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Age-Based Competition Analysis of General Cargo Vessels in Paris MoU Inspections

Paris MoU Denetimlerinde Genel Kargo Gemilerinin Yaşa Dayalı Rekabet Analizi

Araştırma Makalesi/ Research Article

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Özet
Günümüzde tüm sektörler içerisinde yoğun bir rekabet yaşanmakta olup bu durum denizcilik sektöründe daha da belirginleşmektedir. Küresel ticaretin temelini oluşturan deniz taşımacılığında gemilerin denetim süreçleri rekabeti zorlaştıran kritik bir faktördür. Uluslararası gemi denetim rejimleri, gemileri tabi oldukları uluslararası kanunlara uyumu açısından değerlendirerek sektördeki rekabeti belirlemektedir. Paris MoU gibi denetim rejimleri, gemi eksikliklerini değerlendiren ve rekabet dinamiklerini şekillendiren temel unsurlar arasındadır. Bu çalışmada, genel kargo gemilerinin yaş bazlı rekabet analizi yapılmış ve ARIMA modeli ile 2025 yılı rekabetleri tahmin edilmiştir. Paris MoU tarafından 2019-2024 yıllarında gerçekleştirilen denetlere ait sonuç verileri 24 çeyreğe bölünmüş ve genel kargo gemiler 0-5, 5-10, 10-15 ve 15-20 yaş olmak üzere dört yaş grubuna ayrılmıştır. İlk aşamada yaş gruplarının rekabet dinamikleri Gemi Denetim Rekabet Endeksi (Ship Inspection Competition Index - SICI) ile değerlendirilmiş ve SICI değerlerinin güvenilirliği Cronbach's Alpha yöntemi ile test edilmiştir. İkinci aşamada ARIMA modeli ile 2025 yılı sonu için yaş gruplarına göre rekabet tahminleri yapılmıştır.
Sonuçlar, 5-10 yaş grubundaki genel kargo gemilerinin 2025 yılı sonunda diğer yaş gruplarına göre Paris MoU kapsamında gerçekleştirilen denet sonuçlarında karşılaşılan eksiklikler açısından daha avantajlı bir rekabet gücüne sahip olacağını göstermektedir.Çalışmanın, denizcilik sektöründe filo yönetimi ve stratejik karar alma süreçlerinde önemli bir fayda sağlayabileceği ve ayrıca SICI ve ARIMA yöntemlerinin entegrasyonuyla mevcut rekabet dinamiklerini ölçmek ve gelecekteki eğilimleri tahmin etmek için değerli bir akademik çerçeve sunduğu değerlendirilmektedir.

Anahtar Kelimeler: Rekabet, Liman Devleti Kontrolü Denetimi, Denizcilik Yönetimi, ARIMA.

Abstract
There is intense competition in all sectors today, and this situation is more evident in the maritime sector. In maritime transportation, which forms the basis of global trade, ship inspection processes are a critical factor that makes competition difficult. International ship inspection regimes determine competition in sector by evaluating ships in terms of their compliance with international laws to which they are subject. Regimes such as Paris Memorandum of Understanding (MoU) are among the basic elements that evaluate ship deficiencies and shape competition dynamics. In this study, age-based competition analysis of general cargo ships was made and their competition for 2025 was estimated with the ARIMA

model. Paris MoU inspection result data were divided into 24 quarters and the ships were divided into four age groups as 0-5, 5-10, 10-15 and 15-20 years. In the first stage, competition dynamics of age groups were evaluated with Ship Inspection Competition Index (SICI) and reliability of the SICI values was tested with Cronbach's Alpha method. In the second stage, competition estimates based on age groups were made for the end of 2025 with ARIMA model. The results show that general cargo vessels in 5-10 age group will have a more advantageous competitive power compared to other age groups by 2025. It is evaluated that the study can provide significant benefit in fleet management and strategic decision-making processes in the maritime industry and also provides a valuable academic framework to measure current competitive dynamics and predict future trends with the integration of SICI and ARIMA methods.

Keywords*:* Competition, Ship PSC Inspections, Maritime Management, ARIMA.

