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Market Concentration and Cargo Distribution in Türkiye's Ports: A Cargo-Type Based Analysis

Türkiye Limanlarında Pazar Yoğunlaşması ve Yük Dağılımı: Yük Türüne Dayalı Bir Analiz

Türk Denizcilik ve Deniz Bilimleri Dergisi

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Muhammed TURGUT
Tarsus University, Faculty of Applied Sciences, Department of International Trade and Logistics, Mersin- Türkiye

ABSTRACT

This study investigates the market structure and distributional inequality of cargo handled at Türkiye ports between 2017 and 2023, focusing on container and liquid chemical cargo, and between 2018 and 2023 for dry bulk cargo. The research evaluates inter-port competition and the sectoral distribution of cargo flows using annual cargo handling data from ports affiliated with the Türkiye Port Operators Association (TÜRKLİM). The analysis employs multiple quantitative indicators—including the Herfindahl-Hirschman Index (HHI), Gini coefficient, Theil index, and concentration ratios (CR3 and CR5)- to assess competitive dynamics and cargo distribution disparities. The results reveal that the Türkiye port system is highly competitive, characterized by low HHI values and moderate CR3 and CR5 ratios, indicating the absence of monopolistic dominance. However, elevated Gini and Theil index values, along with the Lorenz curve analysis, point to significant inequality in the distribution of cargo across ports. While a small number of large ports dominate in terms of volume, small and medium-sized ports continue to play a critical operational role, contributing to the resilience and flexibility of the system. These findings highlight the need for balanced infrastructure policies that support not only leading ports but also smaller regional actors. By integrating multiple metrics in its analytical framework, the study contributes a novel perspective to the literature on port planning and competition analysis.

Keywords: Port competition, Cargo distribution, Market concentration, Türkiye ports.

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(corresponding author)
E-mail: muhammedturgut@tarsus.edu.tr

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ÖZET

Araştırma, 2017–2023 yılları arasında Türkiye limanlarında konteyner ve sıvı kimyasal yük ile 2018-2023 yılları arası kuru dökme yük özelinde pazar yapısını ve yük dağılımındaki eşitsizlikleri analiz etmeyi amaçlamaktadır. Türkiye Liman İşletmecileri Derneği'ne (TÜRKLİM) üye limanlardan elde edilen yıllık yük verileri kullanılarak, limanlar arası rekabet düzeyi ve yük akışlarının sektörel dağılımı ölçülmüştür. Araştırmada Herfindahl-Hirschman Endeksi (HHI), Gini katsayısı, Theil endeksi ve yoğunlaşma oranları (CR3 ve CR5) kullanılarak, hem rekabet yapısı hem de yük dağılımındaki eşitsizlik ayrıntılı bir şekilde analiz edilmiştir. Bulgular, Türkiye liman sisteminin düşük HHI ve orta seviyedeki CR3 ve CR5 değerleri ile yüksek derecede rekabetçi bir yapıya sahip olduğunu, tekelci eğilimlerin bulunmadığını göstermektedir. Buna karşın, yüksek Gini ve Theil endeksi değerleri ile Lorenz eğrisi analizi, yük dağılımında belirgin bir eşitsizlik olduğunu ortaya koymaktadır. Az sayıda büyük liman yük hacminde lider konumda bulunurken, küçük ve orta ölçekli limanlar operasyonel varlıklarını sürdürerek sistemin esneklik ve dayanıklılık kapasitesine katkı sağlamaktadır. Elde edilen bulgular, Türkiye liman politikalarının yalnızca büyük limanları değil, küçük ve orta ölçekli limanları da kapsayacak şekilde dengeli altyapı yatırımlarıyla şekillendirilmesi gerektiğini ortaya koymaktadır. Çalışma, liman planlaması ve rekabet analizine çok ölçütlü yaklaşımıyla literatüre katkı sağlamaktadır.

Anahtar Kelime: Liman Rekabeti, Yük Dağılımı, Pazar Yoğunlaşması, Türkiye Limanları

1. INTRODUCTION

Ports serve as critical nodes within the global supply chain and play a strategic role in facilitating international trade. In recent decades, the rapid expansion of trade volumes has elevated not only the logistical functions of ports but also their strategic importance in shaping competitive advantage. A port's ability to position itself effectively within an increasingly competitive environment—and to maintain a sustainable presence in the market—has become a key determinant of both regional and global economic integration (Notteboom and Rodrigue, 2005). In this context, analyzing inter-port competition and evaluating the underlying market structure is not only essential for port operators but also increasingly relevant for public policy makers concerned with national logistics and economic strategy.

