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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

Cilt: 10 Sayı: 2 (2024) 57-70

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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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Forecasting Ro-Ro Freight Transportation Demand at Samsun Port: A Hybrid Method Approach

Samsun Limanı'nda Ro-Ro Yük Taşımacılığı Talebinin Tahmini: Hibrit Bir Yöntem Yaklaşımı

Türk Denizcilik ve Deniz Bilimleri Dergisi

Cilt: 10 Sayı: 2 (2024) 71-88

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ABSTRACT

Türkiye's extensive coastline and geopolitics position necessitates the importance of Ro-Ro transportation with neighbouring countries. Türkiye's rapidly growing Ro-Ro transportation significantly contributes to imports and exports, which is of great importance to the national economy. Samsun Port is one of the most active ports in Türkiye's Ro-Ro transportation sector, operating in the Black Sea region. This study examined Ro-Ro transportation at Samsun Port, and future cargo forecasting was conducted. For this purpose, artificial neural networks and time series analysis methods were combined. Input variables used in the study included the number of Ro-Ro ships arriving at the port between 2009 and 2021, population figures, a specialized CPI indicator (fresh fruits and vegetables), and export values. The output variable was the amount of cargo carried by Ro-Ro ships. According to the results obtained, it was observed that Samsun Port would have sufficient capacity for Ro-Ro transportation in the next 27 months in terms of wharf, port area, and operational space.

Keywords: Samsun Port, Ro-Ro transportation, Port capacity, Forecasting

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ÖZET

Türkiye'nin geniş kıyı şeridi ve jeopolitik konumu, komşu ülkelerle Ro-Ro taşımacılığının önemini gerektirmektedir. Türkiye'nin hızla büyüyen Ro-Ro taşımacılığı, ülke ekonomisi için büyük önem taşıyan ithalat ve ihracata önemli katkı sağlamaktadır. Samsun Limanı, Karadeniz bölgesinde faaliyet gösteren, Türkiye Ro-Ro taşımacılığı sektörünün en aktif limanlarından biridir. Bu çalışmada Samsun Limanı'ndaki Ro-Ro taşımacılığı incelenmiş ve geleceğe yönelik kargo miktarı tahminlemesi yapılmıştır. Bu amaçla yapay sinir ağları ve zaman serisi analiz yöntemleri birleştirilmiştir. Çalışmada kullanılan girdi değişkenleri arasında 2009-2021 yılları arasında Samsun Limanı'na gelen Ro-Ro gemilerinin sayısı, nüfus rakamları, özel tanımlı TÜFE göstergesi (taze meyve ve sebze) ve ihracat değerleri yer almaktadır. Çıktı değişkeni ise Ro-Ro gemilerinin taşıdığı kargo miktarıdır. Elde edilen sonuçlara göre Samsun Limanı'nın önümüzdeki 27 ay içerisinde iskele, liman alanı ve operasyonel alan açısından Ro-Ro taşımacılığı için yeterli kapasiteye sahip olacağı görülmüştür.

Anahtar sözcükler: Samsun Limanı, Ro-Ro taşımacılığı, Liman kapasitesi, Tahminleme

1. INTRODUCTION

Ro-Ro transportation has become a significant component of contemporary maritime transportation (Zis and Psaraftis, 2017). Minimizing the vessel's waiting time in ports to reduce transportation freight costs and maximizing profit by increasing the number of voyages are fundamental objectives of this transportation method (Morales-Fusco *et al*., 2010; Jiang *et al*., 2017). Consequently, as the competitive environment within maritime transportation continues to intensify, the importance of Ro-Ro transportation is correspondingly increasing. This transportation model began prominently emerging in global maritime trade during the 1940s, originating in the Scandinavian countries. Initially focused on passenger transportation in European ports, it gradually adapted to cargo transportation, evolving into deep-sea transportation (Özdemir and Deniz, 2013).

Ro-Ro transportation in Türkiye gained significance in 1985 with the commencement of ferry services between Trabzon (Türkiye) and Sochi (Russia) by the M/F Avrasya ferry at Trabzon Port. This development rapidly stimulated the growth of Ro-Ro transportation in Türkiye due to extended queues at border crossings, prolonged waiting times, high highway tolls, inadequate road infrastructure, and safety concerns associated with land-based transportation (Yıldırım, 2006). The increasing volume of trade and the challenges associated with road transportation necessitated the opening new Ro-Ro routes as an alternative to costly air transportation. Routes such as Samsun-Novorosisky, Samsun-Tuapse, Rize-Poti, and Zonguldak-Odessa were established; however, these routes have exhibited variability over time or have been discontinued depending on international developments (Başar *et al*., 2015).

The transportation infrastructure of Samsun province holds significant potential, with its road connections extending to the Samsun-Sivas railway and the Mersin port (Kahveci, 2021). Furthermore, Çarşamba Airport is crucial in providing access to domestic and international routes for reaching Samsun port. The hinterland of Samsun Port's Ro-Ro transportation is illustrated in Figure 1.

Multimodal transportation enables the transition between different modes of transport. Ro-Ro transportation, particularly due to the easy integration of land vehicles onto ships, offers a more flexible and reliable transport option. In Ro-Ro transportation originating from Samsun Port, Trabzon Port, and Zonguldak Ports, the transfer of wheeled vehicles occurs between these ports. Generally, Ro-Ro transportation from Black Sea ports to ports in Russia and Ukraine is increasingly emphasizing the importance of multimodal transportation (Görçün and Görçün, 2018).

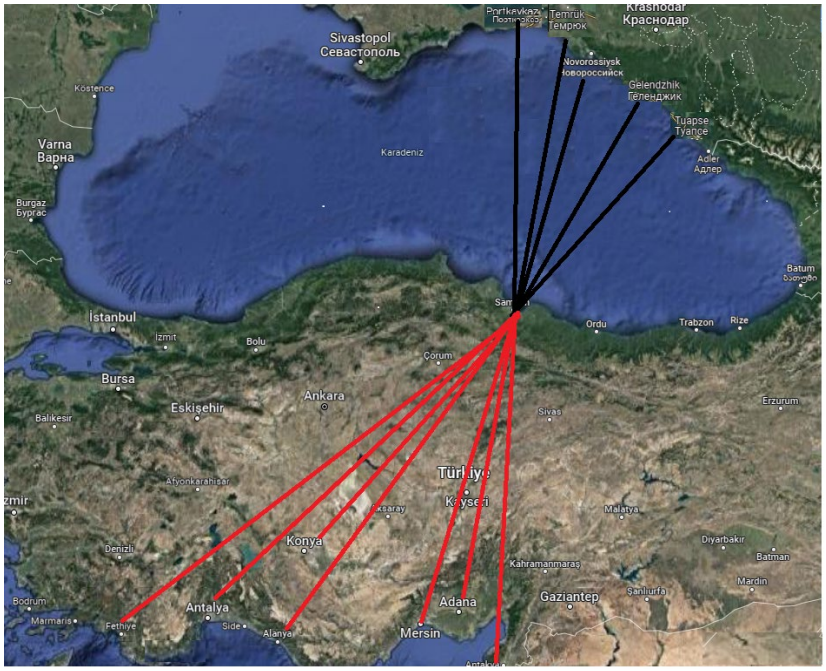

Figure 1. Samsun Port Ro-Ro Transportation Hinterland

Table 1 presents the vehicle statistics for departures, arrivals, and the total number of vehicles at Samsun Port between 2015 and 2022. A decrease in transported vehicles can be observed between 2015 and 2016. This decline can be attributed to the diplomatic crisis that ensued when a Russian jet entered Turkish airspace in 2015 and was subsequently shot down by Türkiye, leading to Russia imposing embargoes on Türkiye in various sectors. However, the issues were resolved through bilateral government negotiations, and maritime transportation services resumed (Köstem, 2018). An increase in demand for fresh fruits and vegetables in Russia and the incentives periodically provided to companies involved in exporting seasonal products from Türkiye have contributed to expanding the shipping fleets of firms operating at Samsun Port.

The traffic of Ro-Ro transportation was concentrated in Novorossiysk, Tuapse, and Gelendzhik ports between 2015 and 2018. However, after 2018, Gelendzhik Port altogether ceased its Ro-Ro ship services. Consequently, the number of Ro-Ro ships at Samsun Port increased, and there was a search for alternative ports like Kavkaz and Temruk. This strategy minimized the queue for Ro-Ro ships to dock at Russian Ro-Ro ports. As depicted in Figure 2, the increase in Ro-Ro transportation at Samsun Port is evident each passing year. Parallel to this increase, the capacity of Samsun Port should be closely monitored, and potential adjustments should be planned, considering that infrastructure developments will take time.

In this study, Ro-Ro capacity forecasting for Samsun Port is conducted using artificial neural networks and time series analysis methods. The continuation of the article is structured as follows. In the second section, existing studies in the literature related to port capacity forecasting are reviewed. The third section presents the materials and methods used in the article. The fourth section includes the results obtained from the analysis of the existing data. In the fifth section, the obtained results are discussed, and finally, the sixth section presents conclusions, recommendations, limitations, and suggestions for future research.

Table 1. Vehicle Statistics Transported on Ro-Ro Lines with International Connections in Samsun Port (Atlantis, 2022)

Year	Port	Arriving Vehicle	Outgoing Vehicle	Total Transported Vehicles
2022	Novorossiysk	1850	2618	4468
	Tuapse	16048	18167	34215
	Kavkaz	16782	17187	33969
	Temruk	2718	3178	5896
Total				**78548**
2021	Novorossiysk	10081	15815	25896
	Tuapse	18949	30013	48962
	Kavkaz	592	526	1118
	Temruk	1790	1961	3751
Total				**79727**
2020	Novorossiysk	5381	6062	11443
	Tuapse	17737	20703	38440
	Temruk	1257	1300	2557
Total				**52440**
2019	Novorossiysk	252	7876	8128
	Tuapse	626	31839	32465
Total				**43150**
2018	Novorossiysk	452	1666	2118
	Tuapse	1733	4269	6002
	Gelendzhik	4712	6748	11460
Total				**19580**
2017	Novorossiysk	3305	3498	6803
	Tuapse	1642	1670	3312
	Gelendzhik	5484	5432	10916
Total				**21031**
2016	Novorossiysk	1568	1845	3413
	Gelendzhik	3040	2863	5903
Total				**20232**
2015	Novorossiysk	2791	7440	10231
	Tuapse	1138	3244	4382
	Gelendzhik	7071	6782	13853
Total				**28466**

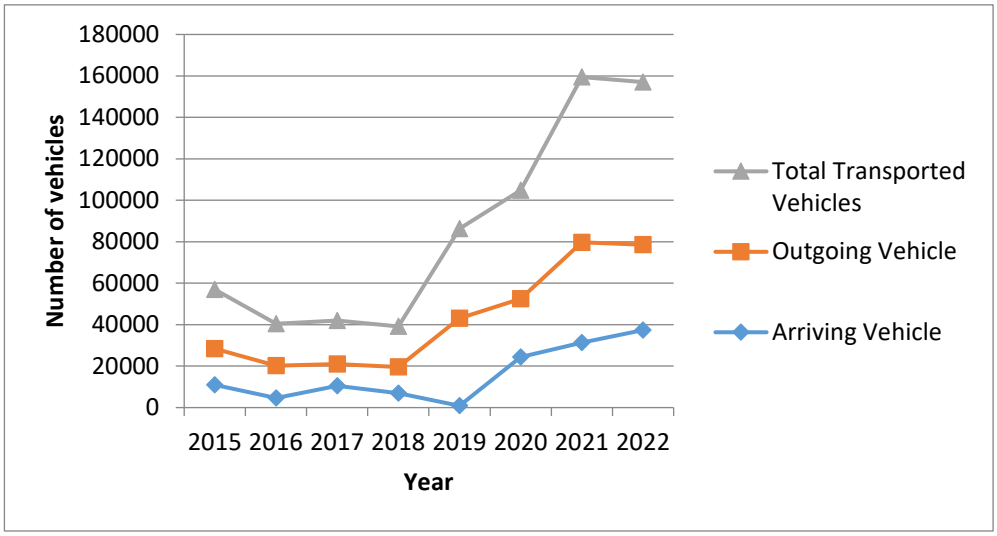

Figure 2. Vehicle Statistics Chart on Ro-Ro Lines with International Connections in Samsun Port (Atlantis, 2022)

2. LITERATURE REVIEW

When examining the literature on transportation demand for ports, studies are frequently focused on forecasting container demand. Simultaneously, these forecasts are often conducted using a hybrid approach, combining multiple models. The parameters used in the forecasting stage are commonly selected from the macroeconomic indicators of the examined region and its hinterland.

Eskafi *et al.* (2021) conducted port capacity forecasting for Isafjordur Port in Iceland, where the handling of different types of cargo takes place. They employed a mutual information approach and Bayesian statistics to eliminate uncertainties in the model and parameters, respectively. A total of six macroeconomic variables were used for forecasting: national gross domestic product (GDP), average annual consumer price index (CPI), world GDP, national export trade volume, national import trade volume, and national population data. The analysis revealed that containerized cargo at Isafjordur Port is projected to increase in future projections, while bulk cargo transported outside of containers is expected to decrease.

Pang and Gebka (2017) utilized three different models to forecast monthly port and individual terminal container transportation demand between 2003 and 2013. These models included Seasonal Autoregressive Integrated Moving Average (SARIMA), Seasonal Holt-Winters with Additive Seasonality (MSHW), and Vector Error Correction Model (VECM). The performance of prediction models was evaluated based on mean absolute error and the square root of mean square error. Results indicated that the MSHW model provided the most accurate predictions for total container volume, while SARIMA produced the least satisfactory in-sample model fit. VECM yielded the best model fits and predictions for individual terminals. Results suggested that the obtained capacity forecasts would be adequate when considering the confidence interval of measurements.

Rashed *et al.* (2018) developed a three-step approach combining the autoregressive distributed lag model (ARDL) with economic scenarios. The empirical analysis relied on a time series spanning from 1995 to 2017 for container volume in the Hamburg-Le Havre (H-LH) range and economic indices. Data such as exports, imports, GDP, and loaded and unloaded container quantities were used as a control group for the period from 2015 to 2017. The study demonstrated an average elasticity of 1.4, indicating a long-term relationship between trade indices and container volume in the H-LH range.

Dragan *et al.* (2021) conducted a study on demand forecasts for supply-demand cargo transportation at the Adriatic Port of Koper and introduced a new forecasting approach called the DFA-ARIMAX model. This model integrates information obtained through dynamic factor analysis (DFA) into the ARIMAX prediction model and includes principal component regression and a Monte Carlo framework to identify port-specific indicators. Using purchasing power, GDP, export, and import data, they compared the accuracy of forecasts obtained with actual data and emphasized the satisfactory performance of the forecasting.

Moscoso-López *et al.* (2019) presented a hybrid approach using Artificial Neural Networks (ANN) and Support Vector Regression (SVR) models by utilizing eight years of daily time series data from Algeciras Port. The model predicted the next seven days and was compared with realized data, revealing that the hybrid use of both models provided superior results compared to individual usage. The authors highlighted the potential usefulness of the algorithm in improving port planning and management.

The increasing demand for maritime transportation, driven by population growth and economic expansion, has gradually started to strain port infrastructure capacities over the years. A review of the literature reveals that forecasting models are frequently employed to balance supply and demand between maritime transportation and port capacity. However, there has been no growth and capacity forecasting study conducted for Ro-Ro transportation at Samsun Port. Within this context, this study holds significant importance in filling this gap in the literature.

3. MATERIAL AND METHOD

This study provides a 27-month forecast of the cargo volume transported by Ro-Ro vessels at Samsun Port. To perform this forecasting, input data encompassing population figures, the Consumer Price Index (CPI), export figures, and the number of Ro-Ro vessels from January 2009 to September 2021 were utilized. Time series analysis and artificial neural networks were applied to these data for forecasting. The primary reason for selecting data between 2009 and 2021 in this study is the absence of data from other years at the port authority from which the data was obtained.

The selection of input variables benefited from previous studies in the literature. These studies indicate that the macroeconomic indicators of the port and its surroundings are the factors that most influence transportation demand (Gökkuş et al., 2017; Gosasang et al., 2018; Eskafi et al., 2021). The aim was to have the selected factors interact with each other at the minimum level. Otherwise, by influencing each other, these factors may lead to overestimating prediction quantities.

This study aims to forecast the amount of cargo carried by Ro-Ro ships departing from Samsun Port. It will be determined whether Ro-Ro transportation from Samsun Port, including the number of ships departing from the port and the cargo transport from the port, affects the port's capacity. In this context, the preliminary hypothesis of the study is defined as "The amount of cargo transported from Samsun Port in Ro-Ro transportation will increase by the end of 2023.

3.1. Data Set

In determining input variables, a literature review was conducted, followed by the compilation of parameters commonly used in analogous forecasting studies. Subsequently, the created parameter list was scrutinized by experts, and the four most significant parameters influencing the cargo volume in Ro-Ro transportation were included as input variables in the study.

In this context, the number of vessels, which plays a crucial role in determining the cargo volume, was utilized as an input variable (Czermański, 2017). Furthermore, the Consumer Price Index (CPI), which exerts a mutual influence on the transported goods and freight prices, was considered an input variable because it affects the quantity of cargo transported by Ro-Ro (De Monie *et al*., 2011). Additionally, the population of Samsun is recognized as a significant factor influencing port activities. It is well-known that port activities increase in regions with a dense population (Yüksekyıldız, 2010; Czermański, 2017). Lastly, the monetary values of goods exported from Samsun Port also play a pivotal role in forecasting the cargo volume to be transported. Variations in export figures from the port will directly impact the increase and decrease in cargo volume, making it an important input variable in the study (Guo and Yang, 2019).

The information related to the data used in the study was obtained from datasets provided by official institutions through online sources and compiled in a format suitable for the study. The input variable, which consists of the number of Ro-Ro vessels, and the output variable, which involves the cargo volumes transported by Ro-Ro, were obtained from the Samsun Port Authority (Samsun Port Authority, 2021). The input variables, including the Consumer Price Index (CPI) and population values, were sourced from the Turkish Statistical Institute, while the export figures for Samsun province were retrieved from the website of the Türkiye Exporters Assembly (TIM, 2021; TURKSTAT, 2021a; TURKSTAT, 2021b).

3.2. Time Series Analysis

Time series are numerical quantities that represent the successive changes of variables from one period to another, depending on the values those variables have taken. While the obtained data don't need to occur sequentially, having them arranged at regular intervals can be beneficial to understanding how the series is formed (Box *et al*., 2015; Montgomery *et al*., 2015).

In time series analysis, numerous methods have been developed for predicting future observations using past and current period observation values. These methods are illustrated in Figure 3 (Oğhan, 2010)

In the conducted study, the Exponential Smoothing method of Winters (1960), which is one of the exponential smoothing methods, was employed. This method is used for forecasting time series that exhibit seasonal fluctuations and trends. The time series components that this method applies to are the seasonal component, the average level, and the slope. The process of updating forecasts in time series that adhere to the mathematical inequalities is calculated sequentially according to the following formulation (Oğhan, 2010).

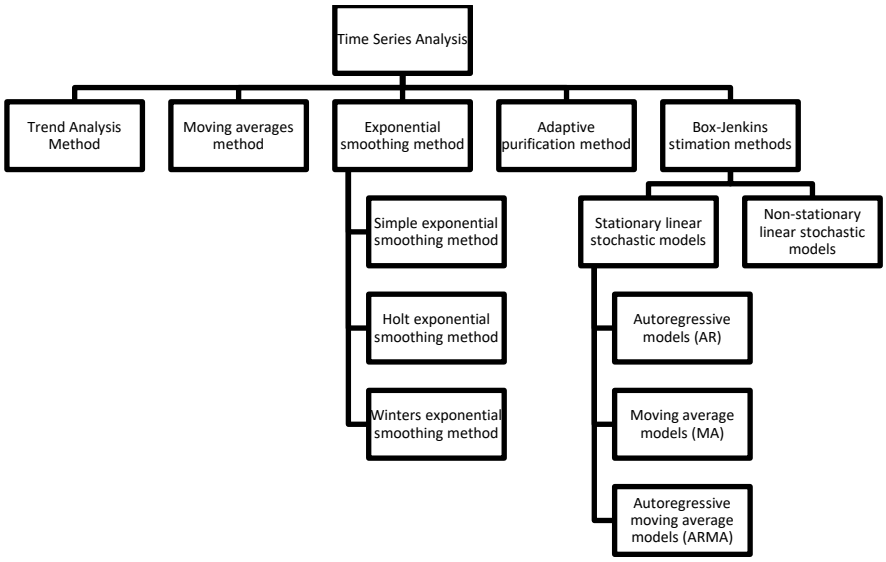

Figure 3. Types of Time Series Analysis Methods (Oğhan, 2010)

Update the average level:

$$a_T = \alpha\left(Y_t - M_t\left(T-s\right)\right) + \left(1-\alpha\right)\left(a_{T-1} + b_{T-1}\right) \quad (1)$$

It is represented as follows:

$a_T =$ New smoothing forecast for the average level at period T

α = Smoothing coefficient for the average level

$Y_t - M_t\left(T-s\right) =$ The deseasonalized original data at period T

$a_{T-1} =$ The old smoothing forecast for the average level at period (T-1)

$b_{T-1} =$ The old smoothing forecast for the slope at period (T-1)

Update the slope:

$$M_{T+S}\left(T\right) = \delta\left(Y_T - a_T\right) + \left(1-\delta\right)M_T\left(T-s\right) \quad (2)$$

It is represented as follows,

$M_{T+S}\left(T\right) =$ New smoothing forecast for the seasonal component in period T

$\delta =$ Smoothing coefficient of seasonal component

$Y_T - a_T =$ Seasonal variation in data obtained by subtracting a new estimate of the mean level from the original data

$M_T\left(T-s\right) =$ It is the old smoothing coefficient of the seasonal component in the period (T-s).

Estimated values of the observation in the additive model:

$$\hat{Y}_{T+1} = a_T + b_T + M_{T+1}\left(T+1-s\right) \quad (3)$$

It is represented as follows,

$\hat{Y}_{T+1} =$ Forecast for the (T+1)th period

$a_T =$ Smoothing estimate of the average level in period T

$b_T =$ Smoothing estimate for slope in period T

$M_{T+1}\left(T+1-s\right) =$ It is a smoothing estimate for the period (T+1) made in the period (T+1-s).

Updating predictions in series suitable for the multiplicative model:

$$a_T = \alpha\left[\frac{Y_T}{M_T\left(T-s\right)}\right]+\left(1-\alpha\right)\left(a_{T-1}+b_{T-1}\right) \quad (4)$$

$$b_T = \gamma\left(a_T - a_{T-1}\right)+\left(1-\gamma\right)b_{T-1} \quad (5)$$

$$M_{T+S}\left(T\right) = \delta\left[\frac{Y_T}{a_T}\right]+\left(1-\delta\right)M_T\left(T-s\right) \quad (6)$$

It is done in the form.

Predictive values of observation in multiplicative model:

$$\hat{Y}_{T+1} = \left(a_T + b_T\right)*M_{T+1}\left(T+1-s\right) \quad (7)$$

It is done in the form (Kadılar, 2005).
The values for a and b in the equations were obtained using the decomposition method and regression analysis method in Winters' exponential smoothing method. When employing Winters' exponential smoothing method, to generate reliable results for forecasts, like in the simple exponential smoothing method, the smoothing coefficient MAD (Mean Absolute Deviation) representing the mean of the least squares for prediction confidence intervals is calculated (Kadılar, 2005)
Exponential smoothing methods, which take into account all factors used in the calculation of time series, are considered suitable techniques in contemporary applications due to their cost-effectiveness and the minimal time required for their implementation (Oğhan, 2010).

3.3. Artificial neural networks

Artificial neural networks (ANNs) have emerged through the mathematical modelling of the learning process, inspired by the stages of human brain learning (Kabalcı, 2014). Within this network, artificial neurons functionally resemble the working system of biological neurons (Şenalp, 2017). Structurally, ANNs consist of numerous interconnected nerve cells, referred to as neurons. These neurons, termed as such, constitute the fundamental processing mechanism within ANN (Figure 4).

3.3.1. Artificial Neural Networks Structure

Artificial neural networks are formed by the functional structures of multiple artificial nerve cells coming together as nodes, neurons, or nerves. Generally, the cells are organized into three layers, and the parallel assembly of elements creates each layer. These layers are as follows (Öntemel, 2016):

- Input layer: The cells in this layer are responsible for receiving information from the external world and transmitting it to intermediate layers. In some networks, there is no information processing in the input layer.
- Hidden layers: These layers process the information received from the input layer and send it to the output layer. Multiple intermediate layers can exist in a network.
- Output layer: The cells in this layer process the information received from the intermediate layers and generate the output that the network should produce for the input set presented in the network's input layer. The produced output is then transmitted to the external world (Figure 5).