1. Introduction

The maritime sector is a strategic sector that forms the backbone of global trade and has a direct impact on economic growth. In this context, general cargo vessels play an important role in maritime transportation with their flexibility to carry different types of cargo and their wide operational coverage. However, increasing competition conditions are forcing ship operators and shipowners to develop more sustainable strategies. Competition in the maritime sector is not only determined by traditional factors such as cost and operational efficiency, but also the fact that ships pass the inspections they encounter without any problems, which is one of the main determinants of competition, stands out as a critical factor in maritime transportation.

International inspection frameworks such as Paris MoU PSC (Port State Control), one of the inspection regimes implemented globally, directly affect the competitive dynamics in the sector by evaluating the safety standards and operational compliance of ships and provide an international framework that aims to increase maritime safety. In an increasingly competitive market, shipping companies' ability to maintain their commercial sustainability depends on their ships fully complying with international regulations and safety standards. The safe management of maritime transport activities is very important for the sustainability of maritime sector activities, which is one of the important actors of international trade (Yorulmaz & Avcı, 2022). In this context, successfully passing international inspection processes stands out as a critical element not only in terms of fulfilling safety and operational standards, also in terms of increasing the sustainability and competition of commercial activities. In this context, competition in the maritime sector is not limited to traditional elements such as cost advantage and service quality, but also the performance demonstrated in inspection processes and the level of compliance with international regulations play a decisive role. For commercial vessels,

completing inspection processes completely and being ready for continuous inspections has become one of the basic conditions for achieving a competitive position in the sector. In this process, the effective management of inspection preparation and compliance processes by ship crew is considered a critical responsibility in terms of the ship's ability to continue its commercial activities. Regional inspection mechanisms create a natural competitive environment in the sector by determining the safety and operational standards of ships. Inspection results are considered an important commercial criterion in the evaluation of ships within the scope of voyage charter, time charter or bare charter contracts. In particular, regardless of the age of the ship, the frequency of deficiencies detected in previous inspections or the ship's detention history are among the critical indicators that directly affect its commercial position in the market. In this context, successfully managing inspection processes and ensuring full compliance with regulations has become one of the fundamental elements of gaining competitive advantage in the maritime sector. In this context, SICI will contribute to the determination of competitive advantages in the sector and a better understanding of the impact of inspection processes on commercial competition by providing a competition measurement mechanism specific to the maritime sector.

Maritime transport is one of the most important industries in global trade, and the analysis of competition dynamics in the sector is of great importance. In this study, general cargo ships were divided into four different age groups in order to create a practical model for measuring competition in the maritime transport sector, and the results of 14.492 inspections conducted by the Paris MoU were examined. A total of 37.711 deficiencies were identified within the scope of the inspection data, and the competition analysis between age groups was carried out based on these deficiencies. The reliability test was performed using the Cronbach Alpha method on the SICI results and it was concluded that the results were reliable. In the second step of study the data obtained as a result of the competition analysis conducted with SICI was used to forecast competition according to the age groups of general cargo vessels by the end of 2025 using the ARIMA method.

This study aims to contribute to the determination of sectoral strategies and to provide an academic framework for the prediction of future competition dynamics by revealing the relationship between inspection results and competition.

2. Literature Review

Fundamental studies on competition constitute an important infrastructure for understanding the concept of competition in maritime literature. In this context, according to Schumpeter (1942), competition is influenced by prices as well as innovative processes, such as the development of new products, production methods, markets and organizational structures. According to Porter (2011), who emphasizes competition as the primary driver of economic growth, innovation and productivity, competitive advantage arises not only from price competition but also from broader strategies focusing on quality and innovation. Deming (2018), in his work "Out of the Crisis", explain that competition should be measured by quality rather than price through quality management and continuous improvement processes. As stated in the definitions, competition can be measured on different parameters such as quality and competitive power, other than price, and the definition of competition is used in a wide academic field in many branches of science, from economics to health and even agriculture.