Since the 1960s, the deepening of international trade and the technological transformation of the transport sector have driven a structural evolution in the role and functions of ports. The widespread adoption of containerization, the development of multimodal transport solutions, and the digitization of logistics have made port hinterland structures significantly more flexible (Song and Panayides, 2008). With the expansion of transportation networks and the increase in freight capacity, ports are no longer confined to their traditional hinterlands; they are now able to serve broader geographic regions. This shift has intensified competition among ports operating within the same macro-regions. Today, a port's competitive position is determined not merely by geographic advantage but by a combination of factors such as infrastructure investment, service quality, specialization, and operational efficiency (Luo *et al.*, 2022).

Within this framework, concentration measures have emerged as critical analytical tools for assessing the sectoral positioning of ports. Market concentration reveals how total cargo volume within a specific cargo type is distributed among competing ports, and whether this distribution reflects a competitive or monopolistic structure. Such metrics make it possible to gauge the market influence of individual ports and provide a solid empirical foundation for infrastructure investment decisions and regulatory policy interventions (Notteboom and Yap, 2012). A high level of concentration may indicate the dominance of a few ports, potentially leading to market imbalances, whereas lower concentration generally corresponds to a more competitive and evenly distributed port network. In this context, measuring cargo handling concentration holds substantial importance for sectoral competition analysis, infrastructure planning, and policy formulation. As concentration increases, it may impact service quality and pricing dynamics, while excessive concentration can lead to quasi-monopolistic conditions. Conversely, lower levels of concentration tend to reflect healthier competition across the port system (Notteboom, 2010).

The primary objective of this study is to analyze market concentration in Türkiye ports based on cargo types and to uncover structural shifts that have occurred over time. Focusing on three major cargo categories—container, dry bulk, and liquid chemical—the analysis is grounded in a longitudinal dataset spanning several years. Specifically, the period from 2017 to 2023 is examined for container and liquid chemical cargo, while dry bulk cargo is analyzed from 2018 to 2023. The study employs widely accepted structural concentration metrics, including the Herfindahl-Hirschman Index (HHI), concentration ratios (CR3 and CR5), and the Gini coefficient. These analytical tools offer a robust and complementary framework for assessing the intensity and dynamics of inter-port competition across different cargo segments.

The findings of this study reveal both general and cargo-specific structural patterns within the Türkiye port market, offering valuable insights for reshaping port policy, guiding infrastructure investments, and fostering sustainable competition. Moreover, the study seeks to provide a novel and timely perspective on the evolving impact of Türkiye's port system on regional market structures.

1.1. Literature Review

Ports represent one of the most critical components of global trade and logistics networks, playing a pivotal role in national economies. As globalization intensifies, supply chains become more complex, and regional trade dynamics continue to shift, analyzing the competitive structure of ports and their cargo-handling capacities has gained increasing significance in both academic and operational contexts. In particular, examining market structures, concentration levels, and the competitive positioning of ports across various cargo types (e.g., container, dry bulk, liquid chemical) is essential not only for enhancing logistical efficiency but also for informing national and regional development strategies. In line with this need, a growing body of research has assessed port performance and competitiveness using a range of analytical methods, offering insights into prevailing trends across different geographical contexts. The following section provides a synthesis of the key contributions in the existing literature.

Bayraktutan and Özbilgin (2013) examined the role of the Kocaeli ports within the Türkiye economy and their impact on international trade. Emphasizing the significance of maritime transportation at both global and national scales, the study evaluated the geographic location, infrastructure conditions, and contributions of the Kocaeli ports to the surrounding industrial landscape. The findings suggest that despite their strategic location, the Kocaeli ports have not fully realized their potential due to infrastructure deficiencies. While the study highlights the critical importance of increased port investment for both regional development and the national economy, it also points to current infrastructural inadequacies as a key limitation.

Ateş *et al.* (2013) assessed the 2011 performance of nine container terminals located in six Black Sea countries using the Data Envelopment Analysis (DEA) method. As part of the TRACECA program, terminals in Türkiye, Georgia, Ukraine, Bulgaria, and Romania were included in the analysis, along with Russia as a non-member country. The results indicated that the Poti and Novorossiysk terminals operated with relatively high efficiency, whereas the Burgas terminal recorded the lowest performance. The study underscores the importance of adopting internationally recognized performance indicators for ports to remain competitive in the global maritime arena.

