevent this situation, nearby ports should collaborate and direct vessels to the underutilized port facilities. This way, queue problems at congested ports can be mitigated. As a result of the study, efficiency factors that need to be taken into consideration by various stakeholders, such as academic researchers, planners, port managers, and ship agents, and cannot be measured with numerical methods, have been analysed.

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CONFLICT OF INTERESTS

The authors decelerate that they have no conflict of interest.

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5. REFERENCES

Ateş, A. (2010). Türkiye Konteyner Terminallerinde Verimlilik Analizi, Doktora Tezi, Atatürk Üniversitesi Fen Bilimleri Enstitüsü, Erzurum.

Barros, C.P., Athanasious, M. (2004). Efficiency in European Seaports with DEA: Evidence for Greece and Portugal. *Maritime Economics & Logistics* 6(2): 122-140.

Bayar, S. (2005). Veri Zarflama Analizi Kullanılarak Liman Verimliliğinin Ölçülmesi: Türk Limanlarından Bir Örnek, Yüksek Lisans Tezi, İstanbul Üniversitesi Fen Bilimleri Enstitüsü, İstanbul.

Bolat, F. (2010). Marmara Bölgesi Limanlarının Ana (HUB) Liman Özellikleri Yönünden Potansiyellerinin İncelenmesi, Doktora Tezi, İstanbul Teknik Üniversitesi Fen Bilimleri Enstitüsü, İstanbul.

Çağlar, V. (2012). Türk Özel Limanlarının Etkinlik ve Verimlilik Analizi, Doktora Tezi, DEÜ Sosyal Bilimler Enstitüsü, İzmir.

Çağlar, V., Esmer, S., Oral, Z.E. (2010). Özelleştirme ve Özelleştirme Aşamasında Olan Limanların Sektörel İncelenmesi, Türkiye'nin Kıyı ve Deniz Alanları VIII. Ulusal Kongresi, Nisan-Mayıs, Bildiriler Kitabı II, pp. 925-935 Trabzon.

Coto-Millan, P., Banso-Pino, J., Rodriguez-Alvarez, A. (2000). Economic Efficiency in Spanish Ports: Some Empirical Evidence. *Maritime Policy and Management* 27(2): 169-174.

Cullinane, K.P.B., Song, D.W., Gray, R. (2002). A Stochastic Frontier Model of the Efficiency of Major Container Terminals in Asia: Accessing the Influence of Administrative and Ownership Structures. *Transportation Research Part A* 36: 743-762.

Cullinane, K.P.B., Song, D.W., Ji, P., Wang, T.F. (2004). An Application of DEA Windows Analysis to Container Port Production Efficiency. *Review of Network Economics* 3(2).

Cullinane, K.P.B., Wang, T.F., Song, D.W., Ji, P. (2006). The Technical Efficiency of Container Ports: Comparing Data Envelopment Analysis and Stochastic Frontier Analysis. *Transportation Research Part A: Policy and Practice* 40, 4.

Ersoy, Y. (2021). Performance Evaluation in Distance Education by Using Data Envelopment Analysis (DEA) and TOPSIS Methods. *Arabian Journal for Science and Engineering* 46: 1803–1817.

Estache, A., Gonzalez, M., Trujillo, L. (2002). Efficiency Gains from Port Reform and the Potential for Yardstick Competition: Lessons from Mexico. *World Development* 30(4): 545-560.

Fahim, P.B., Rezaei, J., Montreuil, B., Tavasszy, L. (2022). Port performance evaluation and selection in the Physical Internet. *Transport Policy* 124: 83-94.

Frankel, E.G. (1987). *Port Planning and Development*, New York, John Wiley&Sons.

Ghiara, H., Tei, A. (2021). Port activity and technical efficiency: determinants and external factors. *Maritime Policy & Management* 48(5): 711-724.

Görçün, Ö.F. (2021). Efficiency analysis of Black Sea container seaports: application of an integrated MCDM approach. *Maritime Policy & Management* 48(5): 672-699.

Itoh, H. (2002). Efficiency Changes at Major Container Ports in Japan: A Window Application of Data Envelopment Analysis. *Review of Urban and Regional Development Studies* 14(2): 133–152.

Likert, R. (1932). A Technique for the Measurement of Attitudes. *Archives of Psychology* 140: 5-55.

Liu, Z. (1995). The Comparative Performance of Public and Private Enterprises: The Case of British Ports. *Journal of Transport Economics and Policy* 29(3): 263-274.

Martinez-Budria, E., Diaz, A.R., Navarro, I.M., Ravelo M.T. (1999). A Study of The Efficiency of Spanish Port Authorities Using Data Envelopment Analysis. *International Journal of Transport Economics* 26(2): 237–253.

Martínez Moya, J., Feo Valero, M. (2017). Port choice in container market: a literature review. *Transport Rev.* 37 (3): 300–321.

Ministry of Maritime Affairs, (2010). *Türk Limanları için Liman Yönetim Modeli Oluşturulması Hakkında Rapor,* Deniz Ticareti Genel Müdürlüğü, 65 s, Ankara.

Nazemzadeh, M., Vanelslander, T. (2015). The container transport system: selection criteria and business attractiveness for North-European ports. *Marit. Econ. Logist*. 17 (2): 221–245.

Niavis, S., Tsekeris, T. (2012). Ranking and Causes of Inefficiency of Container Seaports in South-Eastern Europe. *European Transport Research Review* 4(4): 235-244.

Notteboom, T., Coeck, C., Van Den Broech, J. (2000). Measuring and Explaining the relative Efficiency of Container Terminals by Means of Bayesian Stochastic Frontier Models. *International Journal of Maritime Economics* 2(2): 83-106.

Oliveira, G.F., Cariou, P. (2011). A DEA Study of the Efficiency of 122 Iron Ore and Coal Ports and of 15/17 Countries in 2005, *Maritime Policy & Management: The Flagship Journal of International Shipping and Port Research* 38(7): 727-743.

Reel, Y., Terzi, N. (2008). The Challenges and Opportunities for Turkey's Port Sector. *Management and Education, Academic Journal* 4(2): 110-116.

Rezaei, J., Van Wulfften Palthe, L., Tavasszy, L., Wiegmans, B., van der Laan, F. (2019). Port performance measurement in the context of port choice: an MCDA approach. *Manag. Decis*. 57 (2): 396–417.

Tezbaşaran, A.A. (1997). *Likert Tipi Ölçek Geliştirme Kılavuzu,* s. 56, Ankara, Türk Psikologlar Derneği Yayınları.

Tongzon, J. (2001). Efficiency Measurement of Selected Australian and Other International Ports Using Data Envelopment Analysis. *Transportation Research Part A: Policy and Practice* 35(2): 113–128.

Tovar, B., Wall, A. (2022). The relationship between port-level maritime connectivity and efficiency. *Journal of Transport Geography* 98, 103213.

Valentine, V.F., Gray, R. (2000). The Measurement of Port Efficiency Using Data Envelopment Analysis, Special Interest Group on Maritime Transport and Ports, International Workshop, 8-10 June, Genoa, Italy.

Wang, L. (2011). Study of Port Logistics Marketing Under the Environment of Supply Chain. *International Journal of Business and Management* 6(3): 267.

Yuen, C.L.A., Zhang, A., Cheung, W. (2012). Port competitiveness from the users' perspective: an analysis of major container ports in China and its neighboring countries. *Res. Transport. Econ.* 35 (1): 34–40.