In literature, numerous studies have been conducted on competition. Arslan's (2022) study emphasizes the critical role of the human factor in maintaining the sustainability of shipping agencies within highly competitive environments. The research highlights that achieving a competitive advantage in the maritime sector depends significantly on effective communication in customer relations and a rapid, solution-oriented approach to meeting customer expectations. Furthermore, the study underlines the importance of human resource management as a key driver in shaping competitive strategies. In her study, Yalnız (2025) examined the impact of technology on employment in leading countries in textile and ready-made clothing exports with the Revealed Technological Index (RTI) she developed and classified the countries according to their technological competitive advantage. In the competitive maritime market, the choice of ship tonnage is also a critical factor that directly affects the operational efficiency and profitability of companies. Arıcan et. Al (2022) analyzed the criteria determined by taking the opinions of experts working in leading maritime companies in Türkiye with the ELECTRE method. The results revealed that ships in the 3001-5000 gross tonnage range provide a competitive advantage. Yalnız et al. (2022) compared the countries in the world textile and ready-made clothing sector with Revealed Comparative Advantage (RCA) and Relative Trade Advantage (RTA) indexes between 2000-2020. The study examined the strategies of developing countries to increase their competitive advantage and the effects of these strategies on global competition and export policies. The findings reveal the impact of global competition on production and trade models and show how developing countries adapt to these dynamics.

Increasing competition conditions force businesses to fulfill their social, economic and environmental responsibilities in order to ensure their continuity (Arslan, 2023). In the intense competitive environment that has emerged in the maritime industry, in addition to these responsibilities, legal responsibilities arising from international agreements must also be fulfilled in order for ships to pass the inspections they encounter without any problems. In maritime literature, competition has been made measurable with Ship Inspection Competition Index (SICI), through the results of inspections that ships are subjected to, and which have an important place in terms of their commercial survival. In the study, competition analysis was carried out through inspection with SICI (Yalnız, & Çetin, 2024). The statistical analyses conducted in the study by Yılmaz and Ece (2017) demonstrated a significant correlation between ship age and the outcomes of port state control inspections. Similarly, it was concluded that there is a statistically significant relationship between the number of deficiencies detected and the probability of the ship being detained. These findings show that the age of the ship and the number of deficiencies are critical determinants in the inspection processes and that these factors significantly increase the risk of being detained. The study conducted by Kim and Kong (2008) stated that the highest detention rate was observed in ships aged between 20 and 25 years. In addition, according to the model created with SPSS Binary Logistic Regression Analysis, it was concluded that the riskiest ship group was general cargo vessels.

When the literature on the subject is examined, many studies have been found that were conducted with the ARIMA model. ARIMA is a time series model that is based on explaining univariate data and can make accurate predictions from time series. Munim & Schramm (2017) used ARIMA model to estimate container shipping freight rates between Far East and Northern Europe. The study revealed that ARIMA gives better results than other models in short-term forecasts and general price increases have a significant effect on fluctuations in freight rates. The study "Forecasting of demand using ARIMA model" by Fattah, et. al (2018) models the demand forecast in a food company with a time series approach. In the study using the ARIMA model, the company's past sales data were analyzed and the model proved to be an effective tool for production planning and inventory management by achieving successful results in the 95% confidence interval in demand forecasting. Akkan and Calisir (2022) used ARIMA and other classical time series models to estimate the handling quantities of container ports in Türkiye. In the study, data between 2013-2021 were analyzed and it was estimated that the ARIMA (1,1,1) model showed the best performance and that container handling quantities will increase in the future.

In the literature, various indexes are widely used to measure competition in global markets and analyze sectoral dynamics. These indexes generally focus on measuring factors such as economic performance and trade advantages. However, the absence of an existing index that directly measures competition based on inspection results in the maritime literature reveals a significant gap in the literature. In order to address this gap, a new methodological tool, the Ship Inspection Competition Index was developed to assess competition in the maritime sector through inspection results. SICI was designed as a systematic indicator that allows measuring competition levels by analyzing the inspection results of ships.

3. Methodology

In an environment where intense competition is experienced in the international maritime transport sector, inspection processes stand out as one of the natural determinants of competition. In this context, examining the impact of inspection mechanisms implemented in the international maritime transport sector on competition dynamics offers an important research area in terms of theory and practice.