Demiroğlu and Eleren (2014) conducted a comparative analysis of three major Türkiye ports with rail connectivity (Izmir-Alsancak, Istanbul-Haydarpasa, and Mersin) against selected EU ports, including Rotterdam, Antwerp, Hamburg, Marseille, Algeciras, Piraeus, and Thessaloniki, using a set of logistics-based criteria. Employing the PROMETHEE method, the study ranked ports based on factors such as quay length, terminal area, maximum draft, rail access, and proximity to airports. The results placed Rotterdam, Antwerp, and Hamburg at the top of the rankings, while Türkiye ports ranked lower due to physical limitations such as shallow drafts and limited terminal space. Despite Türkiye's favorable geostrategic location, the study emphasized the need for substantial improvements in port infrastructure and suggested that these limitations should be addressed through proactive public-sector involvement.

Varan and Cerit (2014) analyzed the impact of post-1997 privatization on market concentration and competition within Türkiye's container port sector. To assess the degree of competition in the industry, the study employed statistical indicators such as the Herfindahl-Hirschman Index (HHI) and the CR4 concentration ratio. The findings indicate that the privatization process successfully stimulated private-sector investment and enhanced competition. However, port performance was also found to be significantly influenced by broader macroeconomic and institutional factors. The authors emphasize that to translate the competitive advantages gained by new entrants into sustainable global competitiveness for Türkiye, port policies and sectoral regulations must be continuously refined.

De Oliveira and Cariou (2015) investigated the impact of competition on port efficiency using data from 200 container ports for the years 2007 and 2010. In the first stage, port efficiency scores were estimated using a sequential Data Envelopment Analysis (DEA) approach, followed by a second-stage analysis employing a bootstrapped truncated regression model to identify the determinants of efficiency. The results show that port efficiency tends to decline as regional competition intensifies within a 400–800 km radius, while competition at the local (<300 km) and global (>800 km) scales does not have a statistically significant effect. Additionally, the study found that port investments may temporarily reduce efficiency scores in the short term, whereas ports with higher market shares tend to perform more efficiently. While the study challenges the assumption that inter-port competition always enhances efficiency, it also notes important limitations, including the lack of terminal-level data and the constraints of country-level aggregation.

Akgül (2018) analyzed the market structure and competitive dynamics of cruise ports in Türkiye using cruise passenger traffic data from 2003 to 2017. The study employed CR3, CR5, and the Herfindahl-Hirschman Index (HHI) to measure market concentration, while competitiveness was assessed using Shift-Share Analysis across three sub-periods: 2003–2007, 2008–2012, and 2013–2017. The findings indicate that Türkiye's cruise port market exhibits an oligopolistic structure, though competitive pressure has increased in recent years. Despite the overall decline observed in 2016 and 2017, the ports of Çeşme and Bodrum emerged as standout performers, recording growth in cruise passenger numbers and earning the distinction of "rising stars." The study underscores the need for strategic planning to enhance the competitiveness of Türkiye cruise ports, while also acknowledging limitations related to data availability and the influence of external shocks.

Constantinos and Theodore (2019) examined cargo concentration trends in U.S. West and East Coast container ports during the 2005–2015 period. Using a combination of concentration metrics, including CR4, CR8, the Herfindahl-Hirschman Index (HHI), the Gini coefficient, and the Lorenz curve alongside Shift-Share Analysis, the study assessed the distribution of container flows across major ports. Contrary to earlier findings that suggested a low-concentration market structure, the results indicate that port activity during this period exhibited moderate to high levels of concentration. The growing dominance of mega-carriers and global terminal operators was identified as a key driver of this shift, leading to the aggregation of container volumes at select gateway ports. The authors emphasize that this trend carries significant implications for port policy and infrastructure planning.

Feng *et al.* (2020) analyze the evolution of the container throughput within the Yangtze River Delta, China's most developed multi-port system. In addition to classical measures like HHI, Gini, CR, Aitchison distance, and Shift-Share analysis, the study introduces an innovative ternary diagram method to simultaneously and visually explore market concentration, inequality, and competition. Findings indicate that while Shanghai held an oligopolistic dominance until 2001, it gradually lost ground to Ningbo-Zhoushan (ZPG), leading to a more balanced competitive structure. The study argues that this novel graphical approach offers a powerful tool to understand the spatio-temporal evolution of port systems.