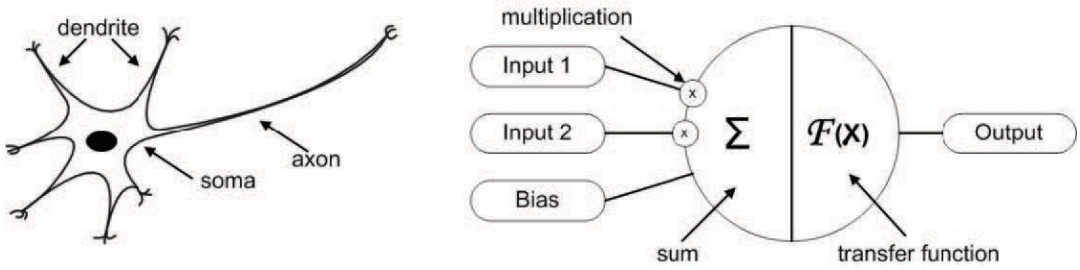

Figure 4. Biological Neural Cell and Artificial Neural Network (Krenker *et al*., 2011)

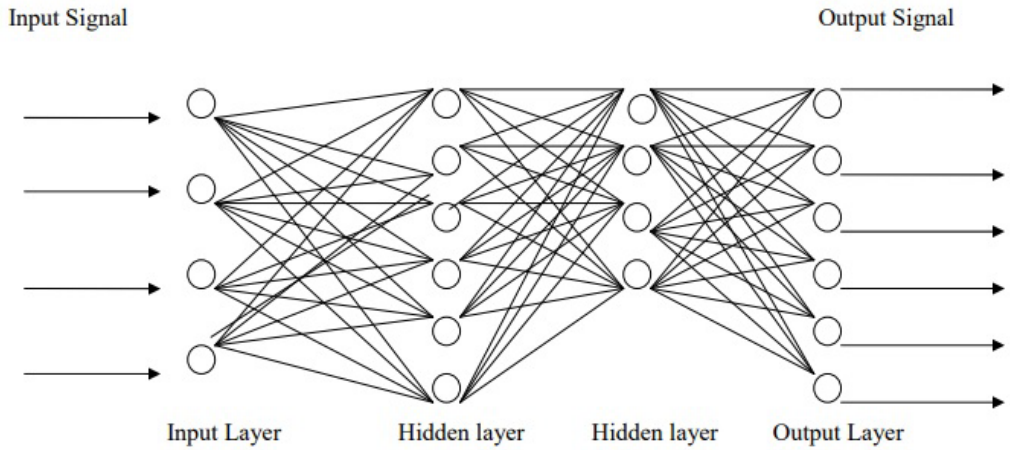

Figure 5. Multilayer feedforward ANN structure (Eluyode and Akomolafe, 2013)

4. RESULTS

4.1. Time Series Analysis Input Variables Forecasting

In the initial phase of the study, Time Series Analysis was conducted using the exponential smoothing method with the assistance of the STATISTICA software package. The primary reason for choosing this method was that in models created using other time series analyses, the significance coefficients often turned out to be relatively low, failing to provide accurate results (Winters, 1960; Oğhan, 2010). During time series analysis, the method to be used for making the best predictions based on the entered values can be determined by the program. Therefore, in the study, the prediction method that provides the best forecasting and has the lowest error rate has been preferred. In this context, since the lowest error rate was observed to be obtained using the linear regression method, this method has been chosen in the study.

In the analyses conducted to form input variables, the additive method was used for ship numbers, population, and CPI forecasts, while the multiplication method was employed for export figures. The parameters Alpha, Delta, and Gamma coefficients, and error terms for each input value, obtained through time series analysis, are provided in Table 2. Furthermore, the resulting forecast results are presented in Table 3 and illustrated in Figure 6.

The time series analysis conducted in this study has shown the presence of seasonal fluctuations in the number of ships departing from Samsun Port over 27 months. It is predicted that 1664 ships will depart from the port by the end of December 2023. Examination of historical data reveals periodic increases and decreases in the number of Ro-Ro ships, with variations occurring in the number of ships departing from the port during specific periods. Therefore, the forecasting results exhibit a similarity in structure to previous periods (MAPE=68.867). The origin of achieving a high MAPE (Mean Absolute Percentage Error) value in the

prediction of the incoming ship count is attributed to the significant fluctuations during the previously mentioned jet crisis period.

The time series analysis conducted for the Consumer Price Index (CPI) values in Samsun province indicates that the increasing trend observed in previous periods is expected to continue in future periods. It is forecasted that the CPI value will reach 1128.422 by December 2023. Given the current economic crisis and exchange rate fluctuations, relevant institutions (Turkish Statistical Institute, Central Bank, Ministry of Trade, etc.) have also indicated that CPI values will likely increase in the coming periods. Therefore, it is assumed that the CPI forecasts made in this study provide accurate results, considering the current economic conditions (MAPE=6.097).

Table 2. Prediction Parameters Obtained for Input Variables

Value	Ship number	CPI	Export figures	Population
Method	Additive	Additive	Multiplication	Additive
Alpha coefficient	0.284	1.000	0.330	1.000
Delta coefficient	0.000	0.502	0.000	1.000
Gamma coefficient	0.043	0.000	0.052	0.000
Mean error	-3.468	-0.673	989.422	-65.310
Mean absolute error	11.405	18.860	7354.116	649.509
Sums of squares	33863.126	102618.654	19135315146	389408409.285
Mean square	221.327	670.710	125067419.255	2545153.002
Mean percentage error	-34.055	-0.553	-2.346	-0.005
Mean abs. perc. error	68.867	6.097	16.440	0.050

Table 3. Input Variables Time Series Analysis Prediction Results

No	Date	Number of ships prediction (pcs)	CPI prediction (index value)	Export value prediction (thousand US $)	Population prediction (people)
154	1.10.2021	59	768.744	137137	1346863
155	1.11.2021	66	777.787	135444	1347815
156	1.12.2021	67	797.722	135938	1348789
157	1.01.2022	50	850.289	124669	1348117
158	1.02.2022	48	872.204	129904	1349030
159	1.03.2022	52	888.924	149224	1349949
160	1.04.2022	50	893.423	140063	1350872
161	1.05.2022	62	873.126	150447	1351779
162	1.06.2022	61	863.118	137569	1352726
163	1.07.2022	47	860.805	151691	1353699
164	1.08.2022	50	861.555	146143	1354642
165	1.09.2022	48	879.213	174269	1355590
166	1.10.2022	67	915.655	173446	1356543
167	1.11.2022	74	926.817	170530	1357501
168	1.12.2022	75	948.901	170408	1358481
169	1.01.2023	58	1003.648	155628	1357815
170	1.02.2023	56	1027.776	161508	1358734
171	1.03.2023	60	1046.739	184808	1359658
172	1.04.2023	59	1053.514	172811	1360587
173	1.05.2023	70	1035.526	184951	1361500
174	1.06.2023	70	1027.859	168528	1362452
175	1.07.2023	56	1027.923	185200	1363431
176	1.08.2023	59	1031.083	177842	1364380
177	1.09.2023	57	1051.185	211397	1365334
178	1.10.2023	76	1090.108	209755	1366293
179	1.11.2023	83	1103.786	205616	1367257
180	1.12.2023	84	1128.422	204878	1368243

The time series analysis conducted based on the export figures from Samsun province considers the seasonality of export figures. Looking at export values with periodic increases and fluctuations, it is observed that trend values are on an increasing trajectory. As a result of the forecasting, it is anticipated that export figures will continue to rise in the upcoming 27-month period, reaching around 204878 thousand US dollars by the end of 2023. Considering the current conditions, with the significant increase in the exchange rate of the US dollar, which has led to record-breaking exports in the economic landscape, the export forecast in this study appears to be quite successful (MAPE=16.440). The high MAPE value observed here, similar to the incoming ship count, is attributed to the effects of significant fluctuations during the jet crisis period.

In the population figures for Samsun province, which served as the final input variable for the prediction, it is estimated that the population will be 1368243 people by the end of December 2023. Due to Samsun's geographically and economically advantageous position, it is known to receive constant migration from neighbouring provinces. When examining data from previous periods, it is evident that the population of Samsun province has consistently increased over the years. Therefore, these forecasts reflect an unchanging pattern, with the population increasing. Looking at TURKSTAT (Turkish Statistical Institute) data for population forecasts by years and provinces, the predictions made for Samsun province are found to be quite similar to TURKSTAT data (MAPE=0.050).

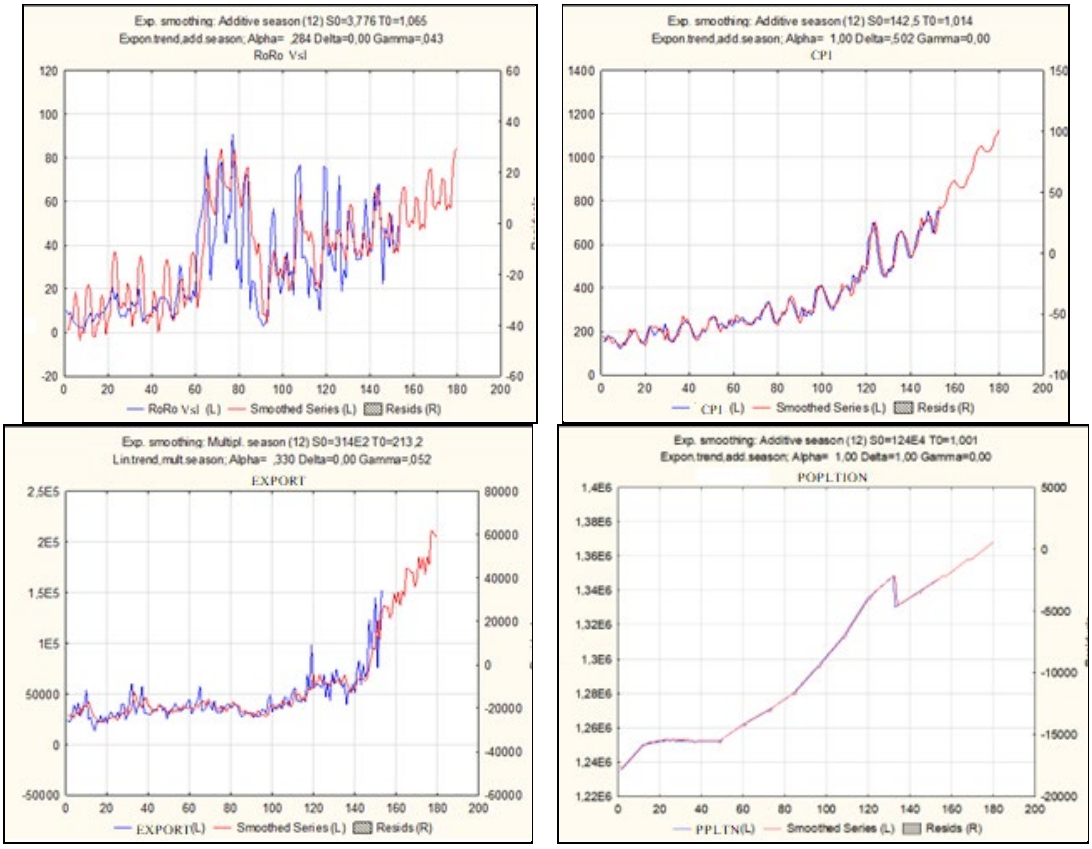

Figure 6. Input Variables Prediction Graphs

4.2. Output Variable Prediction with Artificial Neural Networks

Using the results of Time Series Analysis for input variables, the prediction of the output variable, which is the amount of cargo transported by Ro-Ro ships, was carried out using the "Artificial Neural Networks" module in MATLAB. For this purpose, an artificial neural network architecture consisting of four input

variables and one output variable was created. The constructed artificial neural network includes one hidden layer with ten neurons and one output layer with one neuron (Figure 7).

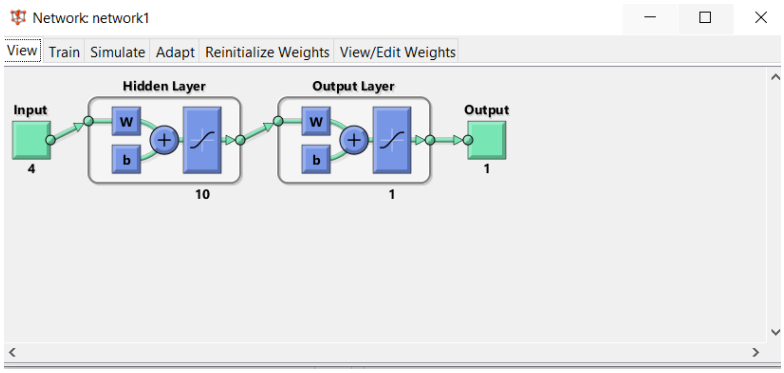

Figure 7. Artificial Neural Network Architecture

In determining the number of layers and neurons in the constructed artificial neural network, a trial-and-error method was used to identify the artificial network that yielded the best results. The maximum error threshold (max_fail) for training the artificial network was set to 1000 as a parameter. No changes were made to the other values.

Before creating the artificial neural network, various learning methods and transfer functions were employed through a trial-and-error approach to obtain output results. It was observed that the best results were achieved when using the backpropagation weight/bias learning function "learngdm" with momentum and the variable learning rate gradient descent "traingdx" algorithm. The "tansig" transfer function was utilized. After training the constructed artificial neural network, the performance values and regression coefficients are presented in Figure 8.

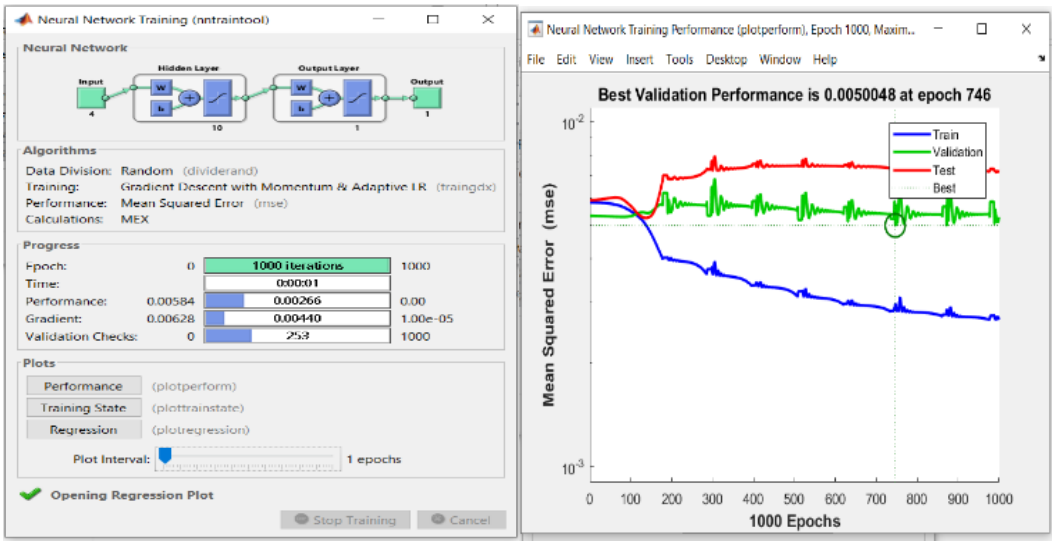

Figure 8. ANN Training and Performance Screen

The results obtained from the artificial neural network regression in the study reveal high values, indicating a significantly high predictive capability of the constructed network. Figure 9 shows a training accuracy rate of 95.6% was achieved, with a validation rate of 92.5% for the training data and a validation rate of 93.5% for the test data. The overall accuracy rate of the entire network architecture was 94.5%. Examining these accuracy rates, it is evident that the predictions will yield highly accurate results

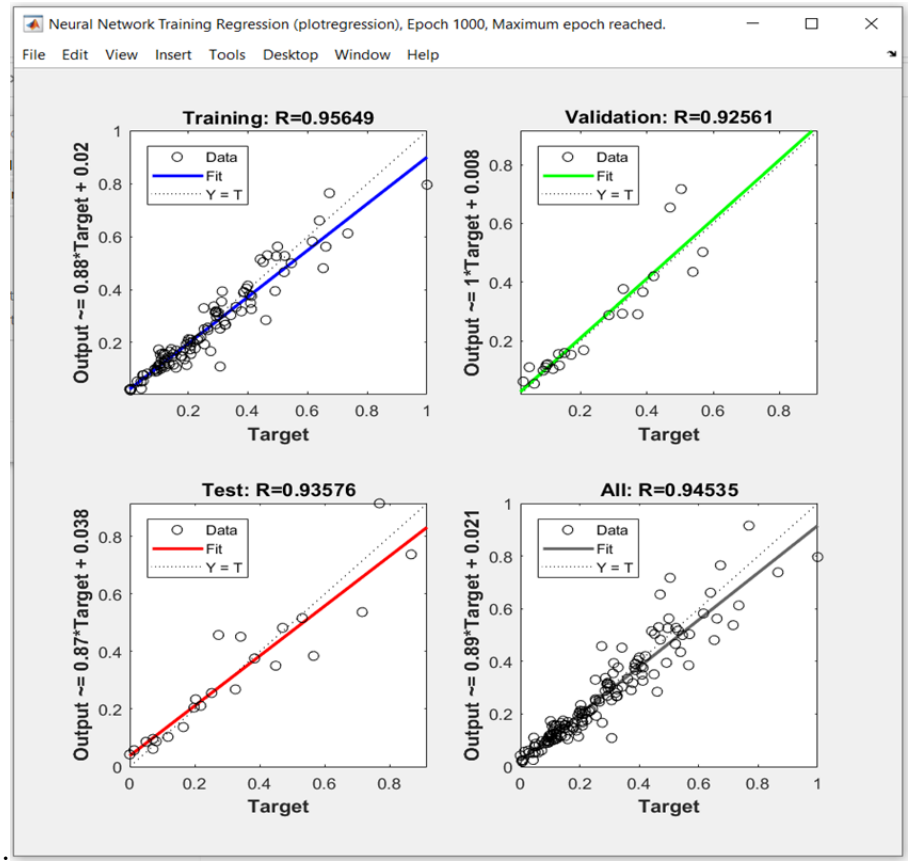

Figure 9. ANN Regression Values Screen

Following the training and testing processes, the artificial neural network was provided with 27-month data for the four input variables (Population, CPI, Export, Ro-Ro Count), and the network was tasked with making predictions. The artificial neural network's predictions for the 27-month Ro-Ro cargo amount (in tons) to be transported according to the new data are presented in Table 4. According to the predictions, the amount of Ro-Ro cargo to be transported from Samsun in December 2023 is estimated to be 65774.9 tons. The total cargo amount to be transported over the 27 months is projected to be 1622448.8 tons. The results obtained from forecasting with artificial neural networks reveal that the data exhibit seasonality similar to past years and a slight trend, as depicted in Figure 10. The reliability of the hybrid algorithm was tested by comparing the obtained total predicted cargo handling values with the actual data. The predictions were subjected to correlation analysis with the actual transportation quantities obtained from Samsun Port Authority, resulting in an accuracy rate of 73% (Table 5.) (Samsun Port Authority, 2023).

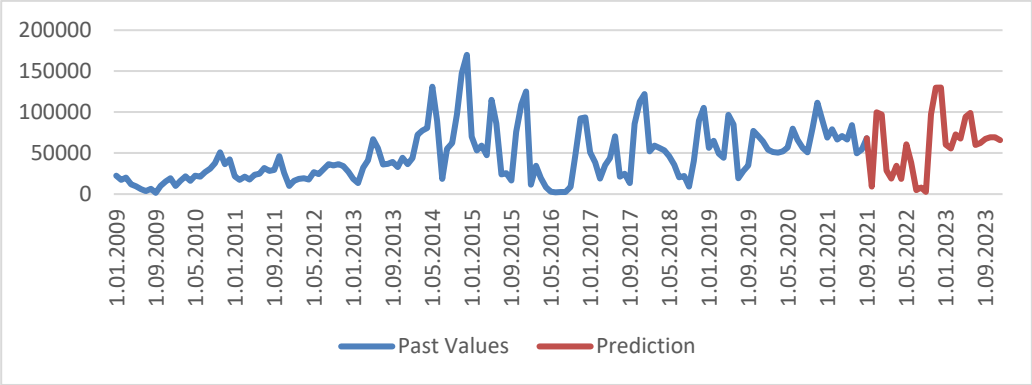

Figure 10. Ro-Ro Handling Past Values and ANN Prediction Results

Table 4. Estimation of the Amount of Cargo to be Transported by Ro-Ro in Samsun Port

Date	Prediction (tons)	Date	Prediction (tons)
1.10.2021	9338.639	1.11.2022	129844.874
1.11.2021	99892.975	1.12.2022	129986.780
1.12.2021	97094.882	1.01.2023	60328.826
1.01.2022	28780.391	1.02.2023	55799.336
1.02.2022	18903.814	1.03.2023	72683.198
1.03.2022	34420.243	1.04.2023	67653.165
1.04.2022	18735.536	1.05.2023	94285.518
1.05.2022	60572.615	1.06.2023	99068.103
1.06.2022	38428.898	1.07.2023	60092.792
1.07.2022	4728.207	1.08.2023	62156.942
1.08.2022	7855.984	1.09.2023	67414.831
1.09.2022	2706.098	1.10.2023	69250.786
1.10.2022	97290.902	1.11.2023	69359.523
		1.12.2023	65774.926
		Total	**1622448.781**

Table 5. Correlation Analysis Between Amount of Cargo Transported and Hybrid Model Estimation

Date	Actual (tons)	Prediction (tons)	Date	Actual (tons)	Prediction (tons)
1.10.2021	75210	9338.639	1.11.2022	148425	129844.874
1.11.2021	65010	99892.975	1.12.2022	139900	129986.780
1.12.2021	47930	97094.882	1.01.2023	76400	60328.826
1.01.2022	45925	28780.391	1.02.2023	53240	55799.336
1.02.2022	86025	18903.814	1.03.2023	72400	72683.198
1.03.2022	100175	34420.243	1.04.2023	89660	67653.165
1.04.2022	63500	18735.536	1.05.2023	76525	94285.518
1.05.2022	68225	60572.615	1.06.2023	90100	99068.103
1.06.2022	58775	38428.898	1.07.2023	40325	60092.792
1.07.2022	111175	4728.207	1.08.2023	93750	62156.942
1.08.2022	75210	7855.984	1.09.2023	65000	67414.831
1.09.2022	65010	2706.098	1.10.2023	100450	69250.786
1.10.2022	47930	97290.902	1.11.2023	110275	69359.523
			Calculated correlation		**0.728**

5. DISCUSSION

Based on predictions derived from time series analysis of input variables, an artificial neural network method was employed to forecast the total cargo volume transported by Ro-Ro (Roll-on / Roll-off) within 27 months. The results of this forecasting, conducted using MATLAB, indicate an estimated total cargo transportation of 1622448.8 tons from Samsun port until the end of 2023. The findings reveal that the predicted cargo volumes exhibit seasonal increases and decreases when examined monthly. When these prediction results are compared with previous period data, they demonstrate a striking resemblance in values, and nearly identical patterns of both increases and decreases are observed during similar periods.

According to data from the Port Operators Association of Turkey (TURKLIM), Samsun port's annual handling capacity is reportedly 50000 vehicles. Assuming that each truck has a capacity of approximately 28-30 tons, the Ro-Ro cargo capacity of the port ranges between 1400000 tons and 1500000 tons annually. The estimated Ro-Ro cargo volume for the 27 months amounts to 1622448.8 tons. For 2023 alone, an estimated 843867.9 tons of cargo transport are projected. Based on this assessment, it can be concluded that Samsun port's capacity is deemed sufficient (TURKLIM, 2021).

When examining the research conducted for Samsun port, particularly regarding the prediction of Ro-Ro transportation in the upcoming periods, there is limited existing literature on this topic. Nevertheless, studies related to other types of cargo can be found. In a study conducted by Yüksekyıldız (2010), the estimation of cargo volume to be handled in Samsun port was carried out. The study employed regression analysis and conducted cargo predictions based on different scenarios. The study results indicate an increase in the cargo handling volumes from Samsun port over the years. This study's findings align with the results of the study conducted by Yüksekyıldız (2010), which also estimated an increase in the handled cargo volume in both works.

In the study conducted by Özdemir (1993), the evolutionary history of Ro-Ro transportation in Türkiye and the technical specifications of Ro-Ro vessels during this development process were analyzed in detail. The research underscores that Ro-Ro transportation has undergone a rapidly evolving historical development. This study comprehensively examines the shift from land to sea transportation over time by truck fleets, which play a significant role in trade between European countries and Türkiye. The findings obtained by Özdemir are corroborated by our article for Samsun Port as well. Artificial neural networks trained using historical data and time series analysis algorithms indicate that the number of ships departing from Samsun Port and the cargo volume will continue to increase.

Aksoy (2011) conducted a study examining the processes within Ro-Ro terminals, explicitly focusing on the procedures of trucks disembarking from ships and those arriving by road to be loaded onto Ro-Ro vessels. This investigation emphasized factors such as gamma rays used in X-ray machines, weighing scales for measuring the tonnage of trucks, areas where trucks await vessels, and loading and unloading ramps within the terminals. A simulation model was developed using the "Arena 11.0" simulation program in conjunction with these factors. The model was run repeatedly ten times over 30 days to obtain results. These outcomes led to the identification of potential problems during operations and the proposal of possible solutions. The results indicate that the current capacity of Samsun Port is sufficient. However, the existing situation should be closely monitored, and predictions should be made in advance regarding when the capacity may be exceeded to prevent potential revenue losses.