This study examines in detail how inspection processes shape competition in the sector and analyzes not only the economic aspect of competition but also how it is shaped in the legal and regulatory framework. In this direction, the Ship Inspection Competition Index (SICI) was created in order to evaluate the level of competition among ships subject to inspection regimes. The numerical data obtained through this index contribute to sectoral analyses by providing a broader perspective on competition in the sector (Yalnız & Çetin).

In the study, the SICI method and the ARIMA model were used in an integrated manner. Based on these data, the competition analyses of general cargo ships for four different age categories (0-5,5-10,10-15 and 15-20) and a total of twenty-four quarters, divided into four quarters each year between 2019-2024, were conducted using the SICI method. In order to test the reliability of the index results, a reliability analysis was conducted using Cronbach's Alpha coefficient. This test was used to assess the internal consistency of the SICI values, and a high reliability coefficient was obtained (Cronbach Alpha > 0.70). This result shows that the SICI method is a reliable competition analysis tool.

Based on the SICI results, the competition status of general cargo vessels according to age groups was analyzed using the ARIMA model. ARIMA model were introduced to the literature in 1970 by George Box and Gwilym Jenkins, who worked on future predictions. It is a powerful tool for predicting future trends using historical time series data.

In the study, the most suitable ARIMA parameters were tested with the Akaike Information Criterion (AIC) and the white noise assumption of the residuals. The methodological framework of the study consists of the following steps:

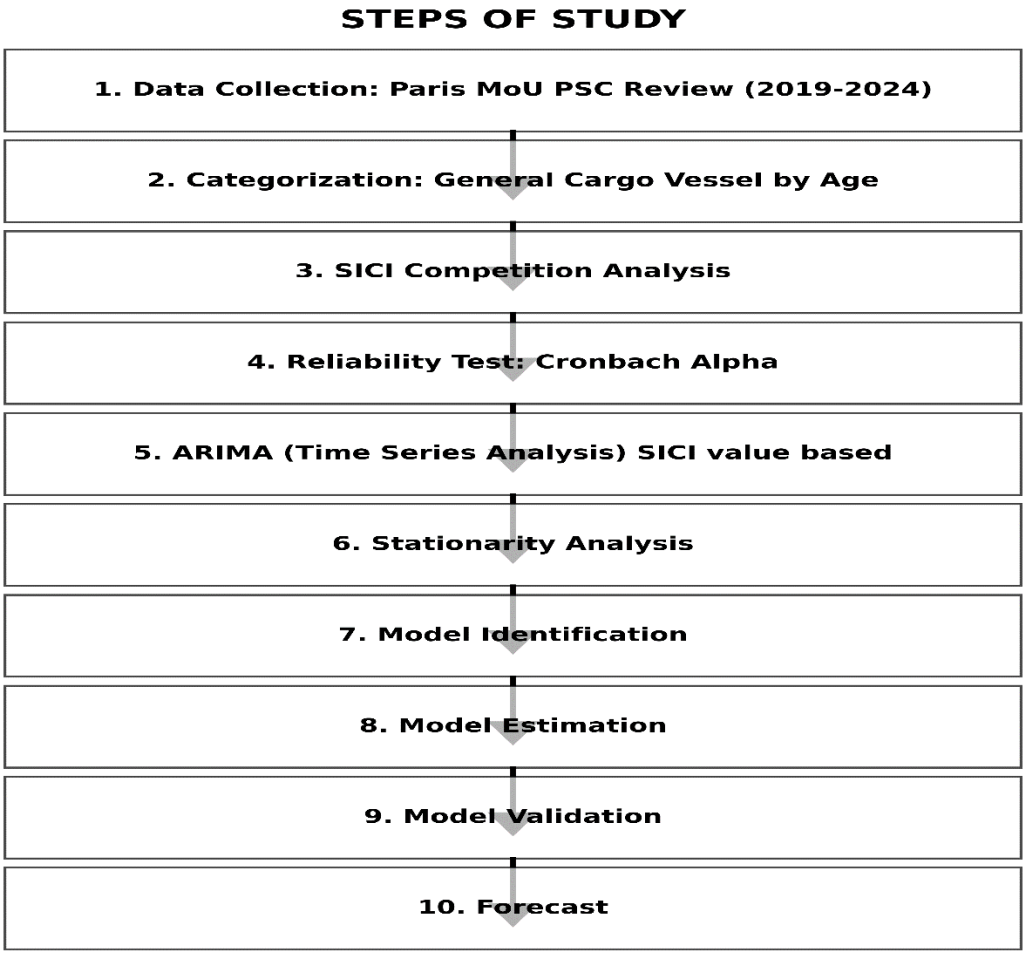

Figure 1. Steps of study

SICI is an index created to calculate competitiveness based on the results of inspections. The SICI formula (Eq.1) is as follows:

$$SICI = \frac{\left(\frac{\sum I_{xr}}{\sum I_{xi}}\right)}{\left(\frac{\sum I_{ar}}{\sum I_{ai}}\right)} \text{(Eq.1)}$$

Where;

$\sum I_{xr}$: Total number of deficiencies or detentions in inspections on a specified ship type,

$\sum I_{xi}$: Total number of inspections encountered on a specified ship type,

$\sum I_{ar}$: Total number of deficiencies or detentions encountered in inspections on all ship types,

$\sum I_{ai}$: Total number of inspections on all ship types.

Table 1. *Definition of SICI values*

SICI Value	Definitions
SICI = 0	Perfectly Competitive
0 < SICI < 1	Competitive Advance
SICI = 1	Equal Competitive
SICI > 1	Competitive Disadvantage

Source: Prepared by the Authors

The index is created assuming that the total number of deficiencies or detentions in all inspections is greater than zero, and the definitions of the SICI ranges are presented in Table 1. According to the SICI formula (Eq.1), a ship type with an index value of zero is considered perfectly competitive, while a ship type with an index value close to zero indicates that it has a competitive advantage in inspections compared to other ship types. When the index value is 1, it is stated that there is no competitive advantage or disadvantage, but a state of equality. On the other hand, ships with a SICI value greater than 1 indicate that they have a competitive disadvantage.

4. Results And Discussion

The main data of this study are the results of 14.492 inspections carried out by the Paris MoU PSC on general cargo ships between 2019-2024. The number of inspections (NoI) carried out by the Paris MoU PSC on general cargo ships in the age groups 0-5, 5-10, 10-15 and 15-20 between 2019-2024 for each quarter and the number of deficiencies (NoD) detected in these inspections are shown in detail in Table 2. The study was carried out on 37.711 deficiencies detected in 14.492 inspections. The general cargo vessels considered in the study are classified according to the specified age groups since they are subject to a special survey process every 5 years.

Table 1. The number of deficiencies and number of inspections (2019-2024)

	2019								2020							
	Q1		Q2		Q3		Q4		Q1		Q2		Q3		Q4	
AGE	NoI	NoD	NoI	NoD	NoI	NoD	NoI	NoD	NoI	NoD	NoI	NoD	NoI	NoD	NoI	NoD
0-5	57	67	50	75	52	66	58	51	40	50	25	13	44	62	53	47
5-10	209	422	182	374	173	298	158	311	90	156	35	19	95	150	91	160
10-15	325	606	324	713	320	778	317	726	287	550	149	274	381	756	289	645
15-20	165	447	155	411	114	263	132	403	143	410	62	118	150	473	152	502
Total	756	1.542	711	1.573	659	1.405	665	1491	560	1.166	271	424	670	1.441	585	1.354
	2021								2022							
	Q1		Q2		Q3		Q4		Q1		Q2		Q3		Q4	
AGE	NoI	NoD	NoI	NoD	NoI	NoD	NoI	NoD	NoI	NoD	NoI	NoD	NoI	NoD	NoI	NoD
0-5	40	25	48	48	61	163	53	68	28	75	23	59	24	45	25	37
5-10	83	167	77	112	98	255	75	125	79	135	73	127	87	115	70	157
10-15	283	610	260	719	305	800	285	794	310	784	248	688	271	852	229	725
15-20	161	348	148	472	185	601	195	503	213	677	182	611	191	554	187	536
Total	567	1.150	533	1.351	649	1.819	608	1.490	630	1.671	526	1.485	573	1.566	511	1.455
	2023								2024							
	Q1		Q2		Q3		Q4		Q1		Q2		Q3		Q4	
AGE	NoI	NoD	NoI	NoD	NoI	NoD	NoI	NoD	NoI	NoD	NoI	NoD	NoI	NoD	NoI	NoD
0-5	28	47	29	40	40	60	36	98	64	92	52	187	47	116	62	136
5-10	69	113	87	158	55	87	55	113	56	114	78	112	81	136	68	128
10-15	285	850	245	733	238	664	212	675	236	781	194	564	215	592	153	457
15-20	273	790	206	608	257	1035	249	907	390	1610	321	1.001	350	1.183	287	1.141
Total	655	1.800	567	1.539	590	1.846	552	1.793	746	2.597	645	1.864	693	2.027	570	1.862