İnce and Güngör (2021) examined the ports of İskenderun and Mersin in terms of their logistics hinterlands and competitive structures, while also evaluating the development of Türkiye's maritime transportation within the context of international trade data. The study analyzed the container-handling capacities, hinterland connectivity, and competitive positioning of the Mersin, Limak İskenderun, and Assan ports, using statistics provided by the Ministry of Transport and Infrastructure as the primary data source. The findings indicate that Mersin Port stands out due to its extensive hinterland and high capacity, while Limak İskenderun and Assan ports have gained prominence in regional competition. Although the study highlights the potential for port investments to enhance Türkiye's role in transit trade, it also notes the lack of detailed hinterland data as a methodological limitation.

Ju *et al.* (2023) analyzed the impact of inter-port competition on operational efficiency using data from 13 Chinese coastal ports covering the period from 2010 to 2019. In the first stage, port efficiency was evaluated through the DEA-CCR and DEA-BCC models to calculate technical, pure technical, and scale efficiency scores. In the second stage, the influence of competition—measured via the Herfindahl-Hirschman Index (HHI)—on each type of efficiency was examined using a panel data regression model. The results indicate that, while overall efficiency levels among Chinese ports were relatively high, increased competition was positively and significantly associated with improvements in operational efficiency.

Kammoun and Abdennadher (2023) examined the determinants of port efficiency using data from 30 European container ports spanning the period from 2005 to 2018, applying a two-stage analytical approach. In the first stage, technical efficiency scores were estimated using the DEA-Window method. In the second stage, the effects of competition and environmental variables on efficiency were analyzed through a bootstrapped truncated regression model. The findings reveal that quay length, vessel call frequency, and the quality of logistics services positively influence port efficiency, while per capita income, investment intensity, and market concentration (as measured by HHI) tend to reduce it. Notably, intense competition can drive ports toward overinvestment, thereby diminishing technical efficiency; proximity to major hub ports also emerged as a significant factor. The study underscores that competition does not automatically enhance efficiency and argues for policy frameworks that account for such complex interactions. It also highlights port-level data limitations as a key constraint.

Quach *et al.* (2024) examined the relationship between port competition and efficiency in Vietnam using data covering the period from 2011 to 2022. Port competition was evaluated through metrics such as the Herfindahl-Hirschman Index (HHI), the Gini coefficient, and market share distributions, while port efficiency was measured using Data Envelopment Analysis (DEA). The findings indicate that inter-port competition in Vietnam has intensified over time, and this increase has had a positive effect on port efficiency. However, during the COVID-19 pandemic, the influence of external factors on efficiency was found to be inconsistent and statistically insignificant. The study highlights that while competition can enhance efficiency under normal conditions, this relationship may fluctuate during periods of extraordinary disruption, such as global pandemics.

Solak Fiskin (2024) examines the evolution of market concentration, inequality, and competition among the three major European container ports—Rotterdam, Antwerp, and Hamburg. Using both traditional concentration measures such as HHI, Gini, CR, Theil-T, and a ternary diagram visualization approach, the study illustrates the competitive dynamics among these ports. Findings indicate that the ports have relatively balanced market shares, reflecting a mature market structure with strong competition. It is also observed that while Hamburg has lost market share in recent periods, Antwerp has gained. The study forecasts that effective competition will likely continue among these ports in the future.

Previous studies on port systems have employed a wide array of methodological frameworks to analyze performance, market concentration, and competitive dynamics across diverse geographical contexts. For instance, Ateş *et al.* (2013) and Ju *et al.* (2023) utilized Data Envelopment Analysis (DEA) to assess technical and scale efficiencies in Black Sea and Chinese ports, respectively, while Quach *et al.* (2024) combined DEA with HHI and Gini metrics in the Vietnamese context. Demiroğlu and Eleren (2014) applied the PROMETHEE method to evaluate competitiveness based on multi-criteria infrastructure parameters. De Oliveira and Cariou (2015) and Constantinos and Theodore (2019) adopted shift-share analyses to investigate temporal shifts in cargo flows and regional dominance. In Türkiye-focused studies, Varan and Cerit (2014) explored the impact of privatization on concentration using HHI and CR4, Akgül (2018) assessed the cruise port segment with CR and shift-share methods, while İnce and Güngör (2021) and Bayraktutan and Özbilgin (2013) concentrated on hinterland structures and infrastructural implications. More recent works by Feng *et al.* (2020) and Solak Fiskin (2024) combined traditional concentration measures (HHI, Gini, Theil, CR) with innovative visualization techniques such as ternary diagrams to explore multi-port system dynamics. In contrast to these varied approaches, the present study applies an integrated suite of concentration and inequality indicators, HHI, Gini, Theil, CR3, CR5, and the Lorenz curve, to systematically quantify market structures and intra-segment disparities across multiple cargo types in Türkiye's ports. By simultaneously evaluating container, dry bulk, and liquid chemical segments within a unified framework, this study complements efficiency- and shift-share-based analyses while also addressing a notable gap in Türkiye-specific research, which has predominantly examined single cargo types or focused narrowly on hinterland and infrastructure dimensions.