In his study, Yıldırım (2006) examined the factors influencing the development of Ro-Ro transportation and took the example of Pendik Ro-Ro Port. It was observed that Ro-Ro transportation is rapidly growing in Türkiye, and the study concluded that long-term investments are necessary in this field. Similarly to Yıldırım's work, this article also observes a rapid increase in Ro-Ro transportation at Samsun Port compared to past years. Within this context, potential additional investments for Samsun Port should be considered in the upcoming period.

6. CONCLUSION AND RECOMMENDATIONS

In this study, demand forecasting for the cargoes transported at Samsun Port's Ro-Ro terminal was conducted using time series analysis and artificial neural networks. A literature review revealed no similar research concerning Samsun Port in the context of Ro-Ro transportation, and the use of these two methods together in a single study was not observed. Therefore, with its unique approach, this study is expected to contribute to the literature significantly.

As observed in the study findings, it is estimated that there will be 84 departures from Samsun Port in December 2023. Upon examining the current structure of the terminal, it is evident that the quay can serve multiple vessels simultaneously. Therefore, there is no need for the port to develop an additional quay at its present state, given that sufficient quay space is available until December 2023. However, when the forecasting results are scrutinized, it is clear that the number of vessels is showing an increasing trend. This implies that additional investments may be necessary in the coming period. Consequently, the number of vessels handled at the port and the terminal's capacity should be closely monitored. Maintenance of the idle quays or the construction of new quays can be undertaken to increase capacity.

On the other hand, the forecasts for December 2023 indicate that the projected cargo volume for Samsun Port will remain below its current capacity. However, similar to vessel count predictions, the transported cargo volume also exhibits an increasing trend. Additionally, adverse weather conditions, when they hinder vessel entries and departures in other ports, lead to vessels departing from Samsun Port to wait in the anchorage areas of different ports, causing a buildup of vessel traffic. This situation delays the return of Ro-Ro vessels to Samsun Port. Considering these two factors, Samsun Port will require dedicated roads to port terminals and areas to accumulate trucks due to waiting to ensure smooth operation in the coming period. This situation should be closely monitored, and the necessary investments and infrastructure developments must be planned accordingly.

Future studies may encompass separate demand forecasts for each terminal at Samsun Port (general cargo, containers, liquid cargo). The impact of diversifying the input variables with different data sources on the results can be examined. Furthermore, the efficacy of varying input variables using various methods in predicting port cargo traffic can be determined. Finally, longer-term predictions can be made to ascertain when an increase in port capacity will be required.

When examining previous studies, it is observed that cargo forecasting is predominantly conducted for container terminals. A comprehensive study specifically for Ro-Ro terminals has not been encountered. Therefore, the current study is deemed to address this gap in the literature. The results obtained from the study are anticipated to fill this void and provide data that port authorities, agents, Ro-Ro operators, and individuals in the maritime sector can benefit from. It is expected that these stakeholders can reevaluate their projections for the future based on the data obtained from the study. The primary reason for selecting data between 2009 and 2021 in this study is the absence of data from other years at the port authority from which the data was obtained, posing a significant constraint in the study.

Port expansions and capacity increases should not be monitored for a certain period of time and future projection studies should be carried out regularly. In future studies, the methods used in this research can be applied to other ports. Additionally, different methods can be used for cargo forecasting in Ro-Ro transportation.

AUTHORSHIP CONTRIBUTION STATEMENT

Tayfun ŞİMŞEK: Conceptualization, Methodology, Validation, Collecting of Data, Formal Analysis, Resources, Writing - Original Draft, Writing-Review and Editing, Data Curation, Software, Visualization.

Fırat SİVRİ: Methodology, Formal Analysis, Writing-Review and Editing, Software, Visualization.

Özkan UĞURLU: Conceptualization, Methodology, Writing-Review and Editing,

Software, Visualization.
Mehmet AYDIN: Conceptualization, Methodology, Validation Formal Analysis, Resources, Writing-Review and Editing, Software, Visualization.

CONFLICT OF INTERESTS

The authors declare that for this article they have no actual, potential or perceived conflict of interests.

ETHICS COMMITTEE PERMISSION

No ethics committee permission is required for this study.

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Application of Fuzzy AHP for Assessment of Transitional Barriers to Electronic Bill of Lading

Elektronik Konşimentoya Geçiş Engellerinin Değerlendirilmesinde Bulanık AHP Uygulaması

Türk Denizcilik ve Deniz Bilimleri Dergisi Cilt: 10 Sayı: 2 (2024) 89-104

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ABSTRACT

Advances in technology have converted the traditional paper-based bill of lading into an electronic bill of lading (eBL) format in recent years. In this regard, different eBL systems have been introduced and are increasingly being employed in the maritime transportation industry. In line with this, some major container shipping lines have started to declare their eBL services to their customers recently. However, it has been observed that there have not been come across any Türkiye origin container shipping lines to utilize eBL systems. Therefore, considering container shipping lines of Türkiye, this paper sought to disclose the barriers to the transition of eBL systems in Türkiye. The barriers have been revealed through literature review and confirmed by industrial experts. Following that Fuzzy-AHP method was performed to prioritize their importance quantitatively. It was revealed that the legal barrier among the main barriers appeared as the most important barrier.

Keywords: Digitalization, Container shipping, Electronic bill of lading, Transitional barriers, Fuzzy AHP.

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ÖZET

Teknolojideki gelişmeler, son yıllarda geleneksel kâğıt tabanlı konşimentoyu elektronik konşimento (eBL) formatına dönüştürmüştür. Bu bağlamda, deniz taşımacılığı endüstrisinde farklı eBL sistemleri tanıtılmış ve giderek daha fazla kullanılmaya başlanmıştır. Bu doğrultuda bazı büyük denizyolu konteyner hatları son dönemde müşterilerine eBL hizmetlerini deklare etmeye başlamışlardır. Ancak, eBL sistemlerini kullanan herhangi bir Türkiye menşeili denizyolu konteyner taşıma hattına rastlanmadığı gözlemlenmiştir. Bu nedenle, Türkiye'deki denizyolu konteyner nakliye hatlarını göz önüne alarak, bu çalışma Türkiye'de eBL sistemlerine geçiş engellerini açıklamaya çalışmaktadır. Engeller, literatür taraması yoluyla ortaya çıkarılmış ve endüstri uzmanları tarafından onaylanmıştır. Daha sonra önemlerini nicel olarak önceliklendirmek için Fuzzy-AHP yöntemi uygulanmıştır. Ana engeller arasında yasal engelin en önemli bariyer olduğu ortaya çıkmıştır.

Anahtar sözcükler: Dijitalleşme, Konteyner taşımacılığı, Elektronik konşimento, Geçiş engelleri, Bulanık AHP.

1. INTRODUCTION

Global competition is becoming more intense day by day, and gaining a competitive advantage is one of the primary goals of businesses. To remain competitive, firms must provide exceptional value to their customers (Balcı, 2021). Philip and Gary (2012) emphasize the need of gaining a competitive advantage and see it as a marketing extension. According to Porter (1985), the proper application of technology can be a source of competitive advantage. Lenka *et al.* (2017) indicate that digitalization is the primary facilitator for value creation in today's highly competitive business environment. Therefore, creating value, and thereby obtaining competitive advantage has become vital for shipping firms to survive in such a dynamic business environment.

Gunasekaran *et al.* (2017) point out that digitalization of the services is regarded to be a crucial source for differentiation and competitive advantage. Aside from the obvious benefits of digital transformation in the shipping industry, shipping firms are also under pressure to digitize their operations. This has become particularly evident in the Coronavirus pandemic period. Digital solutions offered by firms have aided in the continuity of their supply chains (Kamal, 2019). During the early phases of the COVID-19 pandemic, for instance, lockdown measures hampered some courier services, and several importers were unable to discharge shipments from ports owing to the absence of printed bills of ladings (Balcı, 2021). Because actors in the seaway freight processes are interconnected and due to the high cost of transmission, this interconnectedness results in error-prone and delayed procedures (Wunderlich and Saive, 2020). Since the original bill of lading cannot be delivered to the carrier and the delivery order cannot be obtained, delays might occur in receiving the cargoes, and storage, demurrage, detention costs might be incurred, also agglomeration might occur in ports and warehouses. As a result of these situations, prolonged discussions might arise between the seller and the buyer as to who will bear these costs (Manaadiar, 2020).

The document review process takes a long time, and in the worst-case scenario, it takes longer than the actual transportation. Hence, the transportation process is slowed, and the cost of the items rises. In sum, transportation-related documentation obligations contribute to 5–10% of total transportation expenditures. In light of the significant cost pressure, it is thus critical to develop a means to relieve the transport players of the burden of the paper-based documentation process of sea freight. In this regard, the eBL appears as an effective solution to eliminating the disadvantages stemming from paper-based bill of lading. Using the eBL, the complicated paper-based transportation documentation would be avoided. It also eliminates the

complexity of payment methods and the problem of language differences. Utilizing the eBL, the trading process is enormously accelerated and ultimately becomes more cost-effective. Particularly in light of the still-ongoing shipping issue, companies are reliant on more cost savings (Wunderlich and Saive, 2020).

The eBL was developed as a concept about 20 years ago and there have been several initiatives for replacing the paper version of the transportation documents with digital equivalents so far (Dubovec, 2005). Among them, the BOLERO project is the pioneer of this digitization endeavor (Ma, 2000). Based on a widespread opinion, eBL will lead to a radical change in the sector, as it is faster, enables efficient transactions, and reduces costs (document fee, courier costs, etc.), as well as being safer and less risky (Manaadiar, 2020). However, in today's world, shipments under the eBL are limited (Todd, 2019).

Traditional and still widely used bills of lading, especially negotiable and transferable bills of lading, are issued in paper form and stamped by the carrier, usually in 3 copies. For the transported materials to be received, such bills of lading must be physically sent to the buyer by courier (Manaadiar, 2020). Due to the lockdown in many countries caused by the coronavirus pandemic, exporters cannot receive their bills of lading even after the goods have been loaded onto the ship and the ship has sailed. Parallel to this, cargoes that have arrived at the unloading port experience many problems since the bills of lading have not arrived or, in the worst-case scenario, the bills of lading are lost. For this very reason, almost all shipowners and customers wished to have access to e-bill of lading during this period (Manaadiar, 2020).

In line with this, many shipowning firms particularly major ones have started to announce eBL applications. Considering what we're going through right now, it might be the perfect solution. For instance, ZIM broke new ground in this regard and implemented the first pilot e-bill of lading within the scope of blockchain technology in 2017 in cooperation with Sparx and Wave software companies (ZIM, 2017). Similarly, French CMA-CGM, the world's 4th largest container operator, has recently announced its e-bill of lading systems (CMA-CGM, 2019). In this regard, it should be indicated that the Digital Container Shipping Association (DCSA), which was established by major container shipping lines in 2019 to establish information technology standards that would enable the interoperability of the technology solutions across the container industry, published data and procedural standards for the submission of shipping instructions and issuance of the eBL. Via this initiative, the aim of the DCSA is to facilitate the acceptance and adoption of the eBL by different stakeholders in the industry such as regulators, banks, insurers, carriers, and their customers (Digital Container Shipping Association, 2020).

Considering previous studies on the issue, it is observed that the majority of the current literature on eBL is devoted to the legal ramifications of going paperless in shipping transactions and the viability of offering an electronic version that is operationally and legally similar to the traditional paper-based bill of lading considering the various legal frameworks of various nations (Doan, 2018; Arıman and Erol, 2023; Ren, 2023). In this regard, for instance, examining defects of Vietnamese legal mechanism, Doan (2018) provided some recommendations for the use of electronic bills of lading in Vietnam. Similarly, Arıman and Erol (2023) evaluated the applicability of the electronic bill of lading concept for Türkiye by analysing the national legislation and as a result of the study, in relation to the subject, some suggestions have been made to overcome the deficiencies in the domestic legislation. Ren (2023) investigated the extent to which eBLs can be governed by the English legal system and whether electronic tools can replicate the features of paper-based bill of ladings to create an electronically equivalent version of the latter that is both legally and functionally equal. Some of the papers with regard to eBL have also concentrated on the technologic and cyber security aspect of the issue (Kara, 2019; Kapnissis *et al*., 2020; Petronilho *et al*., 2022). Additionally, some papers have partially

revealed the transitional barriers of the eBL qualitatively (Mei and Dinwoodie, 2005; Dubovec, 2005; Civelek *et al.,* 2015; Ziakas, 2018; Civelek and Özalp, 2018; Yıldız and Baştuğ, 2018; Meral, 2020).

The above papers have provided a valuable insight into the advantages and disadvantages of the paperless bill of lading processes. However, each of these papers has solely concentrated on one or more eBL transitional barriers qualitatively and no research papers have comprehensively investigated all possible transitional barriers from a quantitative perspective and assessed their relative importance. Therefore, concentrating on container shipping lines of Türkiye origin, this is a pioneering study that qualitatively and quantitatively examines the barriers to the adoption of eBL systems since no container shipping companies from Türkiye have been found to use eBL systems yet to our best knowledge. There have been many criteria appearing as barriers to transition to the eBL. Identification of these barriers to transition to the eBL, evaluating the significance of these causal barriers would holistically require a well-designed multi-criteria decision making. Fuzzy Multiple Criteria Decision Making approach has been largely used to handle the decision-making problems including multi-criteria choosing and/or assessment of the alternatives (Park *et al.,* 2018; Kamal *et al.,* 2020). In the literature, practical applications of the Fuzzy Analytical Hierarchy Process (Fuzzy-AHP) have revealed advantages for managing qualitative criteria and obtaining accurate findings (Hsieh *et al.,* 2004; Satir, 2014; Chang *et al.,* 2019a). Thus, the Fuzzy-AHP approach was utilized to prioritize the importance of the transitional barriers in adopting the eBL. The rest of the paper is organized as follows. After providing the identifications of the barriers in Section 2, the stages of the employed method are explained in Section 3. Following that the use of utilized methodology on transitional barriers is provided in Section 4. Results of the method are provided, discussed and also some recommendations are proposed in Section 5 and finally, the study is summarized and some suggestions are put forward in the last section.

2. MATERIALS AND METHODS

2.1. Transitional barriers to eBL

To reveal the transitional barriers to eBL in Türkiye, literature was reviewed comprehensively. The possible barriers to the transition to the eBL systems are revealed through literature review utilizing databases such as Google Scholar, Sciencedirect and industrial reports and are suitably placed in the related part of the following section. These barriers are examined under 6 headings as technological, business culture, standardization, adaptation of external stakeholders, legal, reliability barriers, and are explained respectively as follows.

2.1.1. Technological Barrier

Cyber Security Risk: The digital transformation taking place in the maritime transport sector also has negative aspects. Because the developments in technology have created opportunities for maritime transport companies and their commercial stakeholders as well as criminal actors and have made the sector vulnerable to cyberattacks. The increase in the size of cyberattacks is considered to have the potential to disrupt critical infrastructure in the future (Chang *et al.,* 2019b). In particular, the industry's lack of standardization for cyber security, the necessity of establishing an international safety net rather than a domestic approach, and the implementation of a global mandatory standard when necessary will take a long time. The eBL systems are also not immune from the risk of cyberattacks, and cyberattacks stand as a fundamental barrier to the transition from paper bill of lading to eBL systems (Kara, 2019).

Counterfeiting / Fraud Risk: One of the main risks attributable to the electronic format of the bill of lading is the vulnerability of the bill of lading to fraudulent practices. To put it simply, hackers can have access to data, albeit any encryption-decryption system. It is technically possible to create a fake copy of the original bill of lading and the created copy may be indistinguishable from the original. It should also be noted that, since it is in written form, it

is much easier to detect a forgery in a printed bill of lading compared to a computer-generated counterfeit copy (Ziakas, 2018).

2.1.2. Business Culture Barrier

Negative Perception of Stakeholders: Stakeholders in the supply chain such as consignor, carrier, consignee, bank may have a negative view of this technology. Thus, it is necessary to build trust in these systems in order to improve the attitude of users regarding eBL (Mei and Dinwoodie, 2005).

Resistance to Change: Employees may be reluctant in the digitalization process of documentation of the bill of lading. Employees' negative attitudes towards the electronic documentation system are most likely due to resistance to change and the system's lack of interoperability (Civelek *et al.,* 2015).

2.1.3. Standardization Barrier

Electronic signature: The legal validity of electronic documents is based on the electronic signature they carry. Also, the legal validity of the electronic signature is based on the electronic signature laws of the countries. The legal basis of the Bill of Lading is based on transnational commercial law (lex mercatoria), international law, rules, and agreements. The lack of an integrated system that brings together all the parties involved in a foreign trade transaction, the differences between countries, and the fact that electronic signature applications are not accepted in every country stand as one of the obstacles to the widespread adoption of the eBL (Civelek and Özalp, 2018).

Utilization of Different Platforms: The use of different eBL platforms such as Bolero, Seadocs, Wave, E-Title, and Tradelens is another challenge for the universal acceptance of these systems for companies trading internationally. Attitudes in countries adopting the eBL may change and do not necessarily have to be compatible with all international markets, especially countries that are slow to implement new technology. These complications can arise in matters of commercial disputes and litigation (Marsh, 2016).

2.1.4. Adaptation Barrier of External Stakeholders

Adaptation of State Institutions: As long as government agencies are ready for eBL integration, it will facilitate the transition. For example, it is important that some documents, including the bill of lading, are fully completed in such a way that they can be submitted to the customs administration, depending on the way the goods arrive. Here, for example, the fact that the customs administration does not have a technological infrastructure that can accept eBL constitutes a serious barrier.

Adaptation of Banks: One of the serious obstacles to the spread of eBL is that banks prefer to provide financing to the parties by using the original, paper bills of lading as collateral, which still reflects the ownership of the goods in practice. The importer can obtain the necessary documents for importation and clear the goods from customs only by paying the original, physical bill of lading to her bank (Meral, 2020). In addition, the fact that banks are not ready and familiar with the use of eBL poses a serious obstacle. The use of eBL remained limited due to the problems experienced by the banking sector. Traditional eBL's have compatibility problems with the financial system. For example, while TradeCard and GlobalTrade are fully supported in the financial system, SeaDocs and Bolero project could not be included in the banking system (Yıldız and Baştuğ, 2018). For example, the lack of support from the banking industry is stated as an important reason for the failure of the Bolero eBL system (Dubovec, 2005).

Adaptation of P&I and Cargo Insurance Companies: The issue of whether the disputes/risks that may arise from a shipment containing eBL will be covered appears as an obstacle to the transition to the eBL system due to the fact that the P&I Club (Protection and Indemnity Club) or cargo insurers do not approve any eBL system (Global Trade Review, 2021a).

2.1.5. Legal Barrier

Inadequacy of Domestic Legislation: In the event that a bill of lading is prepared

electronically, it has not been fully clarified whether it will be qualified as a negotiable document. Assuming that the reference to the validity of the eBL in the Commercial Code of Türkiye is made to all issues related to the bill of lading in the aforementioned law, it can be claimed that the eBL has the same value as the printed bill of lading. However, a legal arrangement should be made in a way that leaves no room for doubt as to whether the eBL has the qualification of negotiable paper, and many problems related to the relevant issue should be resolved with this legislation (Kara, 2019). Since the legal infrastructure of the countries does not allow the implementation of the eBL, its usage could not become widespread (Meral, 2020).

Differences Between Foreign Legislation: In case of a dispute arising from bills of lading in international trade, the legal systems to be applied may differ from country to country. In this regard, customers using eBL should be careful and check whether the legal status of such documents is accepted as valid digital documents in the laws of the country (Turk P&I, 2021). In this context, the issue should be standardized by the relevant international organizations to eliminate the conflicting situations that may arise from the eBL. The fact that the Rotterdam Rules, which is one of the first efforts in this context, have not been fully implemented yet is one of the factors underlying the failure of the eBL to become widespread (Meral, 2020).

2.1.6. Reliability Barrier

Consignor/Consignee Trust Issue: The parties involved in the import/export business do not want their bills of lading to be recorded in the main database of the companies which are providing this electronic service due to the confidentiality of the shipment information (Yıldız and Baştuğ, 2018).

Carrier's Trust Issue: In the eBL systems, the rights and responsibilities of the parties are parallel to the printed bills of lading. But the most obvious difference between them is the procedure that makes the endorsement transfer of the bill of lading possible between the exporter and the importer. The eBL system is built on a kind of digital signature system. Here, the encrypted codes are produced by the carrier, and when the owner of the cargo changes, the encrypted code is replaced by the carrier with the new ones. At this point, when the carrier informs the owner of the goods about the place and time of delivery, the cargo owner must determine the buyer of the cargo precisely and convey the key code and delivery conditions. On the other hand, this mechanism does not work effectively in practice. Some carriers complain about the loss of key roles during the digital signature process, and doubts arise about the security of these private keys generated and the uniqueness of the electronic documents produced as a result (Yıldız and Baştuğ, 2018).

2.2. Establishment of Hierarchical Structure

After reviewing the literature regarding transitional barriers to the eBL system, a set of interviews was conducted to validate the findings of the literature review and reveal any additional transitional barriers for container shipping companies. Before performing the interviews, the experts were shortly informed concerning the aim of the research and fuzzy-AHP implementation. An Excel sheet, that includes identifications of the barriers, was sent to the interviewees. In the interviews, the industrial experts were asked to modify the barriers if they felt any barriers indicated in the Excel sheet are inappropriate, to confirm and support the barriers if they thought the barriers are appropriate, or to suggest other relevant barriers if they felt there exist some other barriers that have been considered but yet mentioned in the provided Excel sheet.

In total, 13 experts from different segments of the container shipping lines participated in the interviews. These experts who contributed to the hierarchical structure of the barriers have been actively engaged in the maritime container shipping industry for a long time. They have been employed in various positions in the container shipping industry such as vice general manager, documentation manager, forwarder relations manager, trade line manager, academician with a freight forwarding background etc., and details of the experts are

presented in Table 1. Based on the outcomes of the interviews, all the barriers provided in the literature review section are endorsed by the consensus of experts, no extra barriers are specified and the ultimate hierarchical structure appears as given in Figure 1.

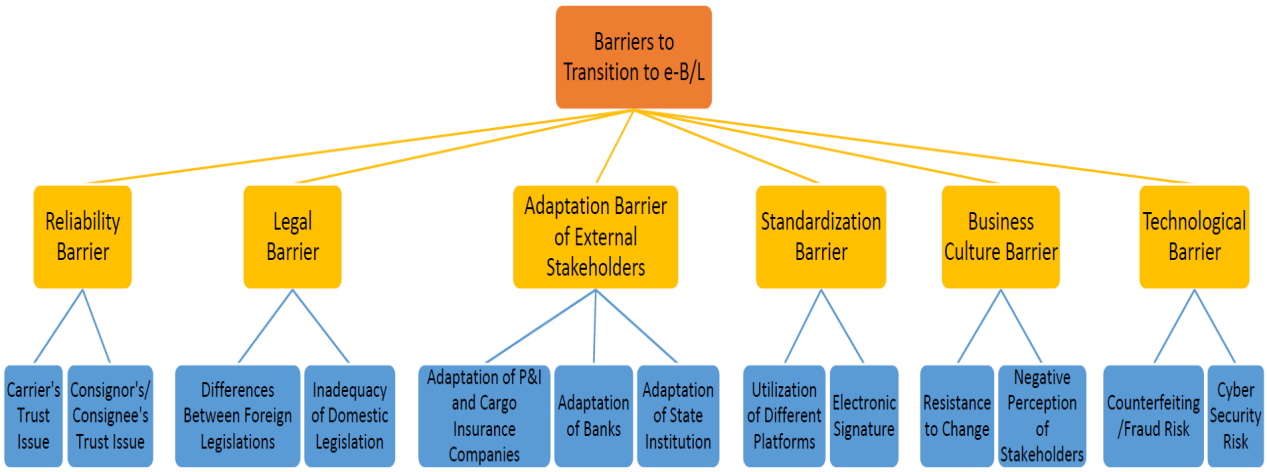

Figure 1. Hierarchical structure for barriers to transition to eBL usage

Table 1. Details of the experts

Position	Education	Industrial Experience (years)
Assistant General Manager	Maritime Transportation Management Engineering (Bsc)	17
Procurement Manager	Maritime Transportation Management Engineering (Bsc)	14
Ocean Freight Manager	Maritime Business (Bsc)	17
Associate Professor (Maritime)	Phd	17
Assistant Professor (Maritime)	Phd	14
Senior Export Specialist	International Trade and Logistics (Bsc)	5
Trade Lane Manager	Maritime Transportation Management Engineering (Bsc)	16
Senior Export Specialist	International Trade (Bsc)	6
Documentation Chief	Logistics (Bsc)	15
Forwarder Relationship Manager	High School	31
Ocean Freight Specialist	Maritime Business (Bsc)	12
Export Manager	Maritime Transportation Management Engineering (Bsc)	16
Documentation Manager	Shipping Operations & Port Technology (Bsc)	23

2.3. Fuzzy Analytical Hierarchy Process (FAHP)

Due to the ambiguous nature of decision-making problems, humans frequently fail to describe their preferences exactly in many practical scenarios (Kamal, 2021b; Kamal and Kutay, 2021). Zadeh (1965) originally presented the fuzzy set theory, which was geared to the rationality of uncertainty owing to vagueness, to deal with the ambiguity of human thought (Beşikçi *et al.*, 2016). FAHP method is considered to be a suitable method for this research since expert opinion will be employed in weighing the transitional barriers to adopting the eBL usage.