Source: Prepared by the Authors

SICI deficiency values are shown in Table 3, calculated with the number of deficiency (NoD) and number of inspection (NoI) data obtained from the Thetis system. The Thetis System is a digital platform developed by the European Maritime Safety Agency (EMSA) to facilitate the management and coordination of inspections conducted by port state control mechanisms.

Table 2. SICI values as per Paris MoU PSC based on deficiencies (2019-2024)

YEAR	2019				2020				2021			
AGE OF VESSEL	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
0-5	0.58	0.68	0.60	0.39	0.60	0.33	0.66	0.38	0.31	0.39	0.95	0.52
5-10	0.99	0.93	0.81	0.88	0.83	0.35	0.73	0.76	0.99	0.57	0.93	0.68
10-15	0.91	0.99	1.14	1.02	0.92	1.18	0.92	0.96	1.06	1.09	0.94	1.14
15-20	1.33	1.20	1.08	1.36	1.38	1.22	1.47	1.43	1.07	1.26	1.16	1.05
YEAR	2022				2023				2024			
AGE OF VESSEL	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
0-5	1.01	0.91	0.69	0.52	0.61	0.51	0.48	0.84	0.41	1.24	0.84	0.67
5-10	0.64	0.62	0.48	0.79	0.60	0.67	0.51	0.63	0.58	0.50	0.57	0.58
10-15	0.95	0.98	1.15	1.11	1.09	1.10	0.89	0.98	0.95	1.01	0.94	0.91
15-20	1.20	1.19	1.06	1.01	1.05	1.09	1.29	1.12	1.19	1.08	1.16	1.22

Source: Prepared by the Authors

In the study, in order to test the reliability of SICI values, Cronbach's Alpha coefficient developed by Cronbach (1951) was calculated using the Python statistics program. Cronbach Alpha Coefficient is 0.97, and since the coefficient value is above 0.70, this value is an indicator of very high reliability. The annual trends of SICI-deficiency values by age of general cargo ships based on Paris MoU PSC Inspections (2019-2024) are shown in figure 2.