While many previous studies have focused on efficiency (e.g., through Data Envelopment Analysis [DEA] or PROMETHEE) or traffic shifts (via shift-share analysis), the present study adopts a different analytical focus. By employing a suite of concentration and inequality indices—namely HHI, Gini, Theil, CR3, CR5, and the Lorenz curve—this research directly quantifies market structure and distributional dynamics across cargo types. This approach allows for a more structural understanding of inter-port competition, offering a complementary but methodologically distinct contribution to the literature on port competitiveness and spatial analysis.

2. METHODOLOGY

This study employs quantitative analytical methods to assess the competitive structure of Türkiye ports and to measure the extent of inequality in cargo distribution. The analysis is based on cargo-handling data for the period 2017–2023 for container and liquid chemical cargo, and 2018–2023 for dry bulk cargo. Each cargo type is evaluated separately, followed by an integrative assessment of the overall cargo structure. This approach enables the identification of both segment-specific dynamics and broader patterns in the competitive and concentration structures of the Türkiye port system.

2.1. Data sets

The data used in this study were derived from annual cargo-handling statistics provided by the Turkish Port Operators Association (TÜRKLİM). The dataset consists of annual data covering the period from 2017 to 2023. The scope of analysis covers container and liquid chemical cargo handled by TÜRKLİM member ports between 2017 and 2023, as well as dry bulk cargo data recorded between 2018 and 2023. Only the data from TÜRKLİM-affiliated port operators were included in the analysis, forming the core dataset for evaluating market concentration and distributional inequality in the sector.

TÜRKLİM is the most comprehensive and influential representative body of the port industry in Türkiye. Established in 1996, the association currently includes a wide range of public and private port operators across the country. As of 2024, TÜRKLİM has 78 member port operators, collectively responsible for over 85% of Türkiye's total port cargo throughput (TÜRKLİM, 2024). This figure clearly demonstrates the critical role of TÜRKLİM-affiliated ports in terms of both cargo volume and logistical infrastructure within the national port system.

Although the dataset spans a relatively limited number of years, employing a diverse set of concentration and inequality measures provides a multi-faceted view of the market structure. Each metric captures different aspects—such as average concentration (HHI), top-tier dominance (CR3, CR5), overall inequality (Gini, Theil), and distributional patterns (Lorenz curve)—thereby offering complementary insights.

2.2. Methods and analytical tools

To evaluate the competitive structure and cargo distribution inequality across Türkiye ports, this study employs a range of quantitative measurement tools. To capture concentration and inequality levels through a multidimensional lens, several widely recognized analytical techniques are utilized, including the Herfindahl-Hirschman Index (HHI), the Gini coefficient, the Theil index, concentration ratios (CR3 and CR5), and the Lorenz curve.

2.3. Herfindahl-Hirschman index (HHI)

The Herfindahl-Hirschman Index (HHI) is widely used in the literature due to its straightforward calculation and its ability to account for the market shares of both large and small firms. Notably, in 1982, the U.S. Department of Justice incorporated the index into its merger guidelines, making it a standard tool in antitrust enforcement and a benchmark for assessing industrial concentration (Singh, 2012). The HHI is calculated by summing the squares of the market shares of all firms within the market. Its fundamental mathematical formulation is presented in the equation below (Bikker and Haaf, 2002).

$$HHH = \sum_{i=1}^{n} s_i^{\,2} \tag{1}$$

In this formula:

- N: denotes the total number of ports analyzed.
- S_i: represents the market share of the i-th port (e.g., annual share in TEUs for a specific cargo type).