The AHP method is largely employed in multiple criteria decision-making approaches

and has been utilized in many fields (Seo *et al.,* 2018; Çakir, 2019; Ha *et al.,* 2021). This method, however, is frequently criticized for its inability to assign precise numerical values to comparison judgments and for being ineffectual when performed to ambiguous problems. To handle fuzzy comparison matrices, several scholars have merged the Fuzzy theory with the AHP approach since the standard AHP still cannot provide adequate guidance regarding the extremely ambiguous environment (Chang *et al.,* 2019a; Kamal *et al.,* 2020; Ergin, 2021). One of these approaches is the extent analysis method developed by Chang (Chang, 1996) and in this paper, the extent fuzzy AHP is utilized in order to prioritize the transitional barriers in adopting eBL. $X = \{x_1, x_2, ..., x_n\}$ be an object set, and $U = \{u_1, u_2, ..., u_m\}$ be a goal set. Based on Chang's approach, each criterion is taken and the extent analysis is performed for each target. Therefore, m extent analysis values can be achieved for each object. These values are provided as follows.

M^j_{gi} = extent analysis value for each object

$$M^1_{gi}, M^2_{gi} ..., M^m_{gi}, \ i = 1,2,...,n, \tag{1}$$

At this point, $M^j_{gi} \ (j = 1,2,\ldots,m)$ are all triangular fuzzy numbers and linguistic scale utilized in this research is indicated in Table 2 (Ho, 2011).

Table 2. Triangular Fuzzy Numbers

Linguistic Scale	Triangular Fuzzy Numbers	Reciprocal Triangular Fuzzy Numbers
Absolutely Important	(9,9,9)	(1/9,1/9,1/9)
Intermediate	(7,8,9)	(1/9,1/8,1/7)
Very Strong	(6,7,8)	(1/8,1/7,1/6)
Intermediate	(5,6,7)	(1/7,1/6,1/5)
Strong	(4,5,6)	(1/6,1/5,1/4)
Intermediate	(3,4,5)	(1/5,1/4,1/3)
Weak	(2,3,4)	(1/4,1/3,1/2)
Intermediate	(1,2,3)	(1/3,1/2,1/1)
Equally Important	(1,1,1)	(1,1,1)

The stages of Chang's extent analysis can be presented as in the following (Chang, 1996).

Stage 1: The value of the fuzzy synthetic regarding the ith object is outlined as in the following:

S_i = the value of fuzzy synthetic extent regarding the ith object.

$$S_i = \sum_{j=1}^{m} M^j_{g_i} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M^j_{g_i} \right]^{-1} \tag{2}$$

$\sum_{j=1}^{m} M^j_{g_i}$ to compute the value; the fuzzy addition operation of m extent analysis values for a particular matrix is executed like so:

$$\sum_{j=1}^{m} M^j_{g_i} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j \right) \tag{3}$$

$$\sum_{i=1}^{n} \sum_{j=1}^{m} M^j_{g_i} = \left(\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i \right) \tag{4}$$

The inverse of the vector in equation (4) is computed as follows.

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M^j_{g_i} \right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i} \right) \tag{5}$$

Stage 2: The degree of possibility of $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$ is framed as

$$V(M_2 \geq M_1) = \sup_{y \geq x} \lfloor \min(\mu_{M_1}(x), \mu_{M_2}(y)) \rfloor \tag{6}$$

and the equivalent can be stated as follows;

$$V(M_2 \geq M_1) = hgt(M_1 \cap M_2) = \mu_{M_2}(d) = \begin{cases} 1, & \text{if } m_2 \geq m_1, \\ 0, & \text{if } l_1 \geq u_2, \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & \text{otherwise,} \end{cases} \tag{7}$$

where d is the ordinate of the highest intersection point D between between M1 and M2.

Stage 3: The possibility degree of convex fuzzy values being greater than k convex fuzzy values $M_i (i = 1,2,.....,k)$ can be given as follows;

$$V(M \geq M_1, M_2, ..., M_k) = V[(M \geq M_1) \text{ and } (M \geq M_2) \text{ and } ... \text{and } (M \geq M_k)] = \min V(M \geq M_i), \quad i = 1,2,....., k. \tag{8}$$

$$d'(A_i) = \min V(S_i \geq S_k), \tag{9}$$

For $k = 1,2,....., n; k \neq i$. After the weight vector is given by

$$W' = (d'(A_1), d'(A_2), ..., d'(A_n))^T \tag{10}$$

Here $A_i (i = 1,2,....., n)$ are n elements.

Stage 4: Normalized weight vectors are as in the following.

$$W = (d(A_1), (A_2), ... d(A_n))^T \tag{11}$$

Here, w is a non-fuzzy number (Chang, 1996).

3. APPLICATION OF FUZZY AHP ON TRANSITIONAL BARRIERS TO EBL

Following the establishment of the hierarchical structure, it is attempted at comparing the main and sub-criteria of the transitional barriers according to their degree of importance. To do this, the FAHP (Fuzzy Analytic Hierarchy Process) questionnaire, which was created to determine the importance levels of these factors, was presented to the interviewed experts, and finally, among them, 11 experts filled out the questionnaire and sent them back. The data obtained from the questionnaires were evaluated with the synthetic extent analysis developed by Chang (1996), which is one of the solution methods of the FAHP application, and 6 main factors (criteria) and 13 sub-factors were ranked according to their importance in terms of being an obstacle to the use of eBL.

Six main factors which are technological barrier (TB), business culture barrier (BCB), standardization barrier (SB), external stakeholder adaptation barrier (ESAB), legal barrier (LB), and reliability barrier (RB), and 13 sub-factors which are cybersecurity risk (CSR) and counterfeiting/fraud risk (CFR), stakeholder negative perception (NPS) and resistance to change (RC), electronic signature (ES) and use of different platforms (UDP), adaptation of state institution (ASI) and adaptation of banks (AB) and adaptation of P&I and cargo insurers companies (APCIC), the inadequacy of domestic legislation (IDL) and differences between foreign legislation (DBFL), consignor's/consignee's trust issue (CCTI), and carrier's trust issue (CTI), determined within the scope of the study were compared in pairwise form by 11 experts using the fuzzy linguistic statements provided in Table 2. Therefore, 64 pairwise comparisons performed by each expert were combined with the FAHP via geometric mean, which enables multiple expert decisions to be represented as a single consensus decision in group decision-making processes. Due to the non-reciprocity, power condition of the group's common pairwise comparison matrices, using the arithmetic mean at this step is not suggested (Ossadnik *et al.,* 2016). The geometric mean method used in the creation of the joint decision matrix of the expert group was applied as given in eq.12 (Davies, 1994).

$$I_{ij} = \left(\prod_{k=1}^{K} I_{ijk}\right)^{\frac{1}{K}}, m_{ij} = \left(\prod_{k=1}^{K} m_{ijk}\right)^{\frac{1}{K}}, \quad u_{ij} = \left(\prod_{k=1}^{K} u_{ijk}\right)^{\frac{1}{K}} \tag{12}$$

Where, $K = \{1,2,3,\ldots,k\}$ represents the set of the expert group participating in the evaluation, $I_{ijk}, m_{ijk}, u_{ijk}$ represent respectively, the lower, middle and upper limit values of the i factor of the kth expert according to the j factor and I_{ij}, m_{ij}, u_{ij} represent respectively, the lower, middle and upper values of the i factor of the expert group as the geometric mean of the importance level according to the j factor.

The judgments of 11 experts were combined and the common decision matrix of the group was formed via the geometric mean method. Based on this common decision matrix, the weights of the priority degrees of the criteria relative to each other were calculated with the synthetic extent analysis method. For this study, the joint decision matrix of the group consisting of 11 experts and the weights of the priority degrees are provided as in Table 3.

In the AHP method, the reliability of the results is measured by the consistency index. A consistency index below 0.1 reflects that the survey responses are consistent and reliable. In this study, the consistency index of the joint decision matrix obtained from the responses of 11 experts was calculated as 0.007. Since the inequality 0.007<0.1 is satisfied, the results of the study are consistent and reliable.

Table 3. Joint Decision Matrix of the Expert Group and Weights of Main Factors

	TB	BCB	SB	ESAB	LB	RB	Local Weights
TB	(1.00,1.00,1.00)	(2.89,3.42,4.00)	(1.57,1.91,2.29)	(0.64,0.78,0.92)	(0.46,0.52,0.57)	(0.94,1.07,1.21)	0.00
BCB	(0.25,0.29,0.35)	(1.00,1.00,1.00)	(0.41,0.51,0.68)	(0.25,0.28,0.33)	(0.14,0.16,0.19)	(0.28,0.36,0.46)	0.00
SB	(0.44,0.52,0.64)	(1.47,1.96,2.44)	(1.00,1.00,1.00)	(0.30,0.37,0.47)	(0.19,0.23,0.28)	(0.32,0.39,0.52)	0.00
ESAB	(1.08,1.28,1.56)	(3.03,3.57,4.00)	(2.12,2.70,3.33)	(1.00,1.00,1.00)	(0.42,0.48,0.60)	(0.78,1.00,1.25)	0.16
LB	(1.75,1.92,2.17)	(5.26,6.25,7.14)	(3.57,4.35,5.26)	(1.67,2.08,2.38)	(1.00,1.00,1.00)	(1.37,1.82,2.34)	0.78
RB	(0.82,0.93,1.06)	(2.17,2.78,3.57)	(1.92,2.56,3.13)	(0.80,1.00,1.28)	(0.43,0.55,0.73)	(1.00.1.00,1.00)	0.06

Local weights expressing the priority values of the main factors are calculated as follows according to Table 3. In this calculation, firstly, the synthetic extent values of each factor were determined as follows:

$$S_{TB} = (7.5,8.7,9.99) \otimes \left(\frac{1}{61.15},\frac{1}{52.04},\frac{1}{43.74}\right) = (0.12,0.165,0.229)$$

$$S_{BCB} = (2.33,2.6,3.01) \otimes \left(\frac{1}{61.15},\frac{1}{52.04},\frac{1}{43.74}\right) = (0.037,0.049,0.069)$$

$$S_{SB} = (3.72,4.47,5.35) \otimes \left(\frac{1}{61.15},\frac{1}{52.04},\frac{1}{43.74}\right) = (0.059,0.084,0.123)$$

$$S_{ESAB} = (8.43,10.03,11.74) \otimes \left(\frac{1}{61.15},\frac{1}{52.04},\frac{1}{43.74}\right) = (0.134,0.19,0.27)$$

$$S_{LB} = (14.62,17.42,20.29) \otimes \left(\frac{1}{61.15},\frac{1}{52.04},\frac{1}{43.74}\right) = (0.233,0.33,0.466)$$

$$S_{RB} = (7.14,8.82,10.77) \otimes \left(\frac{1}{61.15},\frac{1}{52.04},\frac{1}{43.74}\right) = (0.114,0.167,0.247)$$

The triangular fuzzy numbers of synthetic extent values obtained as above and the minimum degree possibilities were calculated as follows.

$$d'(A_i)=\min V(S_i \geq S_k),\ k=\{1,2,3,\ldots,n\};\ k \neq I$$

$$d'(1)=\min V(S_1 \geq S_2,S_3,S_4,S_5,S_6) = \min(1.00,1.00,0.25,0.00,0.95)$$

$$d'(2)=\min V(S_2 \geq S_1,S_3,S_4,S_5,S_6) = \min(0.00,0.25,0.00,0.00,0.00)$$

$$d'(3)=\min V(S_3 \geq S_1,S_2,S_4,S_5,S_6) = \min(0.04,1.00,0.00,0.00,0.10)$$

$$d'(4)=\min V(S_4 \geq S_1,S_2,S_3,S_5,S_6) = \min(1.00,1.00,1.00,0.21,1.00)$$

$$d'(5)=\min V(S_5 \geq S_1,S_2,S_3,S_4,S_6) = \min(1.00,1.00,1.00,1.00,1.00)$$

$$d'(6)=\min V(S_6 \geq S_1,S_2,S_3,S_4,S_6) = \min(1.00,1.00,1.00,0.83,0.08)$$

The weight vector of the factors obtained from the minimum degree possibility values calculated in the previous part was formed as $W'=(0.00,0.00,0.00,0.21,1.00,0.08)^T$ and the normalized weight vector was formed as $W'=(0.00,0.00,0.00,0.16,0.78,0.06)$. According to these findings, the priority degrees of the obstacles encountered in the use of eBL were listed as 0.78, 0.16, 0.06, 0.00, 0.00, 0.00, respectively, as LB, ABES, RB, TB, BCB, SB. The normalized weight vectors representing the priority degrees of the sub-factors under the main factors were determined by applying the same principles. The joint decision matrices, local weight vectors and global weights of the sub-factors related to each main factor are given in Tables 4-10:

Table 4. Joint Decision Matrix and Local Weights of Sub-Factors of TB

	CSR	**CFR**	**Local Weights**
CSR	(1.00,1.00,1.00)	(1.13,1.27,1.42)	1.00
CFR	(0.7,0.79,0.88)	(1.00,1.00,1.00)	0.00

Table 5. Joint Decision Matrix and Local Weights of the Sub-Factors of BCB

	NPS	**RC**	**Local Weights**
NPS	(1.00,1.00,1.00)	(1.59,1.78,1.95)	1.00
RC	(0.51,0.56,0.63)	(1.00,1.00,1.00)	0.00

Table 6. Joint Decision Matrix and Local Weights of the Sub-Factors of the SB

	ES	**UDP**	**Local Weights**
ES	(1,00,1.00,1.00)	(0,79,0.82,0.86)	0.00
UDP	(1.16,1.22,1.27)	(1.00,1.00,1.00)	1.00

Table 7. Joint Decision Matrix and Local Weights of the Sub-Factors of the ESAB

	ASI	**AB**	**APCIC**	**Local Weights**
ASI	(1.00,1.00,1.00)	(1.78,2.04,2.35)	(1.11,1.35,1.6)	1.00
AB	(0.43,0.49,0.56)	(1.00,1.00,1.00)	(1.01,1.26,1.5)	0.00
APCIC	(0.63, 0.74, 0.9)	(0.67,0.79,0.99)	(1.00,1.00,1.00)	0.00

Table 8. Joint Decision Matrix and Local Weights of the Sub-Factors of the LB

	IDL	**DBFL**	**Local Weights**
IDL	(1.00,1.00,1.00)	(0.63,0.68,0.74)	0.00
DBFL	(1.35,1.47,1.59)	(1.00,1.00,1.00)	1.00

Table 9. Joint Decision Matrix and Local Weights of the Sub-Factors of the RB

	CCTI	**CTI**	**Local Weights**
CCTI	(1.00,1.00,1.00)	(2.01,2.2,2.37)	1.00
CTI	(0.42,0.45,0.5)	(1.00,1.00,1.00)	0.00

Table 10. Local and Global Weights of Main and Sub-Factors

Main Factor	**Sub Factor**	**Local Weight**	**Global Weight**
TB (0.00)	CSR	1.00	0.00
	CFR	0.00	0.00
BCB (0.00)	NPS	1.00	0.00
	RC	0.00	0.00
SB (0.00)	ES	0.00	0.00
	UDP	1.00	0.00
ESAB (0.16)	GIA	1.00	0.16
	BA	0.00	0.00
	PICA	0.00	0.00
LB (0.78)	DDL	0.00	0.00
	DFL	1.00	0.78
RB (0.06)	SRTI	1.00	0.06
	CTI	0.00	0.00

4. FINDINGS AND DISCUSSION

As obtained from the findings, considering the main barriers, the most important barrier to the transition to eBL appears as LB (0.78). From this point of view, it is understood that the steps taken towards the digitalization of the global maritime transport networks must first of all be within the limits determined by legal frameworks. This finding implies that the priority concerning the transition to eBL should be given to eliminating the lack of legal infrastructure. In this context, the United Nations Commission on International Trade Law (UNCITRAL) Model Law on Electronic Transferable Records (MLETR) appears as an effective tool to combat the problems stemming from the legal issues. MLETR was adopted by UNCITRAL on 13 July 2017 to guide the states to eliminate the confusion caused by different practices and rules in international trade with transferable electronic records. The aim of the Model Law is to provide functional equality (same legal standing) between the traditionally issued paper-based transferable documents (e.g. bill of lading) and the electronic records (e.g. eBL) (İstemi, 2020). So far, some countries adopted the MLETR such as Singapore and Bahrain and it is considered that adopting the MLETR by the government of Türkiye into domestic legislation would address the problem to a large extent. The container shipping lines which are operating in Türkiye are relatively small firms considering Alphaliner Top 100 list and such an adoption, as indicated by Paul Mallon, director of legal and regulatory affairs at Bolero International, instills more confidence in smaller organizations that may have been hesitant to participate in (Global Trade Review, 2021b; Alphaliner, 2022). Taking the sub-factors of the legal barrier into account, it is found that differences between foreign legislation are given the highest importance. This is an expected situation since the fact that maritime trade to large extent occurs internationally.

Considering the main barriers, what follows the LB is ESAB (0.16) and RB (0.06), respectively. As a result of the evaluation of the expert group, the fact that the ESAB main factor ranks second compared to other factors undoubtedly highlights the importance of the integration of government institutions (customs, etc.), banks, and marine insurers, which are among the most important stakeholders of maritime trade, to each other and the system.

When the sub-factors of ESAB are examined, it has been determined that the adaptation of government institutions has priority over the other two sub-factors in this group. Thus, it is crucial to make the digital infrastructure of the related governmental bodies ready for eBL systems for transition. Also, it is observed that adaptation of P&I and cargo insurance barrier is given less importance. The fact that the majority of the domestic container shipping firms have their insurance services from I&G P&I Clubs and I&G is increasingly recognizing new eBL systems implies why less importance is given to this sub-factor (Turkpandi, 2015). The RB was another main factor to focus on as a result of the evaluations. Although reliability is being tried to be eliminated with blockchain technology, the parties involved in the transportation process are concerned about the presence of the customer and commercial information in the databases of 3rd party service providers regarding the eBL technologies currently in use. In this group, it was revealed that the concerns of the sender/receiver of the commercial product are a sub-factor that should be emphasized more than the concerns of the carrier. Therefore, efforts of the firms which are providing eBL services should be canalized more on customers of the carrier firms to alleviate their trust issue rather than carrier firms.

As a result of the opinions of the expert group, it has been evaluated that the effects of the main factors of TB, BCB, and SB and their sub-factors may be seen as insignificant compared to the main factors listed above. However, the fact that the importance degrees obtained from the combined joint decision matrix of the expert group are 0.00 does not mean that these factors do not affect the eBL transition process. It is known in the literature that this is a handicap arising from the fuzzy-AHP application and if one factor is not considered more important than the other, it is known that it occurs because the evaluators focus on the factors that are

considered more important (Beşikçi *et al.,* 2016). From this perspective, it would be a mistake to think that the transition to the eBL, which is one of the steps of digitalization in maritime transport, will not be affected by the TB factor. It is also obvious that a change and transformation process in which TB is effective will cause some adaptation problems arising from the business cultures of those working in that sector. The SB, on the other hand, will be a problem that may be faced by countries and parties in order to make widespread use of the new developing situation. The fact that the current eBL technologies are different platforms causes some problems and prevents the eBL application from becoming widespread.

The results of the sub-factors of the technologic barrier point out that cyber security risk is given the highest importance. Therefore, under thetechnological barrier, the utmost importance should be given to the elimination of the cyber security risks by the firms which are providing eBL services. On the other hand, the outcomes of the sub-factors of the business culture barrier indicate that resistance to change is given less importance. The fact that newly employed personnel graduates familiar with digitalization makes it possible to minimize their resistance to change in adopting new technologies such as eBL compared to the personnel who come from a relatively low educational background and build their experience in the company over time. This personnel is called “alaylı” in Turkish and they have more resistance to adopting new technologies, and their share among company employees is constantly decreasing in today’s business environment. When it comes to the sub-factors of the standardization barrier, it is revealed that utilization of different eBL platforms appears as the highest barrier. In this context, it should be indicated that there are many different service providers such as edoxOnline, Wave, Tradelens, essDocs, and Bolero, hence there should be standardization in these systems established (Kamal, 2021a). According to Oswald Kuyler, managing director of the Digital Standards Initiative of the International Chamber of Commerce, achieving a standardized eBL is a foundational part of the digital transformation process (Global Trade Review, 2020). In this context, the DCSA initiative published eBL standards for data and process in 2020 as part of a larger effort to standardize shipping paperwork and enable end-to-end digitalization of trade (Digital Container Shipping Association, 2020).

5. CONCLUSION

Bill of lading is the most crucial document used in maritime transportation since it establishes that goods were taken over by carriers in the specified condition. The bill of lading is still predominantly used in paper form in maritime transportation. In recent years, however, technological advancements have resulted in the paper-based bill of lading being replaced with an eBL since trading is massively accelerated, made more cost-effective, and several stakeholders participating in the supply chain may benefit from the eBL. This digitalization initiative can provide a vital source for maritime transportation firms for differentiation and competitive advantage. In line with this, efforts to employ eBL systems have been increasing and some major container shipping lines have started to announce their eBL systems recently. On the other hand, it was observed that Türkiye origin container shipping lines have not started to utilize this system yet. In this regard, this paper focused on revealing these barriers to the transition of eBL systems in Türkiye and prioritizing the importance of them among each other quantitatively. To achieve this, the Fuzzy AHP method was exploited. It was revealed that the legal barrier among the main barriers appeared as the most important barrier to the transition to eBL systems followed by adaptation of external stakeholders and reliability barriers, respectively. This study is limited and carried out with the participants only from container shipping lines and in a further study, this research can be extended by including experts from the different segments of the shipping industry such as dry bulk and tanker shipping and also the customers of the carriers to reflect a broader perspective.

AUTHORSHIP CONTRIBUTION STATEMENT

Ozan BAYAZİT: Conceptualization, Methodology, Validation, Formal Analysis, Resources, Writing-Original Draft, Writing-Review and Editing, Visualization, Supervision.
Bünyamin KAMAL: Conceptualization, Methodology, Validation, Formal Analysis, Resources, Writing-Original Draft, Writing-Review and Editing, Visualization, Supervision.

CONFLICT OF INTERESTS

The author(s) declare that for this article they have no actual, potential or perceived conflict of interests.

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Evaluation of Historical Changes Landing Data of Three Important Demersal Fish Species of Black Sea

Karadeniz'in Üç Önemli Demersal Balık Türüne Ait Av Miktarlarının Tarihsel Değişiminin Değerlendirilmesi

Türk Denizcilik ve Deniz Bilimleri Dergisi

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ABSTRACT

In this study, the spatial and temporal changes in the landings of whiting (*Merlangius merlangus*), red mullet (*Mullus barbatus*) and turbot (*Scophthalmus maximus*) caught in the Black Sea were discussed using the open access data set of officially recorded landing statistics published by Turkish Statistical Institute (TUIK). The landings of whiting in Turkish seas increased steadily from 1981 to 1988, reaching the highest amount in the 56-year period in 1988. In order years, fluctuation was observed in the production. The catch quantity of red mullet, which continued to increase until 1989, has been decreasing since then and reached its lowest catch amount since 1971 in the year 2022. Turbot, which had the highest catch in 1983, has a catch amount of less than 1000 tons since the early 2000s. In the period between 1967 and 2022, when comparing the production amounts of the Eastern and Western Black Sea, it was found that the majority of the red mullet and turbot catch was obtained from the Eastern Black Sea. Although the catch amount of whiting was high in the Eastern Black Sea until 2017, it has been determined that the Western Black Sea has had more catch since 2017.

Keywords: Landing statistics, Red mullet, Turbot, Whiting, Black Sea.

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ÖZET

Bu çalışmada, Karadeniz'den avlanan mezgit (*Merlangius merlangus*), barbunya (*Mullus barbatus*) ve kalkan (*Scophthalmus maximus*) av miktarlarının alan ve zamansal değişimleri Türkiye İstatistik Kurumu (TÜİK) tarafından erişime açık olarak yayınlanan balıkçılık istatistikleri kullanılarak ele alınmıştır. Mezgit balığının tüm Türkiye denizlerindeki av miktarı 1981 yılından 1988 yılına kadar düzenli bir artış göstererek 1988 yılında 56 yıllık sürecin en yüksek miktarına ulaşmıştır. Diğer yıllarda dalgalı bir üretim seyri göstermiştir. 1989 yılına kadar artış gösteren bir seyirle devam eden barbunya balığı günümüze kadar azalan oranda av vermiş ve 1971 yılından sonraki en düşük av miktarını 2022 yılında vermiştir. En yüksek av miktarını 1983 yılında veren kalkan balığı 2000'li yılların başından günümüze kadar 1000 tonun altında av vermiştir. 1967-2022 yılları arasındaki süreçte, Doğu ve Batı Karadeniz üretim miktarı bakımından karşılaştırıldığında barbunya ve kalkan balığı av miktarının çoğunluğu Doğu Karadeniz'den sağlanmıştır. Mezgit balığının ise 2017 yılına kadar Doğu Karadeniz'deki av miktarı fazla olmakla birlikte 2017 yılından itibaren Batı Karadeniz'in daha fazla av verdiği tespit edilmiştir.