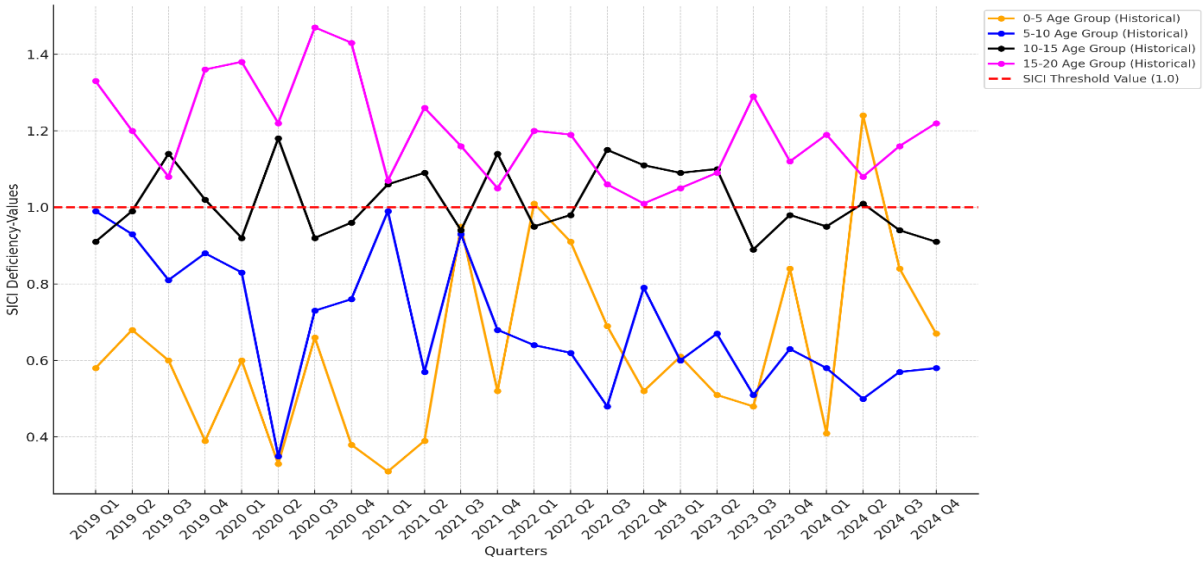

Figure 2. SICI values by age of general cargo vessels based on Paris MoU PSC inspections (2019-2024)

At this stage of the study, prediction will be created for the competition of general cargo vessels that will enter the Paris MoU inspection in 2025 according to their age categories using the ARIMA model based on the data obtained from the SICI. The data were compiled from the Paris MoU inspection results and grouped by quarter (Q1, Q2, Q3, Q4). SICI-deficiency values were calculated for each age group and converted into time series format and age groups were defined as 0-5,5-10,10-15 and 15-20. The stationarity of the time series was checked with the Augmented Dickey-Fuller (ADF) test (Dickey & Fuller, 1979). The ADF test uses the following hypotheses to test whether a time series is stationary:

- H0 (Null Hypothesis): The time series is not stationary ($p>0.05$)
- H1 (Alternative Hypothesis): Time series is stationary ($p<0.05$)

For non-stationary series, stationarity was achieved by applying first and, if necessary, second-degree differencing. The best parameters were chosen during modeling shown in Table 4.

Table 3. ARIMA models

Age Group	ARIMA Model
0-5	ARIMA (1, 1, 1)
5-10	ARIMA (1, 1, 1)
10-15	ARIMA (1, 2, 1)
15-20	ARIMA (1, 0, 1)

Source: Prepared by the Authors

ARIMA models determined for each age group were applied to make forward SICI-deficiency value forecast corresponding to December 31, 2025, shown in fig 3. Model results were obtained and were listed in Table 5.

Table 4. Forecasted SICI values for 2025

Age Group	Forecasted SICI Value (2025)
0-5	0.692
5-10	0.588
10-15	0.905
15-20	1.208