Anahtar Sözcükler: Av istatistikleri, Barbunya, Kalkan, Mezgit, Karadeniz.

1. GİRİŞ

Türkiye sınırlarını kapsayan kıyı uzunluğu 1695 km olan Karadeniz, avcılık yoluyla elde edilen toplam su ürünleri üretiminin %75'ini (TÜİK, 2020) sağlamasına rağmen, 150-200 m'den sonraki derinliklerde hidrojen sülfür gazının varlığı ve oksijenin hızla azalması nedeniyle biyolojik verimlilik ve tür çeşitliliği yönünden oldukça fakirdir (Balkas *vd*., 1990; Zaitsev, 2008).

Karadeniz'in kıyı kesimini, balıkçılık aktiviteleri açısından; Doğu Karadeniz Bölgesi (Gürcistan sınırından Ordu-Ünye sınırına kadar olan bölüm), Orta Karadeniz Bölgesi (Ordu-Ünye ile ve Samsun-Yakakent arasındaki alan) ve Batı Karadeniz Bölgesi (Sinop'tan Bulgaristan sınırına kadar) olmak üzere üç bölüme ayırmak mümkündür. Bu üç bölge balıkçılık faaliyetleri açısından az-çok birbirinden farklı karakteristiklere sahiptir. Doğu Karadeniz'de gırgır balıkçılığı (hamsi, istavrit) ve kıyı uzatma ağları (mezgit, barbunya, kefal, kalkan, palamut gibi) ile avcılık yaygındır. Orta Karadeniz'de dip (mezgit-barbunya) ve pelajik trol (çaça) avcılığı ile, kıyı balıkçılığı kapsamında pelajik ve dip uzatma ağları ve algarna ile deniz salyangozu avcılığı yaygındır. Batı Karadeniz'de ise, pelajik balık avcılığı yapan büyük gırgır tekneleri (hamsi-istavrit, lüfer/çinekop, palamut), kıyı uzatma ağları (barbunya, mezgit, kalkan, lüfer/çinekop, palamut) ve beyaz kum midyesi avcılığı yaygındır (OTB, 2014). Türkiye İstatistik Kurumu (TÜİK), su ürünleri istatistiklerinde Orta ve Doğu Karadeniz'i (Sinop'tan Gürcistan sınırına kadar) bir bütün olarak (Doğu Karadeniz) değerlendirmektedir.

Karadeniz'den elde edilen avın %95'ini pelajik türler %5'lik kısmını ise demersal türler oluşmaktadır. 2022 yılı avcılık yoluyla elde edilen su ürünleri üretimi yaklaşık 335 bin ton olarak gerçekleşmiştir. (TÜİK, 2022). Karadeniz'den avlanan demersal balıkların oranı pelajik balıklara göre düşük olmasına rağmen ekonomik değeri yüksek balıklardır (Karakulak, 2016). Mezgit, barbunya ve kalkan avlanan demersal balıklar içerisindeki baskın türlerdendir. Bu çalışmada Karadeniz demersal balıkları içerisinde ticari değeri oldukça yüksek olan mezgit, barbunya ve kalkan balıklarının 1967-2022 yılları arasında üretim miktarlarındaki değişimi incelenerek analiz edilmiş ve bu üç türe ait balıkçılığın karakteristik özellikleri ortaya konulmaya çalışılmıştır.

2. MATERYAL VE YÖNTEM

Türkiye'de su ürünleri istatistikleri 1967 yılından itibaren yayınlanmaktadır. Su ürünlerine ait istatistikler TÜİK ile Tarım ve Orman Bakanlığı tarafından anket yoluyla toplanmakta ve anketler kapsamında toplanan av verisi türler bazında gruplandırılarak 5 bölge halinde (Akdeniz, Ege, Marmara, Batı Karadeniz ve Doğu Karadeniz)

rapor edilmektedir. Çalışma kapsamında 1967-2022 yılları arasında Karadeniz'in önemli 3 demersal türüne (Mezgit, barbunya ve kalkan) ait zaman serileri kullanılarak, üretim miktarlarında yıllar itibariyle görülen değişimler incelenmiş ve değerlendirmeler yapılmıştır.

Bölgeler bazında yıllık toplam av miktarlarını veren verilerin değerlendirilmesi, TÜİK'in rapor ettiği gibi Batı Karadeniz ve Doğu Karadeniz olarak ele alınmış ve karşılaştırmalar yapılmıştır. Bu amaçla 2000-2022 yılları arasındaki istatistiki verilere TÜİK veri tabanı üzerinden, 2000 yılından önceki verilere ise Devlet İstatistik Enstitüsü tarafından basılan dokümanlardan ulaşılmıştır.

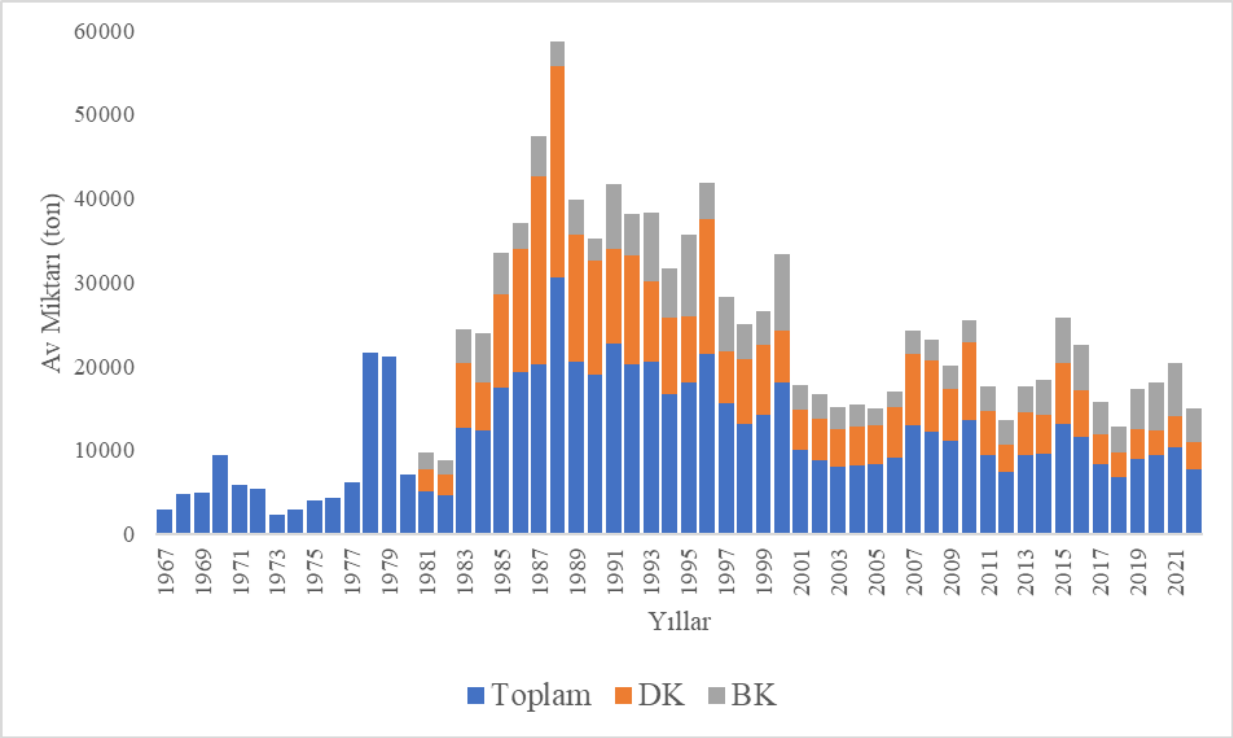
Av miktarlarının istatistiki olarak tanımlanması, hesaplamalar ve grafik çizimleri Microsoft Ofis Excel programında yapılmıştır.

3. BULGULAR

Araştırmada türlere ait istatistiki veriler, tüm denizlerimizdeki toplam üretim miktarları için 1967-2022 yıllarını, Doğu ve Batı Karadeniz'deki üretim miktarları için ise 1981-2022 yıllarını kapsamaktadır. 1967-2022 yılları arasında toplam mezgit üretimi 658630 ton olup, en düşük üretim 2359 ton ile 1973 yılında, en yüksek üretim ise 30488 ton ile 1988 yılında gerçekleşmiştir (Şekil 1). 1988 yılındaki av miktarının yüksek olmasında Doğu Karadeniz'deki mezgit av miktarının payı %83'tür (Tablo 1). 1981-2022 yılları arasındaki toplam mezgit üretim miktarının (555997 ton) %59'u (328821 ton) Doğu Karadeniz'den sağlanmıştır. Mezgit balığının av miktarı bakımından Doğu ve Batı Karadeniz karşılaştırıldığında; 1984, 1995, 1997 ve 2000 yılları ile 2017-2022 yılları arasında Batı Karadeniz'de daha çok av verdiği belirlenmiştir. 1995 yılında toplam mezgit av miktarının (18094 ton) %54'ü Batı Karadeniz'den sağlanmıştır.

Tablo 1. 1981-2022 yılları arasında Türkiye denizlerindeki mezgit, barbunya ve kalkan balığı av miktarlarının (ton) tanımlamalı istatistiki değerleri

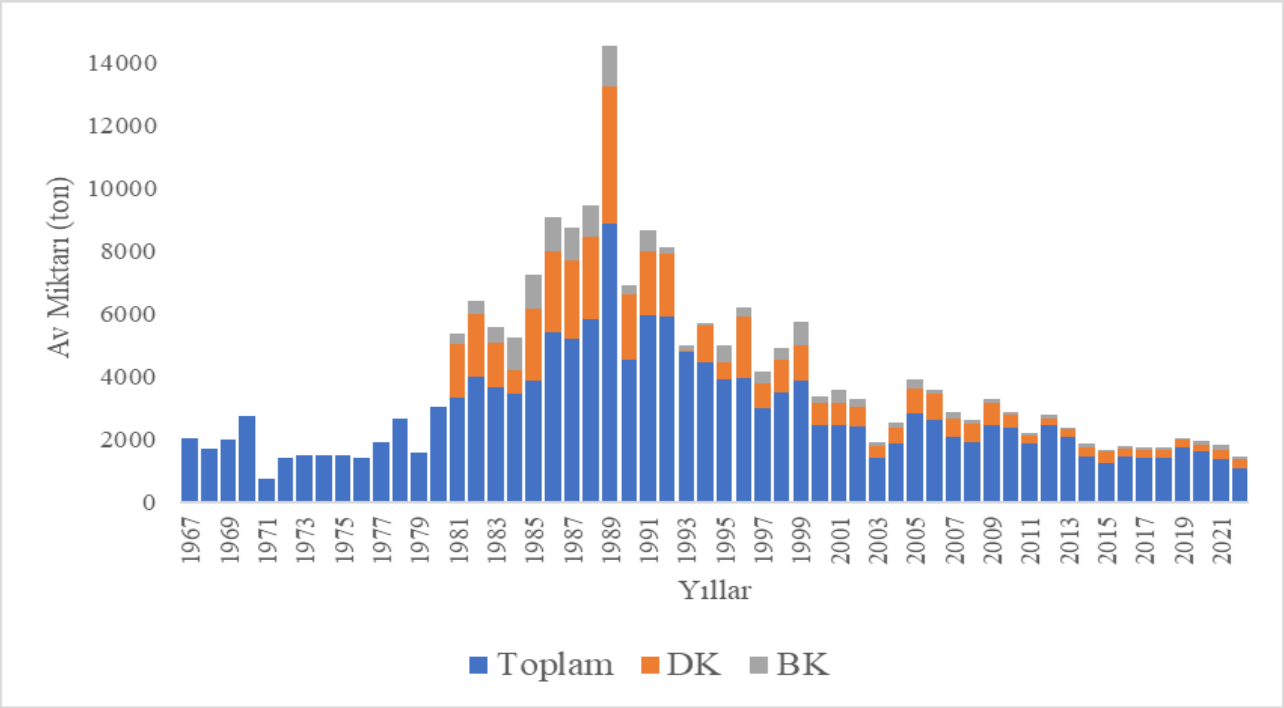
		Doğu Karadeniz	Batı Karadeniz	Marmara	Ege	Akdeniz	Toplam
Mezgit	**En Düşük**	2513	1751	110	2	41	4565
	En Yüksek	25255	9789	3343	629	1035	30488
	Ortalama	7829.07	4243.55	979.21	162.81	244.71	13238.02
	Standart Hata	786.46	300.88	112.96	21.63	34.58	869.02
	Güvenilirlik Düzeyi (%95)	1541.44	589.70	221.39	42.40	67.78	1703.24
Barbunya	**En Düşük**	44	38	3	165	81	1067
	En Yüksek	4.367	1274	561	1917	2970	8883
	Ortalama	1022.26	352.62	118.5	731.45	899.91	3126.29
	Standart Hata	144.15	53.58	19.88	60.63	83.94	259.27
	Güvenilirlik Düzeyi (%95)	282.53	105.01	38.96	118.83	164.52	508.15
Kalkan	**En Düşük**	30	99	10	0.2	1	13
	En Yüksek	1396	3851	636	58	1	5398
	Ortalama	376.36	743.81	81.17	5.52	0.02	1209.93
	Standart Hata	60.24	143.17	16.90	1.52	0.02	196.51
	Güvenilirlik Düzeyi (%95)	118.07	280.61	33.11	2.99	0.05	385.14



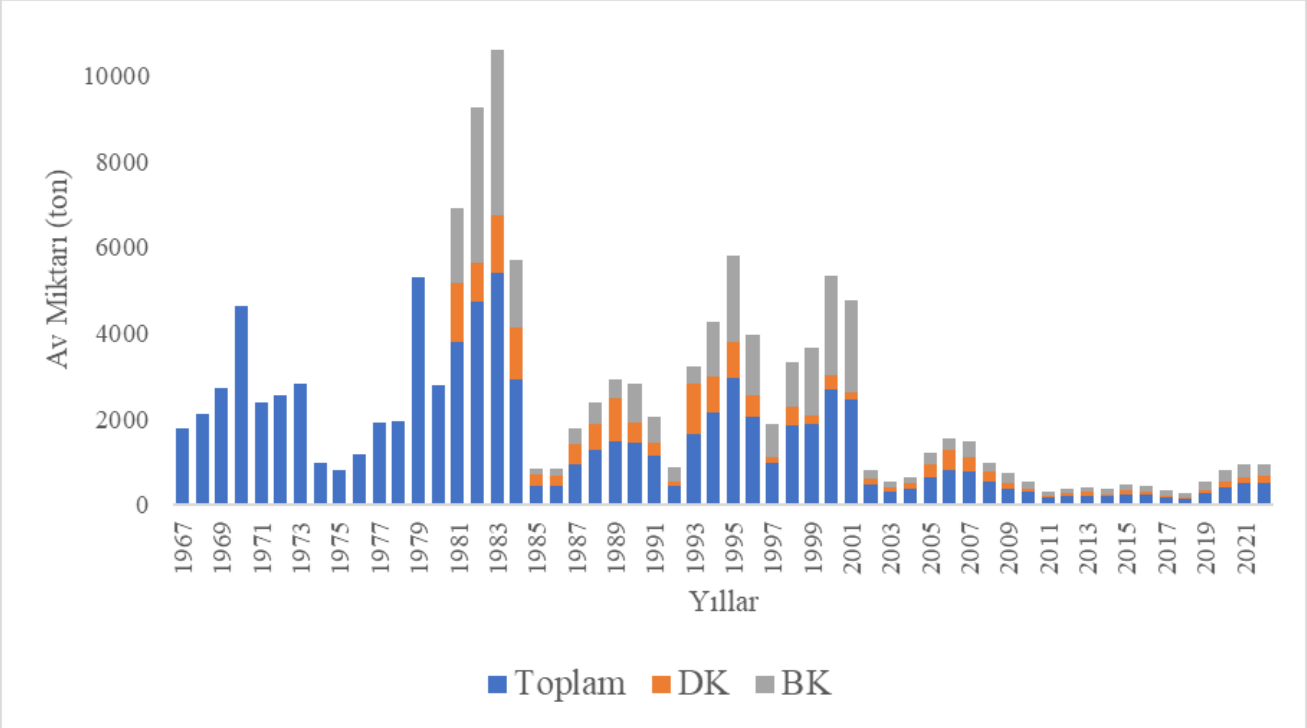
Şekil 1. 1967-2022 yılları arasında Türkiye denizleri ile 1981-2022 yılları arasında Doğu ve Batı Karadeniz'de avlanan mezgit balığı av miktarları

56 yıllık süreçte (1967-2022) barbunya balığının toplam av miktarı 156949 ton olup, en düşük avı 730 ton ile 1971 yılında, en yüksek avı ise 8883 ton ile 1989 yılında vermiştir (Şekil 2). 1989 yılındaki barbunya av miktarının %49'u Doğu Karadeniz'den, %14'ü ise Batı Karadeniz'den sağlanmıştır (Tablo 1). 1981-2022 yılları arasındaki toplam barbunya av miktarı (131304 ton) içerisinde, Doğu Karadeniz %33'lük (42935 ton) oranla birinci sırada, Batı Karadeniz ise %11'lik (14810 ton) oranla dördüncü sırada yer almaktadır. 1981-2022 yılları arasında barbunya balığının Doğu ve Batı Karadeniz'deki av miktarlarına bakıldığında, tüm yıllarda Doğu Karadeniz'de daha çok av verdiği sadece 1984 yılında Batı Karadeniz'deki av miktarının fazla olduğu görülmektedir. Barbunya balığının en çok av verdiği Doğu Karadeniz'de dahil tüm denizlerimizde 2000 yılından 2022 yılına kadar av miktarı 1000 tonun altında gerçekleşmiştir. Bu süreçte sadece Akdeniz 2010-2013 yılları arasında 1000 tonun üzerinde av vermiştir.

1967-2022 yılları arasında toplam kalkan üretimi 84763 ton olup, en düşük üretim 139 ton ile 2018 yılında, en yüksek üretim ise 5398 ton ile 1983 yılında gerçekleşmiştir (Şekil 3). 56 yıllık süreçte, 1983 yılında gerçekleşen en yüksek av miktarında Batı Karadeniz'in payı %71'dir (Tablo 1). 1981-2022 yılları arasındaki toplam kalkan balığı av miktarının (50817 ton) %61'i (31240 ton) Batı Karadeniz'den, %31'i (15807 ton) ise Doğu Karadeniz'den sağlanmıştır. Kalkan balığı av miktarı Doğu Karadeniz'de 2010-2019 yılları arasında, Batı Karadeniz'de ise 2018 yılında 100 tonun altına düşmüştür



Şekil 2. 1967-2022 yılları arasında Türkiye denizleri ile 1981-2022 yılları arasında Doğu ve Batı Karadeniz'de avlanan barbunya balığı av miktarları



Şekil 3. 1967-2022 yılları arasında Türkiye denizleri ile 1981-2022 yılları arasında Doğu ve Batı Karadeniz'de avlanan kalkan balığı av miktarları

4. TARTIŞMA VE SONUÇ

Mezgit, barbunya ve kalkan balığı ekonomik değerinin yüksek olması ve deniz balıkları içerisinde üretim miktarı bakımından yüksek paya sahip olmaları nedeniyle Karadeniz'in önemli demersal türleri arasında yer almaktadır. Bu üç tür için ülkemizde gerçekleştirilen avcılığın önemli kısmı Karadeniz'den sağlanmaktadır.

Türkiye balıkçılığı, su ürünleri faaliyetleri açısından Karadeniz, Boğazlar, Marmara, Ege ve Akdeniz olmak üzere 5 bölgeye ayrılmakla birlikte, üretimin %55'i Karadeniz, %30'u Boğazlar, %10'u Marmara, %2''si Ege ve %3'ü Akdeniz'den sağlanmaktadır. 1966 yılı için, Karadeniz'de 16527 kişi tam, 6482 kişi kısmen balıkçılık faaliyeti göstermekte olup, 10 adedi trol olmak üzere 3265 balıkçı teknesi faaliyette bulunmaktadır. Üretim faaliyetleri yoğun olarak Ordu, Giresun ve İstanbul'un Karadeniz çevresinde gerçekleşmektedir (Koç, 1970). 1984 yılında 7691 balıkçı gemisinin 2260 adedi (42 adet trol teknesi) Doğu Karadeniz'de, 670 adedi (41 adet trol teknesi) Batı Karadeniz'de faaliyet göstermiştir (DİE, 1984). Yeni ruhsat verilmesinin durdurulduğu 2002 yılında Doğu Karadeniz'deki 4301 adet balıkçı gemisinin 130 adedi trol iken Batı Karadeniz'de 2713 balıkçı gemisinin 170 adedi trol gemisi olarak faaliyet göstermiştir (DİE, 2002). 2022 yılı itibariyle toplam deniz balıkları üretiminin %28'i Doğu Karadeniz, %34'ü Batı Karadeniz'den sağlanmaktadır. 355'i trol gemisi ve 3357'si uzatma ağı gemisi olmak üzere toplam 5802 adet balıkçı gemisi Karadeniz'de balıkçılık faaliyetlerinde kullanılmaktadır. Balıkçılıkta çalışanlara bakıldığında 1972'si Batı Karadeniz ve 3454'ü Doğu Karadeniz olmak üzere toplam 5476 kişi balıkçının kendisi ve 10365 diğer çalışanlar (ücretli/ücretsiz çalışan ortak, tayfa, hane halkı çalışan gibi) Karadeniz'de balıkçılıktan geçimini sağlamaktadır (TÜİK, 2022). 1967-2022 yılları arasındaki istatistiklere göre, gelinen noktada, balıkçı gemisi sayısı %44'lük bir artış gösterirken balıkçı sayısında bir düşüş gözlenmektedir. Av çabasındaki artış ve av araç gereçlerindeki teknolojik gelişmeler balık stokları üzerindeki av baskısının artmasına ve zaman içerisinde av miktarlarındaki azalmalara neden olan etkenlerden birisidir.

Mezgit, barbunya ve kalkan balığının avcılığı yaygın olarak dip trolü ve dip uzatma ağları ile yapılmaktadır. Balık popülasyonlarının korunması ve sürdürülebilirliğinin sağlanması amacıyla 22/3/1971 tarihli 1380 Sayılı Su Ürünleri Kanunu kapsamında, ticari amaçlı su ürünleri avcılığına yönelik olarak birtakım yasal kısıtlama ve yasaklamalar getirilmektedir. 1973-2023 yılları arasındaki avcılık dönemlerini kapsayan su ürünleri sirküler/tebliğlerinde küçük ölçekli balıkçılıkta yoğun bir şekilde 12 ay boyunca kullanılan uzatma ağları ve bu ağların kullanımına yönelik olarak herhangi bir kısıtlama bulunmamaktadır. Demersal balıkların avcılığında kullanılan dip trolüne ilişkin zaman yasakları ile türlere ilişkin birtakım kısıtlamalar Tablo 2'de gösterilmektedir (7, 9, 12, 13, 15 ve 19 numaralı sirkülerler ek sirküler olarak çıkarıldıkları için yer verilmemiştir). 1982-83 dönemi 14 numaralı sirkülerde Mezgit balığına getirilen 18 cm boy yasağı aynı dönem çıkarılan 15 numaralı ek sirküler ile kaldırılmıştır. Boy yasakları, 1990-91 dönemine ait 24 numaralı sirkülere kadar çatal boy olarak uygulanmış, 24 numaralı sirkülerden itibaren toplam boy olarak uygulanmaya başlanmıştır.

Doğu Karadeniz'i kapsayan trol yasağına ilişkin ilk düzenleme 1978-1979 av dönemine ait 6 numaralı sirkülerde yapılmıştır. Buna göre Ordu-Bulancak sınırından Hopa'ya kadar tüm karasularımızda dip trolü avcılığı yasaklanmıştır. 1987-86 av dönemini kapsayan 21 numaralı sirkülerde sınır Ordu ili Ünye ilçesi Taşkana Burnu'na çekilmiş, daha sonrasında ise bu sınır, 1988-89 dönemi 22 ve 1989-90 dönemi 23 numaralı sirkülerde Samsun ili Civa Burnu, 1990-91 dönemi 24 ve 1991-92 dönemi 25 numaralı sirkülerde Samsun ili Çaltı Burnu, 1992-93 dönemi 26 ve 1993-94 dönemi 27 numaralı sirkülerde Samsun-Ordu il sınırı, 1994-95 dönemi 28 ve 1995-96 dönemi 29 numaralı sirkülerde Samsun ili Çaltı Burnu, 1996-97 dönemi 30 numaralı sirkülerde Samsun Limanı feneri, 2004-2006 av dönemi 36/1 numaralı sirkülere kadar Samsun-Ordu il sınırı, 36 numaralı sirkülerden itibaren şu an geçerli olan 2020-2024 av dönemi 5/1 numaralı sirkülere

kadar Ordu ili Ünye ilçesi Taşkana Burnu şeklinde değişikliğe uğramıştır.

1983-84 av dönemine ait 16 numaralı sirkülerde, ilk olarak, Başroz (Başkaya) Burnu ile Sinop Burnu-Gerze Köşk Burunları arasında kalan karasularımızda her türlü trol ile avcılık yasaklanmış, 1991-92 yılına ait 25 numaralı sirkülerde Kastamonu ili Cide Köpekkaya Burnu- Sinop ili Gerze, Çayağzı Burnu arasında kalan karasular şeklinde değiştirilmiştir. 1993-94 yılı 27 numaralı sirkülerde Sinop ili İnceburun-Gerze Çayağzı arası, 28 numaralı sirkülerde Sinop ili Ayancık ilçesi Usta Burnu ile Gerze Çayağzı arası, 31 numaralı sirkülerde Sinop İnceburun olarak değiştirildikten sonra 32 numaralı sirkülerde tekrar Ayancık ilçesi Usta Burnu şeklinde değişikliğe uğramıştır. Nihayetinde 2004-2006 av dönemine ait 36/1 numaralı sirkülerden şu an yürürlükte olan 2020-2024 av dönemine ait 5/1 numaralı tebliğe kadar, Sinop ili İnceburun ile Samsun ili Yakakent ilçesi Çayağzı Burnu arasındaki karasularımızda her türlü trol avcılığına yasaklanmıştır.

Batı Karadeniz Bölgesi'ne ait yer yasakları ilk olarak, 1994-95 av dönemi 28 numaralı sirkülerde, Zonguldak ili Ereğli Balıkçı Barınağı ile Sakarya ili Akçakoca Balıkçı Barınağı arasında kalan karasularımızda uygulanmaya başlamıştır. 1996-97 dönemine ait 30 numaralı sirkülerde Akçakoca Balıkçı Barınağı, Bartın ili Amasra ilçesi Dikili Burnu olarak değiştirilmiş ve 35/1 numaralı sirkülere kadar bu şekilde devam etmiştir. 2002-2004 dönemi 35/1 numaralı sirkülerde, Zonguldak ili Ereğli Balıkçı Barınağı ile Bartın ili Amasra ilçesi Tarlaağzı Balıkçı Barınağı arasında kalan karasular şeklinde değiştirilmiş, 2006-2008 dönemi 37/1 numaralı sirkülerden itibaren, Zonguldak ili Ereğli Baba Burnu ile Bartın ili Amasra ilçesi Tekke Burnu arasındaki karasuları olarak tekrar değiştirilmiştir. 2012-2016 dönemi 3/1 numaralı tebliğde Batı Karadeniz'deki bu yasak tamamen kaldırılmış, 2016-2020 numaralı 4/1'den itibaren Zonguldak ili Alacaağzı Burnu ile Bartın ili Amasra ilçesi Tekke Burnu arasındaki karasularımızda her türlü trol avcılığı tekrar yasaklanmış olup bu haliyle uygulanmaya devam etmektedir.

Genç (2000), 1988 ve 1989 yıllarında maksimum düzeye ulaşan barbunya balığı üretiminin daha sonraki yıllarda azalma göstermesinin, pelajik stoklardaki azalmadan dolayı balıkçılık aktivitelerinin demersal balıklara yönelmesinden kaynaklandığını ve barbunya stoklarının bu baskıdan olumsuz yönde etkilendiğini belirtmiştir. Aynı şekilde, Avşar (1998)'da 1961-1991 yılları arasındaki periyotta mezgit stoklarının daha az sömürüldüğünü, sonraki periyotta pelajik stokların çökmesiyle birlikte özellikle hamsi balıkçılığına entegre olmuş gırgırların da trole dönüştürülerek, avcılığın zaten sınırlı olan demersal gruba kaydırıldığını ve bunun sonucu olarak demersal stokların aşırı sömürülmeye başlandığını ifade etmiştir. Çelik Mavruk *vd*. (2021), Türkiye genelinde (Akdeniz, Ege ve Karadeniz) barbungillerin avcılığında en baskın yöntemin dip trolü balıkçılığı olduğunu, bunu fanyalı ve sade uzatma ağlarının takip ettiğini, Marmara'da ise küçük ölçekli balıkçıların toplam ava katkısının daha yüksek düzeyde olduğunu bildirmiştir. Aynı çalışmada av istatistiklerin belirlenmesi esnasında balıkçıların barbun ve tekir balığı arasında tür düzeyinde bir ayırım yapmadığına, barbun ve tekir balıklarına atfen kaydedilen avın büyük ölçüde barbun avını temsil ettiğine, bu süreçte türlerin doğru teşhis edilmesine özen gösterilmesi gerektiğine dikkat çekilmiştir.

Zengin (1998), 1990-1995 yılları arasında Karadeniz'de Kalkan balığı avcılığında %71.8 oranında uzatma ağları kullanıldığını, 75324755 m uzunluktaki uzatma ağları ile her türlü stok üzerinde yoğun bir av baskısının uygulandığını ifade etmiştir. Karadeniz'de kalkan balıklarının %65'nin balığın üreme dönemi olan Nisan-Haziran aylarında avlandığı, ebeveyn ağırlıklı stoğun yumurtlamak üzere sığ-kıyı sularına yöneldiği sırada uzatma ağlarıyla yoğun olarak avlanılmasının stoğun azalmasına neden olduğu bildirilmiştir (Zengin, 2001).

Tablo 2. Su Ürünleri Avcılığını Düzenleyen Avlanma Sirküler/Tebliğlerinde Trol Avcılığı ve Balık Türlerine İlişkin Yasak ve Sınırlamalar (Anonim, 1973-2023) (B: Barbunya Balığı, K: Kalkan Balığı, M: Mezgit Balığı)

Sirküler/ Tebliğ No	Ait Olduğu Av Dönemi	Boy Yasağı (cm)			Yasak Av Sezonu	Türe Özel Yasak Av Sezonu	Av Aracı Yasağı (Kalkan için)
		B	K	M			
1	1973-1974	-	-	-	-	-	-
2	1974-1975	-	-	-	-	-	-
3	1975-1976	-	36	-	-	-	-
4	1976-1977	11	36	-	1 Mayıs-30 Haziran	-	-
5	1977-1978	11	36	-	20 Mayıs-30 Eylül	1 Mayıs-1 Eylül (K) 15 Mayıs-31 Ağustos (B)	-
6	1978-1979	11	36	-	1 Mayıs-30 Ağustos	15 Mayıs-31 Ağustos (K) 1 Mayıs-15 Haziran (B)	-
8	1979-1980	11	36	-	25 Nisan-25 Ağustos	25 Nisan-25 Ağustos (K) 1 Mayıs-31 Temmuz (B)	-
10	1980-1981	11	36	-	5 Mayıs-31 Ağustos	5 Mayıs-31 Ağustos (K) 5 Mayıs-30 Haziran (B)	-
11	1981-1982	11		-	10 Mayıs-31 Ağustos	-	-
14	1982-1983	11	36	18	10 Mayıs-1 Eylül	-	-
16	1983-1984	11	36	-	10 Mayıs-1 Eylül	-	-
17	1984-1985	11	36	-	10 Mayıs-1 Eylül	-	-
18	1985-1986	11	36	-	1 Mayıs-1 Eylül	-	-
20	1986-1987	13	36	-	1 Mayıs-1 Eylül	-	-
21	1987-1988	13	36	-	1 Mayıs-1 Eylül	-	-
22	1988-1989	13	36	-	1 Mayıs-15 Eylül	1 Nisan-1 Haziran (K)	-
23	1989-1990	13	36	-	1 Mayıs-15 Eylül	20 Nisan-20 Haziran (K)	Paraketa
24	1990-1991	13	36	-	1 Mayıs-15 Eylül	1 Mayıs-1 Temmuz (K)	Paraketa
25	1991-1992	13	36	-	1 Mayıs-1 Eylül	1 Mayıs-1 Temmuz (K)	Paraketa
26	1992-1993	13	40	-	1 Mayıs-1 Eylül	1 Mayıs-1 Temmuz (K)	Paraketa
27	1993-1994	13	40	-	1 Mayıs-1 Eylül	-	Paraketa
28	1994-1995	13	40	-	1 Mayıs-1 Eylül	-	Paraketa
29	1995-1996	13	40	15	1 Mayıs-1 Eylül	1 Nisan-1 Haziran (K)	Paraketa
30/1	1996-1997	13	40	15	1 Mayıs-1 Eylül	1 Nisan-1 Haziran (K)	Paraketa
31/1	1997-1998	13	44	-	1 Mayıs-1 Eylül	-	Paraketa
32/1	1998-1999	13	44	-	1 Mayıs-1 Eylül	-	Paraketa
33/1	1999-2000	13	44	-	1 Mayıs-1 Eylül	-	Paraketa
34/1	2000-2002	13	40	-	1 Mayıs-31 Ağustos	15 Nisan-15 Mayıs (K)	Paraketa Fanyalı Ağ
35/1	2002-2004	13	40	-	1 Mayıs-31 Ağustos	15 Nisan-31 Mayıs (K)	Paraketa Fanyalı Ağ
36/1	2004-2006	13	40	-	1 Mayıs-30 Eylül	1 Mayıs-30 Haziran (K)	Paraketa Fanyalı Ağ
37/1	2006-2008	13	40	-	15 Nisan-15 Eylül	1 Mayıs-30 Haziran (K)	Paraketa Fanyalı Ağ
2/1	2008-2012	13	40	13	15 Nisan-15 Eylül	1 Mayıs-30 Haziran (K)	Paraketa Fanyalı Ağ
3/1	2012-2016	13	45	13	15 Nisan-15 Eylül	15 Nisan-15 Haziran (K)	Paraketa Fanyalı Ağ
4/1	2016-2020	13	45	13	15 Nisan-31 Ağustos	15 Nisan-15 Haziran (K)	Paraketa Fanyalı Ağ
5/1	2020-2024	13	45	13	15 Nisan-31 Ağustos	15 Nisan-15 Haziran (K)	Paraketa Fanyalı Ağ

Samsun ve Kalaycı (2004), ekonomik değerinin yüksek olmasından dolayı Kalkan balığının yıllar itibariyle av miktarında meydana gelen azalmaya rağmen, kıyı balıkçılarının daha fazla balık avlayabilmek için kısıtlama, yasak ve yaptırımı olmayan av araçlarını kendi amaçları doğrultusunda kullandıklarını, ağ gözü açıklıklarını giderek düşürmeye ve sade ağlara fanyalar donatmaya yöneldiklerini ve daha çok sayıda küçük bireyleri avladıklarını belirtmişler, bunun sonucu olarak da kalkan stoklarının gelecekte sürdürülebilirliği konusunda bazı sıkıntıların olmasının çok muhtemel olacağını ifade etmişlerdir. Karadeniz'de aşırı avcılık nedeniyle azalan kalkan stoklarına yönelik olarak, Akdeniz Genel Balıkçılık Komisyonu (GFCM) tarafından, 2020 yılından itibaren, geçerliliği 3 yıl olmak üzere kota uygulaması getirilmiştir. Bu kapsamda Karadeniz'deki toplam avlanabilir kalkan balığı miktarı 857 ton olup, Türkiye'ye verilen kota miktarı 497 ton (%58) olarak belirlenmiştir (BSGM, 2019). TÜİK verilerine göre 2020, 2021 ve 2022 yıllarında Karadeniz'deki kalkan balığı av miktarları sırasıyla 389, 461 ve 463 ton olarak bildirilmiştir. Buna göre, yukarıda belirtilen yıllarda, Karadeniz için belirlenen kota miktarına (497 ton) dahi ulaşılamadığı görülmektedir.

Ak ve Balık (2020), 1970'li ve 1980'li yıllarda balıkçı teknesi ve balık unu fabrikası için verilen desteklerin, aşırı avcılık nedeniyle stokların azalmasında önemli rol oynadığını belirtmişlerdir. Tosunoğlu ve Ceyhan (2021), balıkçılık faaliyetlerinin etkin kontrolü için, 2002 yılından bu yana devam eden yeni balıkçı teknelerine ruhsat verilmemesi sisteminin tek başına yeterli olmadığını, av çabalarının kısıtlanmasının yanı sıra av alanları ve süreleri ve hatta balıkların karaya çıkış noktalarının da belirlenmesi gerektiğini bildirmişlerdir.

İklim değişimleri diğer çevresel baskılar ile birlikte balıklar üzerindeki bireysel ve popülasyon düzeyinden tüm ekosistem düzeyine kadar, doğrudan ya da dolaylı olarak, oldukça karmaşık etkiler yaratmaktadır (Brander, 2010). Türkiye'nin Karadeniz bölgesinde baskın olarak yakalanan demersal balık türlerinin (mezgit, barbun, tekir ve kalkan) zaman serisi av miktarlarına bakıldığında 1980'li yılların sonunda av miktarlarının pik yaptığı ve sonrasında kayda değer bir azalma olduğu ve 2000'li yıllardan sonra miktarların daha stabil kaldığı gözlemlenmiştir. Bu süreç Karadeniz ekosistemi için tanımlanmış trofik dönüşüm süreci ile örtüşmektedir (Saygu, 2022). Ötrofikasyonun etkileri tüm Karadeniz'de hissedilmekte olup ekosisteminin yapısını köklü değiştiren bir durumu ortaya koymaktadır. Ötrofikasyonu tetikleyen azot ve fosfor bileşikleri, 162 milyon insanın da dahil olduğu geniş bir Avrupa bölgesi olan Karadeniz Havzası'nın her yerinden gelmektedir (Bat, 2016). Son 50 yıldır balık stokları ve çeşitliliği açısından Karadeniz'in ekolojik yapısı son derece kötü durumdadır. Bu olumsuz yapının iyileştirilebilmesi amacıyla deniz ekosistemini bir bütünsellik içinde değerlendirip yönetme becerisine sahip bir "Ekosistem Temelli Balıkçılık Yönetimi" stratejisinin geliştirilmesi gerekmektedir (Oğuz, 2016).

Sonuç olarak, av miktarlarına bakıldığında, balıkçı gemisi filosunun sabitlenmesi, trol avcılığına getirilen zaman ve bölge yasakları, türlere yönelik boy sınırlamaları ve özellikle kalkan avcılığına yönelik kısıtlamalara (boy yasağı, av aracı yasağı, kota uygulaması gibi) rağmen, 3 tür içinde özellikle 2000'li yıllardan itibaren daha önceki yıllara göre azalma olduğu dikkat çekmektedir. Balık popülasyonları, insan kaynaklı çevre kirliliği, küresel ısınmaya bağlı olarak ortaya çıkan iklim değişiklikleri, av çabasındaki artış ve teknolojik gelişmelere paralel olarak av baskısının artması ve bilinçsiz avcılık gibi birçok faktörün etkisi altındadır. Dolayısıyla sürdürebilirliğin sağlanabilmesi için tüm bu faktörler göz önünde bulundurularak balıkçılık faaliyetlerinin yönetilmesi gerekmektedir. Bu da ancak, ekosistemin iyileştirebilmesine katkı sağlayan, ekosistem yaklaşımlı balıkçılık uygulamalarının benimsenmesi ile mümkün olabilecektir. Stokların iyileştirilebilmesi için kaynaklarımızın mevcut durumunun net bir şekilde ortaya konulup, stoğun kendini yenileyebilme yeteneği belirlenmeli ve buna göre kota uygulamaları getirilmelidir. Bunun yanı sıra, türlerin popülasyon özellikleri dikkate alınarak oluşturulacak spesifik avlanma modelleri, bölgesel balıkçılık modelleri bu sürece katkı sağlayacaktır.

ESER SAHİPLİĞİ KATKI BEYANI

Serap SAMSUN: Yazım-Orijinal Taslak, Yazım-Gözden Geçirme ve düzenleme.

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The Factors of Port Congestion and the Analysis of Strategies Towards Solution

Liman Sıkışıklığı Faktörleri ve Çözümüne Yönelik Stratejilerin Analizi

Türk Denizcilik ve Deniz Bilimleri Dergisi

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ABSTRACT

As a result of the rapidly increasing competitive conditions in the port industry, the concept of port performance has gained great importance. The concept of port congestion, which has been experienced frequently in recent years and deeply affects port performance, also comes to the fore as a problem that needs to be addressed in terms of port competition. Starting from this point in the study, firstly, semi-structured interviews were conducted with the managers of the ports operating in various regions of Türkiye, and the reasons for port congestion and the most frequent periods, the measures that can be taken against port congestion, and the strategies that can be developed were investigated. Then, port congestion factors and preventive strategies were prioritized using Fuzzy AHP-TOPSIS hybrid method. When the results of the semi-structured interviews were analyzed, it was determined that there was a lack of capacity; when the fuzzy AHP-TOPSIS results were examined, it was concluded that unexpected trade density was the most important underlying reason for port congestion. Moreover, according to both the semi-structured interview and Fuzzy AHP-TOPSIS results, it was concluded that cooperation with stakeholders and investment in qualified human resources would be the most effective measures to prevent port congestion. It is thought that the determined and prioritized measures and strategies against port congestion as a result of this exploratory study will benefit the port industry.

Keywords: Port congestion, Port capacity, Cooperation with stakeholders, Semi structured interview, Fuzzy AHP-TOPSIS.

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ÖZET

Liman endüstrisinde hızla artan rekabet koşulları neticesinde liman performansı kavramı oldukça büyük bir önem kazanmıştır. Son yıllarda sıklıkla deneyimlenen ve liman performansını derinden etkileyen liman tıkanıklığı kavramı da liman rekabeti açısından ele alınması gereken bir sorun olarak ön plana çıkmaktadır. Bu noktadan hareketle çalışmada ilk olarak Türkiye'nin çeşitli bölgelerinde faaliyet gösteren limanların yöneticileri ile yarı yapılandırılmış görüşmeler gerçekleştirilerek liman tıkanıklığının sebepleri ve en sık yaşandığı dönemler, liman tıkanıklığına karşı alınabilecek önlemler ve geliştirilebilecek stratejiler araştırılmıştır. Daha sonra ise Bulanık AHP-TOPSIS hibrit yöntemi kullanılarak liman tıkanıklığı faktörleri ve önleyici stratejiler önceliklendirilmiştir. Gerçekleştirilen yarı yapılandırılmış görüşme sonuçları analiz edildiğinde kapasite yetersizliğinin; Bulanık AHP-TOPSIS sonuçları incelendiğinde ise beklenmedik ticaret yoğunluğunun liman tıkanıklığının altında yatan en önemli sebepler olduğu sonucuna ulaşılmıştır. Ayrıca, hem yarı yapılandırılmış görüşme hem de Bulanık AHP-TOPSIS sonuçlarına göre liman tıkanıklığını önlemek adına en etkili önlemler olarak paydaşlarla işbirliği ve kalifiye insan kaynağına yatırım yapılmasının uygun olacağı sonucuna varılmıştır. Keşifsel bir niteliğe sahip olan bu çalışma sonucunda belirlenen ve önceliklendirilen liman tıkanıklığına karşı önlemler ve stratejiler ile liman endüstrisine fayda sağlanacağı düşünülmektedir.

Anahtar sözcükler: Liman tıkanıklığı, Liman kapasitesi, Paydaşlarla iş birliği, Yarı yapılandırılmış görüşme, Bulanık AHP-TOPSIS.

1. GİRİŞ

Küreselleşme ile birlikte ülkeler arası ticaretin yaygınlaşmasıyla günümüzde dünya ticaretinin önemli bir kısmı denizyolu taşımacılığı ile yapılmaya devam etmektedir. 2020 yılında da dış ticarete konu olan yüklerin %89'u denizyolu ile taşınmıştır. Bu taşımacılık türünün uluslararası ticaret için ne kadar önemli olduğu son yarım yüzyılda yaşanan 20 kat artış ile daha net görülmektedir (UTİKAD, 2021). Büyük hacimli yüklerin bir defada taşınabilmesi, maliyet avantajı sağlaması ve diğer taşımacılık modlarından farklı olarak taşımacılık riskinin daha düşük olması gibi avantajlar da deniz taşımacılığını öne çıkarmaktadır (Saban ve Güğerçin, 2009). Küresel boyutta büyük bir öneme ve etkiye sahip olan deniz taşımacılığı, kendi içinde birçok sektör ile de bağlantı bulundurmaktadır.

Limanlar, deniz taşımacılığının en önemli bileşenlerindendir. Deniz taşımacılığına yönelik artan talep ile birlikte limanlar, uluslararası ticaretin en önemli unsurlarından biri haline gelmiştir. Ticaret ve sanayinin gelişimi için önemli bir rol üstlenen limanların hem ulusal hem de bölgesel ekonomiye katkısı yadsınamaz bir gerçektir (Bayraktutan ve Özbilgin, 2013). Ayrıca, liman işletmeciliğinin yüksek rekabet koşulları içermesi önemli miktarda sermaye gerektirmektedir ve yatırımları zorunlu kılmaktadır. Bir diğer yandan, liman endüstrisi iş gücü yoğun bir endüstridir ve ülkeler için önemli bir istihdam kaynağı sağlamaktadır (Bayraktutan ve Özbilgin, 2013; Doğusel, 2021). Bu özelliklerinden ötürü, yük ve yolcuların aktarımlarının sağlandığı, yüklerin elleçlenmesi ve depolanması gibi işlevleri yerine getiren limanlarda, artan rekabet koşulları ile birlikte liman performansı kavramı büyük bir önem kazanmıştır. Denizcilik sektörünün dinamik yapısı, modern ve yüksek kapasiteli gemiler, yeni pazarlar ve yeni ticaret koridorları oluşması ile artan yük hareketliliği ile birlikte liman operasyonlarının hızlı ve kesintisiz sürdürülmesi gerekliliği liman endüstrisinde önemli bir performans göstergesi haline gelmiştir (Akkaynak Çelik ve Başarıcı, 2021). Hinterlantlarında yer alan üretim gücü ile beslenen limanların yük trafiğini pek çok farklı faktör etkileyebilmektedir (Doğusel, 2021). Doğru tahminlenip yönetilemeyen liman trafiği ise liman sıkışıklığı sorununa yol açabilmektedir. Liman endüstrisinde yaşanan bu gelişmelerden hareketle, liman tıkanıklığı sorunu son yıllarda hem sektör hem de akademi

tarafından ele alınması gereken önemli bir gündem olarak ortaya çıkmıştır.

Nitel ve nicel yöntemlerin bir arada kullanıldığı bu çalışmada, ilk olarak Türkiye'de bulunan çeşitli limanlarda görev yapan, liman operasyonları konusunda uzman liman yöneticileri ile yarı yapılandırılmış görüşmeler gerçekleştirilerek limanlarda oluşan tıkanıklığın sebepleri, son yıllarda yaşanan liman tıkanıkları, önleme stratejileri ve liman tıkanıklığı durumunda alınması gereken önlemler araştırılmıştır. Çalışmanın ikinci aşamasında ise Bulanık AHP-TOPSIS yöntemleri kullanılarak liman tıkanıklığı faktörleri ve önleyici stratejilerin önceliklendirilmesi amaçlanmıştır. Çalışmanın içeriğinde ilk olarak liman tıkanıklığı ile ilgili kavramsal çerçeve ve ilgili literatür sunulmuştur. Daha sonra araştırmanın yöntemi, örneklemi ve analiz süreci hakkında bilgi verilmiştir. Araştırma sonucunda elde edilen bulgular incelendikten sonra sonuç ve öneriler kısmı ile çalışma sonlandırılmıştır.

2. KAVRSAMSAL ÇERÇEVE

Limanlar, verdikleri hizmetlerle uluslararası ticaretin önemli bir bileşeni olarak görülmekte ve limanlarda yaşanan aksaklıkların sonuçları tüm dünyadaki ticareti etkileyebilmektedir. Limanların verimli bir şekilde işletilmesi için rıhtımları besleyecek yeterli alana sahip olması, modern teknolojik ulaşım araçları, yeterli kalifiye insan gücü, etkin dokümantasyon süreci ve depolama tesisleri ve gelişmiş bir altyapısının bulunması gerekmektedir (Bolat *vd*., 2020). Ancak bu koşulların karşılanamadığı dönemlerde limanlar açısından hizmet verimsizliği veya hizmet verememe hali ortaya çıkmaktadır. Bu durum literatürde liman tıkanıklığı kavramıyla ifade edilmektedir. Liman tıkanıklığı, literatürde yanaşma için bekleme olarak tanımlansa da (Bolat *vd*., 2020); limanın birçok farklı noktasında (depolama ve istifleme alanlarında, kapıda, gümrük sahalarında gibi) tıkanıklık olarak kendini gösterebilmektedir. Birçok yazar liman tıkanıklıklarının rıhtımda ve liman sahasında oluştuğunu belirterek kategorize etmişlerdir (Zhen, 2016; Talley ve Ng, 2016; Iris *vd*., 2018; Nishimura, 2020). Gidado (2015) tıkanıklığı gemilerin ve yüklerin limandaki gecikmeleri, kuyrukta beklemeleri, ekstra seferleri ve limanda geçirdikleri süreler ile ilgili bir olgu olarak tanımlamıştır.