Source: Prepared by the Authors

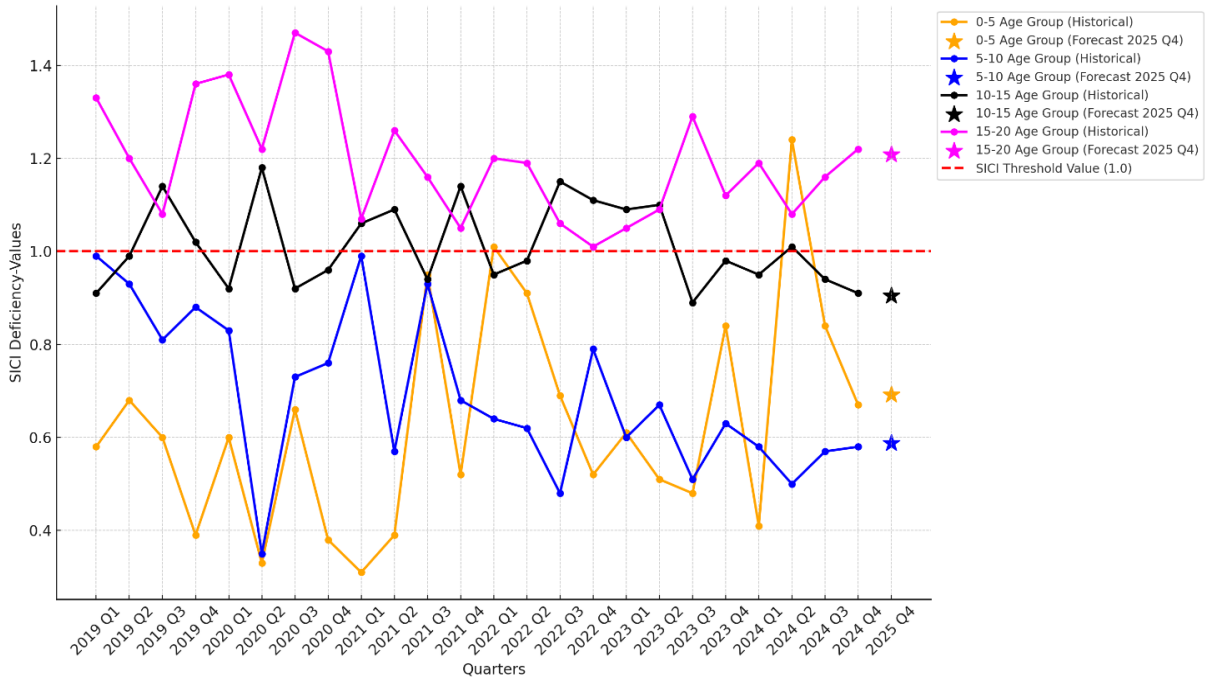

Figure 3. Estimated SICI-deficiency values by end of 2025 based on Paris MoU PSC

Forecasted results provide important clues about the competitive advantages and disadvantages of age groups. The SICI value for ships in the 0-5 age group was estimated as 0.692 and this group remained below the 1.0 threshold, maintaining its competitive advantage. However, when compared to previous years, it was observed that the competitive advantage in this age group started to decrease. General Cargo vessels in the 5-10 age group had the lowest competitive index with an estimated SICI value of 0.588 and stood out as the most advantageous

group compared to other age groups. This shows that this age group generally has a more balanced and sustainable competitive power. The estimated SICI value for general cargo ships in the 10-15 age group is 0.905. This result shows that competitiveness has partially improved in the past periods. General cargo ships in the 15-20 age group had the highest competitive index with an estimated SICI value of 1.208, revealing that the group continues to be at a competitive disadvantage in 2025.

5. Conclusion

In this study, age-based competition analysis based on the inspection results of general cargo ships was carried out using the SICI method based on deficiency data encountered by general cargo ships in the inspections carried out within the scope of the Paris MoU inspection framework. Then, future competition predictions were evaluated using the ARIMA model. General cargo ships were divided into four age groups (0-5, 5-10, 10-15, and 15-20 years) and the inspection data covering a total of 24 quarters between 2019-2024 were analyzed. In the last 12 quarters of the 24 quarters examined in the study, it was observed that ships in the 5-10 age group were more competitive than ships in the 0-5 age group in 8 quarters. In addition, according to the 2025 estimates made with the ARIMA model, it was predicted that ships in the 5-10 age group would be in a more advantageous position in competition compared to ships in the 0-5 age group. The results show that general cargo ships between the ages of 5 and 10 years have higher levels of compliance with international safety, environmental protection and operational standards than the inspection results carried out within the scope of the Paris MoU. These findings show that these ships are in a more advantageous position in terms of technical compliance, planned maintenance processes and compliance with regulatory requirements.

The SICI method was used as a critical tool to measure the competitiveness of ships based on inspection results and provided a comparison of competitive dynamics according to different age groups. The ARIMA model provided a powerful tool to predict future trends of these dynamics and allowed for important inferences to be made regarding sectoral strategies based on ship age groups. The results reveal that the evaluation of the competition of general cargo vessels based on age is an important guide in fleet management, maintenance planning and sectoral strategy development processes. In addition, the obtained ARIMA estimates contribute to a better understanding of future sectoral dynamics and strategic planning regarding the sustainability of competitive advantages.

It is believed that this study provides a valuable resource for policy makers and sectoral decision makers by providing a comprehensive framework for competition analysis in the maritime sector with the integration of both the SICI method and the ARIMA model.

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