Liman tıkanıklığının birçok sebebi vardır. Bu sebepler, dönemlik olarak ortaya çıkarak limanların kapasite açısından eksikliklerini gün yüzüne çıkarabileceği gibi, limanları beklenmedik bir durumla da baş başa bırakabilmektedir. Verimsiz ve eski liman altyapısı, tutarsız hükümet politikaları, küreselleşmedeki teknolojik eğilimlerin karşılanamaması ve bazı limanların insan gücü sorunları, liman hizmetlerinin arzına yönelik aşırı talep, endüstriyel eylemler veya grevler, COVID-19 gibi salgın hastalıklar, tahsis edilen alan veya stok eksikliği, kötü hava koşulları, savaş, sınırlı liman erişimi, liman elleçleme ekipmanı eksikliği, hinterlant tıkanıklığı ve limanın konumu gibi birçok faktör liman tıkanıklığına neden olabilir (Bolat *vd*., 2020). Gui *vd*. (2022) Covid-19 döneminde liman tıkanıklığı riskini oluşturan faktörleri ele almıştır. Buna göre çok büyük konteyner gemileri (mega gemiler-VLCV sınıfı) kullanımı, Süveyş Kanalı'nın tıkanması, iş gücü eksikliği, üretimin belli noktalarda durması, siber saldırılar, konteyner eksikliği (dengesizliği), tır şoförü grevleri, vb. faktörler Covid-19 döneminde yaşanan ve liman tıkanıklığına sebep olan olaylar olmuşlardır. Paul ve Maloni (2010) liman tıkanıklığının sebepleri konusunda dışsal etkenlere odaklanmışlardır ve bu etkenler arasında fırtınalar (kasırga, toz fırtınası, tayfun, vb.), terörist saldırılar ve iş kazalarını ele almışlardır. Limanların konumlandıkları bölgelere özgü mevsimsel etkilerin (hem yük hareketliliği hem de gemi uğrakları bağlamında) liman tıkanıklıklarına etkisi literatürde önemli bir eksik olarak görülebilmektedir. Ayrıca bu sebeplerin risk yönetimi bağlamında değerlendirilmesi ve teorik eşleştirmesinin yapılması bir araştırma boşluğu olarak ön plana çıkmaktadır.

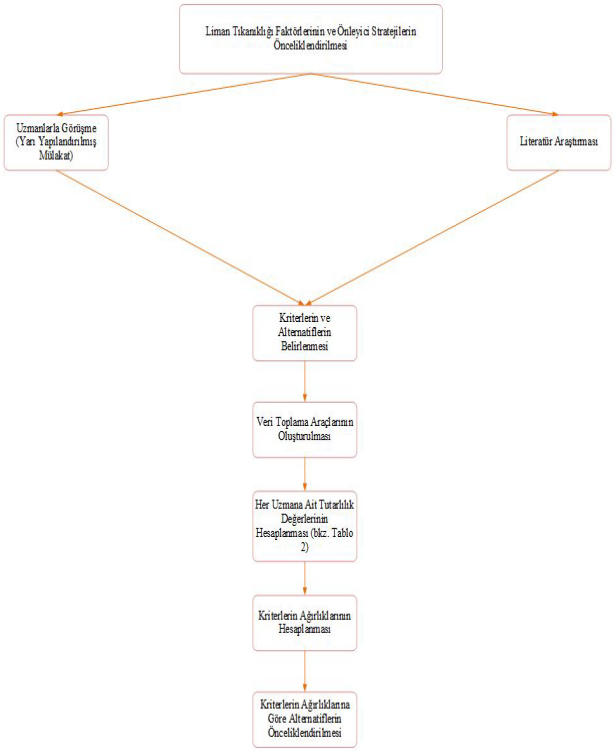
Yukarıda bahsedilen sebeplerle oluşan liman tıkanıklıklarının ciddi sonuçları olabilmektedir. Yük hacimlerinde hızlı artışın liman tıkanıklığına sebep olduğunu belirten Notteboom (2006), liman tıkanıklığının da gemi işletme şirketlerinin de hatasız iş yapma kapasitelerini sınırlandırdığını savunmuştur.

Bununla beraber Yeo *vd*. (2007), yük hacimlerindeki artışı liman tıkanıklığının en önemli nedeni olarak yorumlamış ve Kore'nin Busan limanının tecrübelerini paylaşarak bu tıkanıklıkların müşteri sadakatini azalttığını ve böylece tıkanıklık yaşayan limanların rekabetçi güçlerinin zayıfladığını öne sürmüştür. Liman tıkanıklığı daha uzun bekleme sürelerine ve daha düşük hizmet seviyelerine yol açmakla kalmaz, aynı zamanda azalan gelir, artan borç ve iflas riski ve azalan rekabet gücü gibi uzun vadeli etkileri de beraberinde getirir (Gui *vd*., 2022). Liman tıkanıklıklarının ekonomik sonuçları olduğunu savunan yazarlardan Bolat *vd*. (2020) tıkanıklığın ekstra envanter maliyetlerine ve aşırı yüksek gecikme (demuraj-sürastarya) maliyetlerine neden olduğunu; Wang *vd*. (2020) ise liman tıkanıklığının liman gelirlerini kısıtladığını tespit etmiştir. Liman kullanıcıları da tıkanıklığın sonuçlarından doğrudan etkilenmektedir. Jiang *vd*. (2017) liman tıkanıklıklarının düzenli konteyner taşımacılığı yapan denizcilik şirketlerinin takvim güvenilirliğine zarar verdiğini ifade etmiştir. Bai *vd*. (2022) liman sıkışıklığının navlun fiyatları üzerinde özellikle piyasa baskısının arttığı dönemlerde olumsuz etkisi olduğunu ortaya koymuşlardır. Ortaya konulan bu sonuçların etki analizi sayısal tabanda araştırılmalı ve bu sonuçlardan özellikle hangi liman kullanıcılarının daha yoğun bir şekilde etkilendikleri ortaya konulmalıdır.

Literatürde liman sıkışıklıklarına karşı üretilen çözüm önerileri kısıtlı da olsa konunun ele alınış biçimi önemli bir bakış açısı getirmektedir. García-Morales *vd*. (2015) liman tıkanıklığına deniz tarafı trafiğini düzenleme üzerine çözüm üreterek farklı bir bakış açısı getirmiş ve bu tıkanıklıkların giderilmesi için rıhtım boyunun uzatılması üzerine çeşitli önerilerde bulunmuştur. Literatürde liman tıkanıklığını gidermek üzere modern ekipman kullanmak, terminal boyutlarını ve kapasitelerini genişletmek gibi stratejiler önerilmiştir (Ke *vd*., 2012; Mollaoğlu *vd*., 2019). Takebayashi ve Hanaoka (2021) liman ücretlerini artırmanın liman tıkanıklığı sorununu çözerken karlılığı da artıracağını savunmuştur. Bu noktada literatür, özellikle kapı tarafındaki tıkanıklıkları gidermek, saha verimliliğini artırmak konusunda üretilebilecek stratejiler bağlamında eksik kalmıştır.

3. ARAŞTIRMA YÖNTEMİ

Liman yöneticilerinin liman tıkanıklığı kavramına yönelik algılarının araştırıldığı bu çalışmada nitel ve nicel araştırma yöntemlerinden yararlanılmıştır (Şekil 1).



Şekil 1. Araştırmanın modeli

İlk olarak gerçekleştirilen nitel araştırma ile liman tıkanıklığına sebep olan faktörler ve önleyici stratejiler tespit edilmiştir. Daha sonra gerçekleştirilen nicel analizler ile elde edilen liman tıkanıklığı faktörleri ağırlıklandırılmış ve en iyi çözüm stratejileri tespit edilmiştir. Nitel ve nicel yöntemlerin bir arada kullanılması ile problemi bütüncül bir şekilde ele almak ve nitel olarak ifade edilen algıların nicel yöntemler yardımıyla somutlaştırılması hedeflenmiştir. Nitel araştırmalarda incelenen olay veya olguya yönelik derin bir algıya ulaşma gayreti bulunmaktadır (Morgan, 1996). Nitel araştırmalarda, ürünlerden ya da çıktılardan daha çok süreçler ile ilgilenilir ve bu yüzden anlamlar önem taşımaktadır (Merriam, 1988). Nitel araştırmalarda genellikle gözlem, görüşme,

doküman ve söylev analizi gibi nitel veri toplama tekniklerinin kullanıldığı görülmektedir. Ayrıca, insana ilişkin algı ve olayların, sosyal gerçeklikte ve doğal ortamında derinlemesine incelenmesinin hedeflendiği nitel araştırmalar, farklı disiplinleri birleştiren bütüncül bir bakış açısına da sahiptir (Hatch, 2002; Merriam ve Grenier, 2019).

3.1. Yarı-Yapılandırılmış Görüşme Yöntemi

Bu çalışmada ilk olarak nitel araştırma yöntemlerinden yarı yapılandırılmış görüşme tekniği kullanılmıştır. Nitel araştırmalarda sıklıkla kullanılan veri toplama tekniklerinden biri olan görüşme, görüşme yapılan kişilere kendilerini birinci elden ifade edebilme fırsatı verirken, araştırmacılara da görüşülen kişilerin anlam dünyalarını, bakış açılarını, içinde bulundukları durumlara ait düşünce ve tecrübelerini görüşme yapılan kişilerin ifadeleriyle derinlemesine anlama imkanı sunmaktadır (McCracken, 1988). Yarı yapılandırılmış görüşmeler ne tam yapılandırılmış görüşmeler kadar katı, ne de yapılandırılmamış görüşmeler kadar esnektir. Sahip oldukları belirli düzeydeki standartlık ve esneklik nedeniyle, yazmaya ve doldurmaya dayalı testler ve anketlerdeki sınırlılığı ortadan kaldırması ve belirli bir konuda derinlemesine bilgi edinmeye yardımcı olması nedeniyle araştırmacılar tarafından sıklıkla tercih edilmektedir (Yıldırım ve Şimşek, 2003). Bu yüzden liman yöneticilerinin gözünden liman tıkanıklığının sebepleri ve bu tıkanıklığı önlemeye dair stratejilerin araştırıldığı bu keşifsel çalışmada yarı yapılandırılmış görüşme yöntemi kullanılmıştır. Amaçlı örneklem yoluyla belirlenen liman operasyonları konusunda uzman olan 11 liman yöneticisi ile liman tıkanıklığının sebepleri, son yıllarda yaşanan liman tıkanıklığı deneyimleri, liman tıkanıklığını önleme stratejileri ve liman tıkanıklığı yaşanması durumunda alınacak aksiyonlar ile ilgili soruları içeren yarı yapılandırılmış görüşmeler gerçekleştirilmiştir. Çalışmanın örneklemi ve görüşmelere yönelik detaylar Tablo 1'de belirtilmiştir.

Çalışmanın geçerliliği ve güvenilirliğinin sağlanması adına araştırma soruları ve gerçekleştirilen kodlamalar liman endüstrisi alanında uzman iki farklı akademisyene kontrol ettirilmiş, görüşme yapılacak liman yöneticileri deneyimleri ve çalışma alanlarına göre titizlikle seçilmiş, çalışmada kişi ve kurum bilgilerine yer verilmeden şeffaf bir şekilde elde edilen görüşler analiz edilmiştir.

Tablo 1. Görüşme yapılan uzmanlar ile ilgili bilgiler

Katılımcı No	Deneyim (Yıl)	Eğitim Düzeyi	Pozisyon	Görüşme Süresi	Görüşme Türü
1	11	Lisans	Operasyon Müdürü	-	Elektronik posta
2	10	Yüksek Lisans	Operasyon Müdürü	-	Elektronik posta
3	5	Lisans	Operasyon Şefi	16 dk 48 sn	Yüz yüze Görüşme
4	21	Doktora	Liman Müdürü	12 dk 56 sn	Çevrimiçi Görüşme
5	9	Lisans	Operasyon Müdürü	18 dk 56 sn	Yüz yüze Görüşme
6	21	Doktora	Operasyon Müdürü	23 dk 53 sn	Çevrimiçi Görüşme
7	18	Yüksek Lisans	Operasyon Müdürü	35 dk 43 sn	Çevrimiçi Görüşme
8	13	Lisans	Operasyon Müdürü	25 dk 35 sn	Çevrimiçi Görüşme
9	26	Yüksek Lisans	Liman Müdürü	25 dk 06 sn	Çevrimiçi Görüşme
10	8	Yüksek Lisans	Operasyon Şefi	-	Elektronik posta
11	10	Yüksek Lisans	Operasyon Şefi	18 dk 10 sn	Yüz yüze Görüşme

Yarı yapılandırılmış görüşmelerden elde edilen bulgular ışığında, liman tıkanıklığına neden olan faktörler ve önleyici stratejiler, Tablo 2'de bilgileri verilen uzmanlar tarafından değerlendirilmiştir. Bu uzmanlar, görüşmelere katılan uzmanlardan farklı olarak yoğunlukla saha operasyonlarında bizzat görev alan orta düzey yöneticilerden seçilmiştir. Literatürde de benzer şekilde nitel ve nicel yöntemleri iki farklı uzman grubu ile gerçekleştiren çalışmalar bulunmaktadır (Somsuk ve Laosirihongthong, 2014; Parung *vd.,* 2018; Ayaz *vd.,* 2022). İlgili

uzmanların algısal değerlendirmelerinin mantıksal açıdan tutarlılığı Pekkaya ve Bucak (2018) deki formüller takip edilerek her bir uzman için ayrı ayrı hesaplanmıştır. Değerlendirmeler sonucunda elde edilen veriler, Çok Kriterli Karar Verme (ÇKKV) yöntemlerinden Bulanık AHP (Analytic Hierarchy Process)-TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution) hibrit yöntemiyle analiz edilmiştir.

Tablo 2. Nicel araştırmaya katılan uzmanlara ait bilgiler ve değerlendirmelerinin tutarlılık değerleri

Katılımcı No	Deneyim (Yıl)	Eğitim Düzeyi	Pozisyon	Tutarlılık Oranı
1	9	Lisans	Liman İşletme Müdürü	0.0137
2	7	Lisans	Ticari İş Geliştirme Şefi	0.0365
3	4	Lisans	Rezervasyon Hizmetleri Uzman Yardımcısı	0.0135
4	4	Lisans	Liman Operasyon Uzmanı	0.0002
5	8	Lisans	Liman Operasyon Kıdemli Uzmanı	0.0275
6	9	Lisans	Liman Operasyon Kıdemli Uzmanı	0.0022
7	10	Yüksek Lisans	Operasyonlar Şefi	0.0444
8	5	Lisans	Ro-Ro Vardiya Amiri	0.0444
9	2	Lisans	Ro-Ro Ekip Lideri	0.0444

3.2. Bulanık AHP-TOPSIS Hibrit Yöntemi

Bulanık AHP, karar verme sürecinde kriterleri ağırlıklandırmak ve önceliklendirmek için kullanılan bir yöntemdir. Yöntem, uzmanların değerlendirmelerindeki belirsizliği, tutarsızlıkları ve sübjektifliği hafifletmek amacıyla bulanık sayıları kullanır (Demirel *vd*., 2018). Bulanık AHP, liman seçimi, yer seçimi, personel seçimi, emniyet, güvenlik ve rekabet üstünlüğü gibi alanlarda analiz yapılabilmesine olanak için akademisyenlerce yaygın olarak kullanılmaktadır (Baştuğ *vd*., 2022; Li *vd*., 2020; Mollaoglu *vd*., 2019; Balcı *vd*., 2018; Çelik ve Akyüz, 2018; Nazemzadeh ve Vanelslander, 2015; Tseng ve Cullinane, 2015; Lirn *vd*., 2004). Bu çalışmada, ağırlıkları daha özenli bir şekilde dağıtması ve öznel yargıları daha iyi sansürleyebilmesi sebebiyle Bulanık AHP yönteminin Buckley (1985) tarafından geliştirilen versiyonu kullanılmıştır. Çalışmada ayrıca, liman tıkanıklığına karşı alınabilecek önlemler birer alternatif olarak ele alınmış ve liman tıkanıklığı faktörlerine çözüm olma kapasitelerine sıralanmışlardır. TOPSIS analiz sonuçlarına göre en iyi alternatif, pozitif ideal çözüme (PIS) en kısa mesafede ve dolayısıyla negatif ideal çözüme (NIS) en uzak mesafede konumlanmalıdır (Wang *vd*., 2009). Bu çalışmada Hwang ve Yoon (1981) ve Ertuğrul ve Karakaşoğlu (2008) tarafından uygulanan genişletilmiş Bulanık TOPSIS yöntemi kullanılmıştır. Çalışmada uygulanacak Bulanık AHP – TOPSIS hibrit yönteminin uygulama adımları aşağıda açıklanmıştır.

Adım 1: Hiyerarşi sistemindeki her bir kriterin karşılaştırılmasını içeren ikili karşılaştırma matrisi oluşturulmuştur.

$$A = \begin{pmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{21} & 1 & \cdots & a_{2n} \\ \cdots & \cdots & 1 & \cdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{pmatrix} \quad (1)$$

Buna göre, a_{ij} birer üçgensel bulanık sayı belirtir ve $a_{ij} = l_{ij}, m_{ij}, u_{ij}$ olduğunda, $a_{ij} = l_{ij}, m_{ij}, u_{ij}$ olarak ifade edilir.

Adım 2: Uzmanlardan elde edilen ikili karşılaştırma matrislerinin geometrik ortalaması, Buckley (1985) tarafından önerilen aşağıdaki formülle hesaplanmıştır:

$$a_{ij} = (a_{ij}^1 \otimes a_{ij}^2 \otimes \cdots \otimes a_{ij}^n)^{1/n} \quad (2)$$

Adım 3: Kriter ağırlıklarının hesaplanması için gerekli olan $\tilde{r}_i$ değeri aşağıdaki formülle elde edilmiştir:

$$r_i = (a_{i1}^1 \otimes a_{i2}^2 \otimes \cdots \otimes a_{in}^n)^{1/n} \quad (3)$$

Adım 4: Her bir kriterin ağırlıklarını hesaplamak

için aşağıdaki formül uygulanmıştır.

$$w_i = r_i \otimes (r_1 \oplus r_2 \oplus \cdots \oplus r_n)^{-1} \quad (4)$$

Adım 5: Bulanık Pozitif İdeal Çözüm, FPIS (A^+) ve Bulanık Negatif İdeal Çözüm, FNIS (A^-) değerleri aşağıdaki formül yardımıyla belirlenmiştir:

$$A^+ = (v_1^+, v_2^+, \cdots, v_n^+)$$
$$A^- = (v_1^-, v_2^-, \cdots, v_n^-) \quad (5)$$

($v_j^+ = \max\{v_{ij1}^+\}$ ve ($v_j^- = \min\{v_{ij1}^-\}$, i = 1, 2, ... ,m; j = 1, 2, ... , n olması durumunda).

Adım 6: Her bir kriterin FPIS ve FNIS'ye olan uzaklığı aşağıdaki formül kullanılarak hesaplanmıştır:

$$d_1^+ = \sum_{j=1}^{n} d_v(v_{ij}, v_j^+) \qquad \text{i = 1, 2, ... ,m,}$$
$$d_1^- = \sum_{j=1}^{n} d_v(v_{ij}, v_j^-) \qquad \text{i = 1, 2,…,m} \quad (6)$$

burada dv (…) iki bulanık sayının birbirleri arasındaki uzaklık ölçüsüdür.

Adım 7: Kriterlerin hem FPIS hem de FNIS'ye olan mesafesini aynı anda ifade eden CC_i, alternatiflerin uzaklık katsayılarını verir. Bu katsayılar dikkate alınarak alternatifler sıralanabilir. Her bir alternatifin CC_i değerinin hesaplanmasında aşağıdaki formülden yararlanılmıştır:

$$CC_i = \frac{d_i^-}{d_i^+ + d_i^-}, \qquad \text{i= 1, 2, …, m.} \quad (7)$$

Adım 8: CC_i değerleri irdelenerek alternatifler arasında bir sıralama yapılmıştır. Bu nedenle, alternatif A_i 1'e yaklaştıkça FPIS'ye yaklaşacak ve FNIS'den uzaklaşacaktır.

4. BULGULAR VE TARTIŞMA

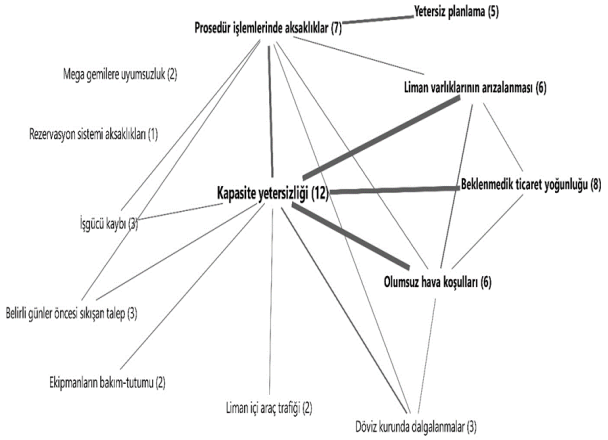
4.1. Liman Tıkanıklığı Faktörleri ve Önleyici Stratejilerin Ortaya Konulması

Yarı yapılandırılmış görüşmelerden elde edilen veriler, nitel metinlerin sistematik olarak değerlendirilmesi ve yorumlanmasına yardımcı olan MAXQDA 2020 paket programı ile analiz edilmiştir. Yapılan görüşmeler neticesinde, liman tıkanıklığının sebepleri, tıkanıklığa engel olmak adına alınabilecek önlemler ve liman tıkanıklığı yaşanması durumunda tıkanıklığı gidermek için kullanılabilecek karşı stratejiler belirlenmiştir. Belirlenen bu sebepler, önlemler ve stratejiler MAXQDA 2020 paket programı ile değerlendirilmiş ve görselleştirilmiştir.

İlk iki soru aracılığıyla elde edilen liman tıkanıklığının sebepleri ve MAXQDA programıyla görselleştirilen sebepler arasındaki ilişki Şekil 2'de gösterilmiştir. Şekil 2 incelendiğinde, en sık dile getirilen liman tıkanıklığı sebebinin 'kapasite yetersizliği' olduğu ve onu 'beklenmedik ticaret yoğunluğu' ve 'prosedür işlemlerinde aksaklıklar' gibi sebeplerin takip ettiği görülmektedir. Katılımcılar kapasite yetersizliğinin liman tıkanıklığı üzerindeki etkisini şu sözlerle ifade etmiştir:

"Yeterli kapınız olacak, yeterli sahanız olacak, yeterli kapasiteniz olacak... Eğer siz kapasitenizin üzerinde yük alıyorsanız elbette liman tıkanıklığı yaşayacaksınız (Katılımcı-6)."

"Son dönemde transit operasyonlarda, transit tahliyelerde, transit yüklemelerde ciddi bir şekilde talep geldi şu anda. İnanın depolarımızın %80'i %90'ı dolu, gelen talepleri de değerlendiremiyoruz, erteliyoruz ya da başka bir limana yönlendiriyoruz (Katılımcı-9)."



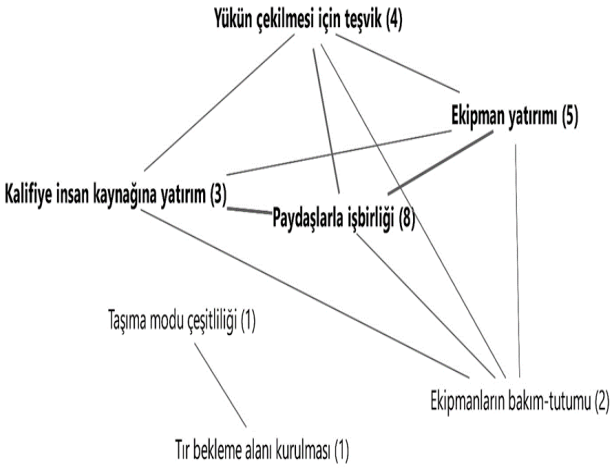
Şekil 2. Liman tıkanıklığının sebepleri

Elde edilen sonuçlar incelendiğinde, kapasite yetersizliğinin diğer sebeplerle sıklıkla ilişkili olarak katılımcılar tarafından ifade edildiği görülmektedir. Bu noktada, özellikle prosedür işlemlerinde aksaklıklar, olumsuz hava koşulları, liman ekipmanlarının arızalanması gibi durumlar limanın tam kapasite çalışmasını engellemekte ve kapasite yetersizliğinin ortaya çıkmasını tetiklemektedir.

Yapılan görüşmelerde ayrıca son beş yılda liman tıkanıklığının yoğun olarak yaşandığı dönemler de sorgulanmıştır. Buna göre, pandemi döneminde, Rusya-Ukrayna savaşı sırasında ve Kahramanmaraş merkezli deprem felaketi sonrasında liman tıkanıklığı ile karşı karşıya kalındığı ifade edilmiştir. Bu dönemlerde aşırı ticari yoğunluk, Rusya'ya uygulanan ambargo neticesinde ortaya çıkan transit ticaret artışı, deprem bölgesindeki liman hareketliliğinin diğer bölgelere kayması bu tıkanıklıkları tetiklemiştir. Üçüncü soruda katılımcılardan liman tıkanıklığına karşı aldıkları önlemlerden bahsetmeleri istenmiştir. Katılımcılardan elde edilen önlemler görselleştirilmiş ve Şekil 3'de gösterilmiştir. Şekil 3 ele alındığında, 'paydaşlarla iş birliği' önleminin en sık başvurulan önlem olduğu tespit edilmiş ve 'ekipman yatırımı' ve 'yükün çekilmesi için teşvik' önlemlerinin sıklıkla başvurulan diğer önlemler olduğu belirlenmiştir. Katılımcılar, paydaşlarla iş birliğinin liman tıkanıklığının önüne geçilmesi noktasındaki önemine şu sözlerle dikkat çekmiştir:

"Her ne kadar direkt limanın muhatabı olmasa da müşterinin temsilcisi olan nakliyeciler ile iletişime geçip saatte kaç ton elleçleyeceğimizi ve buna göre yükü alacak araçların hazır olması gerektiğini söylüyoruz. Bunun dışında sadece tabii nakliyeciler yok, gümrük komisyoncuları, gemi kontrolüne gelecek acenteleri de uyarıyoruz. Bu gibi planlamayı yaptığımız zaman çok büyük sıkıntılarla karşılaşmıyoruz (Katılımcı-4)."

"Hatlar ile olan iletişimi arttırıp geminin tahmini varış süresini daha gerçekçi almayı sağlıyoruz. Bazı önemli operasyonlar öncesi gelecek geminin bulunduğu liman ile iletişime geçip operasyon süresi hakkında bilgi alıyoruz (Katılımcı-10)."



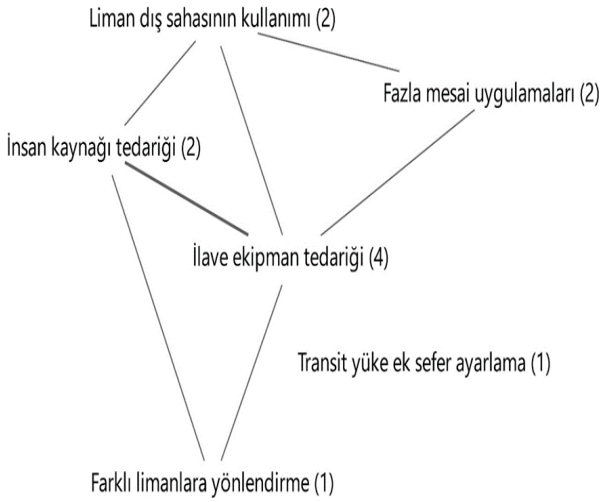
Şekil 3. Liman tıkanıklığına karşı alınabilecek önlemler

Şekil 3 incelendiğinde, paydaşlarla işbirliği önlemi hemen hemen diğer tüm önlemlerle ilişkili olarak görülmüştür. Buna göre, özellikle 'yükün çekilmesi için teşvik' ve 'ekipmanların bakım-tutumu' gibi diğer önlemlerin sağlıklı bir şekilde uygulanabilmesi için paydaşlarla kurulacak iş birliğinin derecesi oldukça önemli görülmüştür. Elde edilen sonuçlar göstermektedir ki liman tıkanıklıklarının önüne geçilmesi için limanların içsel süreçlerini iyileştirmelerinin yanında paydaşlarla ilişkilerini de doğru yönetebilmeleri oldukça önemlidir. Bu durum, son yıllarda limanların dünya ticareti adına bulundukları pozisyon gereği paydaşlarından ayrı düşünülemeyecek örgüt yapıları oldukları ve sorunlarını gidermek için paydaşlarıyla bütüncül bir süreç yönetimine ihtiyaç duydukları şeklinde yorumlanabilir.

Görüşmeler sırasında yöneltilen son soru ile tıkanan bir limanı eski operasyonel düzeyine döndürebilmek için uygulanabilecek stratejiler ortaya konulmaya çalışılmıştır. Bu bağlamda ortaya konulan stratejiler ve bu stratejiler arasındaki ilişki Şekil 4'te gösterilmiştir. Katılımcıların çoğu tıkanan bir limanın ilave ekipman tedariği ile yeniden eski operasyonel düzeyine döndürülebileceğini belirtmiştir. Katılımcılar, ilave ekipman tedariğinin liman tıkanıklığını giderme noktasındaki önemini aşağıdaki cümlelerle vurgulamışlardır:

"Liman tıkanıklığı bizim başımıza çok sık olmasa da nadir olarak geliyor. Biz bununla ilgili ne yapıyoruz, hemen dışarıdan ekipman tedariği, kiralık iş makinesi veya kiralık ekipman buluyoruz (Katılımcı-9)."

"Bu durumu daha az olumsuz etki ile atlatmak için operasyonu hızlandıracak aksiyonlar alınabilir. Vinç verimliliğini optimize etmek adına vinç için çalışan tırların sayısı posta başına arttırılabilir (Katılımcı-10)."



Şekil 4. Tıkanan bir liman için uygulanabilecek stratejiler

Bolat *vd.* (2020) liman tıkanıklığının sebepleri üzerine analizler yaptıkları çalışmalarında birçok benzer sebebi ele almışlardır. Bu çalışma da ortaya konulan sebepler ile ilgili literatür oldukça uyumludur. Bunun ötesinde bu çalışmada değerlendirilen "yetersiz planlama, liman içi araç trafiği, döviz kurunda dalgalanmalar, belirli günler öncesi sıkışan talep" gibi sebepler çalışmanın örneklemine özgü kriterler olarak literatürden ayrışmakta ve çalışmanın özgünlüğüne katkı sağlamaktadır. Liman tıkanıklığını önlemek için Ke *vd.* (2012) ve Mollaoglu *vd.* (2019) modern ekipman kullanmayı, terminal boyutlarını ve kapasitelerini geliştirmeyi önermişlerdir. Bu çalışma ortaya koyduğu önlemlerle belli düzeyde literatür ile uyum yakalasa da liman tıkanıklığına önlem almak adına insan kaynağının niteliğine, paydaşlarla kurulan iletişimin kalitesine verilen önem açısından literatürden ayrışmaktadır. García-Morales *vd*. (2015) bir limanın tıkanıklık probleminin deniz tarafı trafiğinin düzenlenerek giderilebileceğini savunmuştur. Bu çalışmada ise ek olarak hinterlant tarafında saha kullanımına yönelik ve insan kaynağının kullanım oranını artırmaya yönelik stratejiler önerilmiştir.

4.2. Liman Tıkanıklığı Faktörleri ve Önleyici Stratejilerin Önceliklendirilmesi

Yapılan yarı yapılandırılmış mülakatlar sonucunda elde edilen liman tıkanıklığı faktörleri, nitel analizler sonucunda aralarındaki ilişki bağlamında değerlendirilmiştir. Buna göre birbiriyle sıklıkla ilişkilendirilen faktörler şekilde kalın çizgiler ile belirtilmiş (Şekil 2) ve birer kriter olarak ele alınarak çalışmada yürütülen nicel analizlere dahil edilmiştir. Ayrıca, mutabık kalınan faktörlerin yansıtılması açısından, farklı uzmanlar tarafından ortak olarak belirtilmeyen kriterler, nitel analizler sonucunda ortaya konulan 'birlikte oluşturulan kodlar modeli'nde görselleştirilmiş, fakat nicel analizlere dahil edilmemiştir. Benzer şekilde, liman tıkanıklığına karşı alınabilecek önlemler özelinde yapılan nitel analiz sonucunda birbiriyle sıklıkla ilişkilendirilen önlemler (Şekil 3), liman tıkanıklıklarına çözüm olacak birer alternatif olarak kullanılmıştır. Çalışma kapsamında liman tıkanıklığına sebep olan faktörlerin ve önleyici stratejilerin neden-sonuç ilişkisine dayalı olduğu varsayılmaktadır. Bu nedenle sadece birbiriyle ilişkilendirilebilen faktörler çalışma kapsamında ele alınmıştır. Tablo 3'te bu kriterler ve alternatifler tanımlanmıştır.

Tablo 3. Liman tıkanıklığı problemi kriterleri ve alternatifleri

Kriter No.	Kriter Adı	Tanım
K1	Prosedür işlemlerinde aksaklıklar	Yüklerin limana giriş-çıkışları için gerekli formalitelerden (evrak işlemleri, vb.) kaynaklı gecikmeler.
K2	Yetersiz planlama	Yükleme-boşaltma için rıhtım ve liman saha içi trafik planlamalarında yaşanan sorunlar.
K3	Kapasite yetersizliği	Erişilebilirlik kapsamında liman altyapı ve fiziki kapasitesinin yetersizliğinden doğan aksaklıklar.
K4	Liman ekipmanlarının arızalanması	Limanın operasyonel ve yazılımsal ekipmanlarının arızalanması sebebiyle oluşan operasyonlarda aksaklıklar.
K5	Beklenmedik ticaret yoğunluğu	Mevsimsel olarak ve/veya döviz kuru dalgalanmaları sebebiyle artan ticaret hacmine limanların karşılık verememesi.
K6	Olumsuz hava koşulları	Operasyonel faaliyetleri durdurma noktasına getirecek derecede olumsuz hava koşullarının oluşması.
Alternatif No.	**Alternatif Adı**	**Tanım**
A1	Paydaşlarla işbirliği	Liman tıkanıklığına karşı yerel otoriteler, liman başkanlıkları, deniz ticaret odaları, tüm liman kullanıcıları gibi paydaşlarla ortak hareket ederek geliştirilecek önlemler.
A2	Kalifiye insan kaynağına yatırım	Liman tıkanıklığına karşı önlem olarak planlamaları yapacak insan kaynağının transferi veya yetiştirilmesi.
A3	Ekipman yatırımı	Operasyonel hızı artıracak şekilde ilave ekipman yatırımı ve/veya ekipman güncelleme.
A4	Yükün çekilmesi için teşvik	Yük ilgililerinin limandan yüklerini erken çekmesi adına verilebilecek ayrıcalıklar, belirli günlere yönlendirmeler ve destekler.

Liman tıkanıklığı faktörleri kriter olarak ele alınmış ve seçilen uzmanların bu kriterler hakkındaki algıları ölçülmüştür. Yapılan analiz sonucunda, en uygun önlemin belirlenme sürecinde kullanılmak üzere her bir kriterin ağırlığı Bulanık AHP yöntemiyle saptanmıştır (Tablo 4). Buna göre seçilen uzmanlara göre en öncelikli liman tıkanıklığı faktörünün 0,45784 puanıyla 'beklenmedik ticaret yoğunluğu' kriteri olduğu belirlenmiştir. Bu kriteri 0,22005 puanıyla 'kapasite yetersizliği' takip etmektedir. Uzmanlar 'prosedür işlemlerinde aksaklıklar' kriterinin en düşük önceliğe sahip liman tıkanıklığı faktörü olduğuna karar vermiştir. Çalışmada kriter olarak ele alınan liman tıkanıklığı faktörlerinin ağırlıkları göz önünde bulundurularak, bu faktörlere çözüm olabilecek önlemler uzman değerlendirmeleri doğrultusunda analiz edilmiştir. Analizler sonucunda (Tablo 5), 'paydaşlarla iş birliği' yapılması en yüksek puana sahip alternatif olarak ön plana çıkmıştır. 'Paydaşlarla iş birliği' alternatifini sırasıyla 'ekipman yatırımı', 'kalifiye insan kaynağına yatırım' ve 'yükün çekilmesi için teşvik' takip etmiştir.

Tablo 4. Uzman 1'in bulanık ikili karşılaştırma matrisi

	K1	K2	K3	K4	K5	K6
K1	(1,00; 1,00; 1,00)	(0,25; 0,33; 0,50)	(1,00; 2,00; 3,00)	(0,33; 0,50; 1,00)	(0,14; 0,17; 0,20)	(0,17; 0,20; 0,25)
K2	(2,00; 3,00; 4,00)	(1,00; 1,00; 1,00)	(4,00; 5,00; 6,00)	(1,00; 2,00; 3,00)	(0,25; 0,33; 0,50)	(0,33; 0,50; 1,00)
K3	(0,33; 0,50; 1,00)	(0,17; 0,20; 0,25)	(1,00; 1,00; 1,00)	(0,25; 0,33; 0,50)	(0,11; 0,13; 0,14)	(0,14; 0,17; 0,20)
K4	(1,00; 2,00; 3,00)	(0,33; 0,50; 1,00)	(2,00; 3,00; 4,00)	(1,00; 1,00; 1,00)	(0,17; 0,20; 0,25)	(0,25; 0,33; 0,50)
K5	(5,00; 6,00; 7,00)	(2,00; 3,00; 4,00)	(7,00; 8,00; 9,00)	(4,00; 5,00; 6,00)	(1,00; 1,00; 1,00)	(1,00; 2,00; 3,00)
K6	(4,00; 5,00; 6,00)	(1,00; 2,00; 3,00)	(5,00; 6,00; 7,00)	(2,00; 3,00; 4,00)	(0,33; 0,50; 1,00)	(1,00; 1,00; 1,00)

Tablo 5. Kriterlerin bulanık ve durulaştırılmış ağırlıkları

Kriter	Bulanık Ağırlık	Durulaştırılmış Ağırlık
Prosedür işlemlerinde aksaklıklar	(0.001; 0.001; 0.001)	0,00100
Yetersiz planlama	(0.057; 0.080; 0.075)	0,07046
Kapasite yetersizliği	(0.231; 0.231; 0.198)	0,22005
Liman ekipmanlarının arızalanması	(0.109; 0.133; 0.115)	0,11884
Beklenmedik ticaret yoğunluğu	(0.450; 0.443; 0.480)	0,45784
Olumsuz hava koşulları	(0.152; 0.113; 0.131)	0,13181

5. SONUÇLAR

Liman tıkanıklığının sebeplerinin ve liman tıkanıklığına karşı alınan önlemler ve stratejilerin ele alındığı bu çalışmada Türkiye'de faaliyet gösteren liman yöneticilerinin görüşlerine başvurulmuştur. Çalışmada iki farklı uzman grubuna ulaşılarak ilk grupla mülakatlar gerçekleştirilmiş ve uzmanlardan liman tıkanıklığının sebepleri, liman tıkanıklığına karşı alınabilecek önlemler ve geliştirilebilecek stratejiler hakkında görüşleri alınmıştır. İkinci gruba ise ilk grubun ortaya koyduğu faktörler ve stratejiler kullanılarak kriter-alternatif yapısı içerisinde oluşturulmuş veri toplama aracı (anket) uygulanmıştır. Veri toplama aracının uygulanması sonucu erişilen veriler Bulanık AHP-TOPSIS hibrit yöntemiyle analiz edilmiştir. Elde edilen görüşme sonuçları incelendiğinde kapasite yetersizliğinin; Bulanık AHP-TOPSIS sonuçlarına göre ise beklenmedik ticaret yoğunluğunun liman tıkanıklığının altında yatan en önemli sebepler olduğu sonucuna ulaşılmıştır. Öte yandan hem görüşme sonuçları hem de Bulanık AHP-TOPSIS sonuçları liman tıkanıklığını önlemek adına en etkili önlemler olarak paydaşlarla iş birliği ve kalifiye insan kaynağına yatırım yapılmasını ön plana çıkarmıştır.

Türkiye'deki limanların küme şeklinde belirli lokasyonlarda yoğunlaşması ve bu lokasyonların üretim noktalarına yakınlığı ve dolayısıyla yerleşim alanlarının bu çevrelerde kurulması, limanlar açısından bir kapasite sorununu beraberinde getirmektedir. İlgili liman kümelerindeki kapasite yetersizlikleri liman tıkanıklığına sebep olmakta ve bu limanların rakip ülke limanlarına karşı rekabetçi gücünü zayıflatmaktadır. Kapasite yetersizliklerinin oluşturduğu liman tıkanıklığına çözüm önerileri olarak Şekil 4'te gösterilen stratejilerden liman dış sahasının kullanımı (kara limanı gibi), ilave ekipman tedariği (yüksek katlı sistemler kurulması gibi), farklı limanlara yönlendirme gibi stratejiler önerilebilir.

Ön plana çıkan bir diğer liman tıkanıklığı faktörü olan beklenmedik ticaret yoğunluğu, özellikle bazı yüklerin mevsimsel hareketliliği, döviz kurundaki dalgalanmalar, enflasyon beklentisi gibi durumlarda ortaya çıkabilmektedir. Beklenmedik ticaret yoğunlukları kaynaklı tıkanıklıkları gidermek için yoğunluğun zaman aralığına göre stratejilerin belirlenmesi yerinde olacaktır. Örneğin, kısa süreli yoğunluklarda ilave ekipman tedariği (vinç, araç, vb.) ve fazla mesai uygulamaları kullanılabilecekken; orta vadeli yoğunluklarda yine ilave ekipman tedariğinin yanında insan kaynağı tedariği gerekli olabilir. Tablo 6 incelendiğinde, kalifiye insan kaynağına yatırımının liman tıkanıklığını gidermek için ön plana çıkan bir strateji olduğu görülmektedir. Bu noktada beklenmedik ticaret yoğunluklarının yaşandığı dönemlerde kalifiye insan kaynağına sahip olmak süreçlerin planlanması ve doğru stratejilerin üretilmesi noktasında önemli katkı vermektedir.

Tablo 6. Alternatiflerin değerlendirmesi ve sıralamaları

Liman Tıkanıklığı Önlemi	d+	d-	CC	Sıra
Paydaşlarla işbirliği	0.727	0.830	0.533	2
Kalifiye insan kaynağına yatırım	0.734	0.839	0.534	1
Ekipman yatırımı	0.777	0.811	0.511	3
Yükün çekilmesi için teşvik	1.041	0.886	0.460	4

Limanlarda beklenmedik ticaret yoğunluğu ve kapasite yetersizlikleri dolayısıyla ortaya çıkan tıkanıklıklar karşısında alınabilecek en etkili önlem doğru planlamadan geçmektedir. Dolayısıyla kalifiye insan kaynağına sahip olan limanlar bu etkiler karşısında tıkanıklık riskiyle daha iyi baş edebilmektedir. Çalışmada seçilen uzmanlar, bu sebeple kalifiye insan kaynağına yatırım yapılmasını liman tıkanıklığı faktörlerine karşı ön plana çıkarmışlardır. Ayrıca, uzmanlara göre paydaşlarla işbirliği yapılması, beklenmedik ticaret yoğunluklarında ve doluluk oranlarının oldukça yüksek olduğu dönemlerde limanlara yardımcı olacaktır. Liman işletmesinin deniz tarafındaki yoğunluklar konusunda liman başkanlığıyla, kara (hinterlant) tarafındaki yoğunluklar konusunda ise gümrük müdürlükleriyle koordineli çalışması bu yoğun dönemlerin atlatılması açısından kritik öneme sahiptir. Son olarak, kapasite yetersizliklerinin gün yüzüne çıktığı yoğun dönemlerde ilave kapasite çözümleri sunabilecek lojistik merkez, serbest bölge, kara limanı işletmesi gibi paydaşlarla yapılacak iş birlikleri limanın rekabetçi avantajını koruması adına kıymetlidir.

Çalışmanın bir diğer önemli çıktısı olarak, prosedür işlemlerinde aksaklık kriteri en az öneme sahip liman tıkanıklığı faktörü olmuştur. Bu noktada, ülkemizde uygulanmaya başlanan ve yüklerin henüz limana gelmeden gümrük işlemlerinin tamamlanmasını sağlayan 'Liman Tek Pencere Sistemi'nin öneminin vurgulanması yerinde olacaktır. Tüm dünya limanlarında 2024 yılı itibariyle bir zorunluluk olarak kullanılacak bu sisteme geçiş süreci Türkiye'de çok daha hızlı olmuş ve etkileri yavaş yavaş kendini göstermeye başlamıştır. Bunun ötesinde, IMO'nun yayınladığı 'Just in Time Arrival' ilkesi gereği liman varış sürelerini optimize eden sistemlerin limanlar tarafından kullanılması prosedür işlemleri kaynaklı liman tıkanıklarının tamamen önüne geçecektir.

Liman tıkanıklığının azaltılmasında teknolojik gelişmeleri takip etmek limanlara yardımcı olacaktır. Son dönemde hayatımızda oldukça büyük bir öneme sahip olmaya başlayan Endüstri 4.0 bileşenleri denizcilik sektöründe de kullanılmaya başlanmış, adeta Denizcilik 4.0'ın temelleri atılmaya başlanmıştır. Endüstri 4.0'ın en önemli öğretilerinden biri olan veri paylaşımı konusunda şeffaflık ve operasyonel süreçlerde dijitalleşmenin liman tıkanıklığının önüne geçilmesinde önemli belirleyiciler olması beklenilmektedir. Deniz tarafı kaynaklı tıkanıklıkların önlenmesi, deniz kazalarının önlenmesi ile doğrudan ilişkilidir. Bu noktada 'Just in Time Arrival' demirleme sahası trafik yoğunluğunu azaltarak kaza riskini minimize eder. Bu felsefenin amacına ulaşabilmesi için limanların gemiler ile anlık veri paylaşımı oldukça kritiktir. Ayrıca, otonom gemilerin yaygınlaşmasının liman sahası deniz kazalarını azaltması öngörülmektedir. Liman sahası kaynaklı tıkanıklıkların önlenmesinde Endüstri 4.0 bileşenlerinin etkin kullanımı da oldukça kritiktir. Örneğin "Automated Guided Vehicle", "Automated Rail Mounted Gantry Crane", gibi otonom sistemler liman içi yük transferi noktasında verimliliği arttırarak liman tıkanıklığını önleyebilecektir. Yine, "Internet of Things" ve "Internet of Everything" teknolojileri yapay zeka ile uyumlaştırılarak liman sahalarında depolama ve istifleme süreçlerinde kullanıldığı taktirde etkin planlama, boş hareketlerin azaltılması, atıl kapasitenin düşürülmesi noktasında önemli katkılar verebilecektir. Son olarak, liman tıkanıklığının en yaygın sebeplerinden biri olan hinterland kaynaklı aksaklıkların önüne geçilmesinde yine dijitalleşme unsurları kritik rol oynayabilecektir. 01.01.2024 tarihi itibariyle tüm dünyada kullanılması IMO tarafından zorunlu tutulan "Ulusal Tek Pencere Sistemi" özellikle gümrük prosedürlerinin gemi limana gelmeden

gerçekleştirilmesiyle liman kara tarafı trafiğinin önceden planlanmasına imkan vermektedir. Bu tek pencere sistemi yaklaşımı tek pencere evrenine dönüşerek uluslararası ticaretin farklı taraflarını da içine alacak şekilde liman topluluğu sistemi, denizcilik tek pencere sistemi, ticaret tek pencere sistemi gibi yaklaşımlar ile kara tarafı kaynaklı tıkanıklıkların önüne geçilmesi beklenmektedir.

Çalışma ortaya koyduğu tıkanıklık sebepleri, tıkanıklığa karşı geliştirilen önlemler ve stratejilerle literatüre önemli bir katkı sunmaktadır. Ayrıca, liman endüstrisini yakından ilgilendiren ve son dönemlerde sıklıkla yaşanan liman tıkanıklığına yönelik nedenler ve çözüm önerilerinin irdelenmesi sebebiyle de bu çalışma, sektörel anlamda bir yol haritası sunmayı amaçlamaktadır. Çalışmanın kısıtları olarak sınırlı sayıda liman yöneticisi ile görüşülmesi, çalışmanın yalnızca Türkiye limanları özelinde gerçekleştirilmesi öne çıkmaktadır. Gelecek çalışmalarda, liman tıkanıklığı konusunda hem Türkiye limanlarından hem de farklı ülke limanlarından daha fazla katılımcıya ulaşılarak elde edilecek veriler analiz edilerek aradaki farklılıkların yorumlanması faydalı olacaktır. Ayrıca, çalışmada önerilen liman tıkanıklığını önleme stratejilerine dair bir simülasyon çalışmasının yapılması faydalı olacaktır. Çalışma kapsamında yeni teknoloji ekipmanların operasyonel hıza dolayısıyla da liman tıkanıklığının hafifletilmesine etkileri analiz edilebilir. Ayrıca, deneysel olarak daha önce başka limanlarda başarıları kanıtlanmış kalifiye insan gruplarının belli bir limanda istihdam edilmesi sonucunda ilgili limanın tıkanıklık durumuna etkisi gözlemlenebilir.

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İlke Sezin AYAZ: Kavramsallaştırma, Yöntem Bilimi, Doğrulama, Şekilsel Analiz, Kaynaklar, Yazım- Orijinal Taslak, Yazım-Gözden Geçirme ve düzenleme **Umur BUCAK:** Yöntem Bilimi, Doğrulama, Şekilsel Analiz, Kaynaklar, Yazım-Gözden Geçirme ve Düzenleme, Veri İyileştirme, Yazılım, Görselleştirme.

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