In this study, S_i refers to the market share of the i-th port in Türkiye for a specific cargo type. Thus, HHI is used to measure the level of market concentration among ports.

The Herfindahl-Hirschman Index (HHI) was employed to measure the degree of market concentration. It is calculated by squaring the market share of each port and summing these values across all ports. The index serves as a tool to evaluate the level of competition among ports and to identify potential concentration trends within the sector.

- A low HHI value indicates a highly competitive market structure.
- A high HHI value suggests a concentrated market structure

2.4. Gini coefficient

The Gini coefficient was developed by Italian statistician Corrado Gini and first published in 1912. It is one of the most widely used summary measures of inequality and is closely associated with the Lorenz curve. Ranging from 0 to 1, a Gini value of 0 indicates perfect equality, while a value of 1 reflects perfect inequality. The Gini coefficient is a standard tool in econometrics for measuring income inequality across individuals or households (Haidich and Ioannidis, 2004).

$$G = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}\left|x_i - x_j\right|}{2n^2\overline{x}} \tag{2}$$

Here:

- x_i and x_j: denote the total cargo volumes handled by the i-th and j-th ports (e.g., in TEUs).

- N: is the total number of ports analyzed.
- $\bar{x}$: is the average cargo volume handled.

In this study, the Gini coefficient was calculated to measure inequality in cargo distribution. The coefficient indicates the extent to which cargo volumes are evenly or unevenly distributed among ports.

- Values close to 0 indicate a perfectly equal distribution of cargo.
- Values approaching 1 reflect a highly unequal distribution of cargo.

2.5. Theil index

The Theil Index is an inequality measure developed by Theil in 1967, based on the concept of entropy. Designed to reflect the distribution of diversity within a system, the index quantifies disparities in a given dataset. Its formal definition is presented as follows (Ben Hammouda *et al.*, 2006).

$$T = \frac{1}{n}\sum_{i=1}^{n}\left(\frac{x_i}{\bar{x}} ln \frac{x_i}{\bar{x}}\right) \quad (3)$$

Here:

- x_i denotes the total cargo volume handled by the i-th port (e.g., in TEUs).
- $\bar{x}$ is the average cargo volume across all ports.
- n is the total number of ports analyzed.

In this study, the Theil index was employed to measure inequality in the distribution of cargo across ports using a logarithmic approach. While it serves a similar purpose to the Gini coefficient in assessing inequality, the Theil index provides complementary insights due to its greater sensitivity to variations across different levels of cargo volume.

2.6. Concentration Ratios (CR3 and CR5)

Concentration ratios (CR) are among the most commonly used indicators for measuring market concentration. Specifically, the CR3 and CR5 ratios represent the combined market shares of the three and five largest firms in the sector, respectively, and are used to assess how market power is distributed among the dominant players (Shepherd and Shepherd, 2003).

In this study, the CR3 and CR5 values were calculated using the following formulas:

$$CR3 = \frac{\sum_{i=1}^{3} x_i}{\sum_{i=1}^{n} x_i} x100 \quad (4)$$

$$CR5 = \frac{\sum_{i=1}^{5} x_i}{\sum_{i=1}^{n} x_i} x100 \quad (5)$$

Here:

- x_i: denotes the total cargo handled by the i-th port (in TEUs or tons).
- n: is the total number of ports analyzed.

In this study, CR3 and CR5 are employed as standard concentration ratios widely used in the literature to assess market dominance by focusing on the combined shares of the top three and top five players (Shepherd and Shepherd, 2003). The market dominance of the top three (CR3) and top five (CR5) ports was calculated. These ratios indicate the percentage of total cargo handled by the leading three or five ports, effectively answering the question: What share of the market is controlled by the largest players?

2.7. Lorenz Curve

The Lorenz curve is a graphical representation of income distribution, originally developed by Max O. Lorenz in 1905. The degree of deviation from the line of equality indicates the extent of inequality within the population concerning the variable under consideration. Depending on the nature of the data, the Lorenz curve may fall below or above the 45-degree line (Sitthiyot and Holasut, 2021; Haidich and Ioannidis, 2004).

In this study, the Lorenz curve (Figure 1) was constructed as the graphical representation of the Gini coefficient. It allows for a visual evaluation of inequality by comparing the actual distribution of cargo with a perfectly equal distribution. The curve was generated by ranking ports in ascending order based on cargo volume and plotting cumulative cargo shares against cumulative port shares.

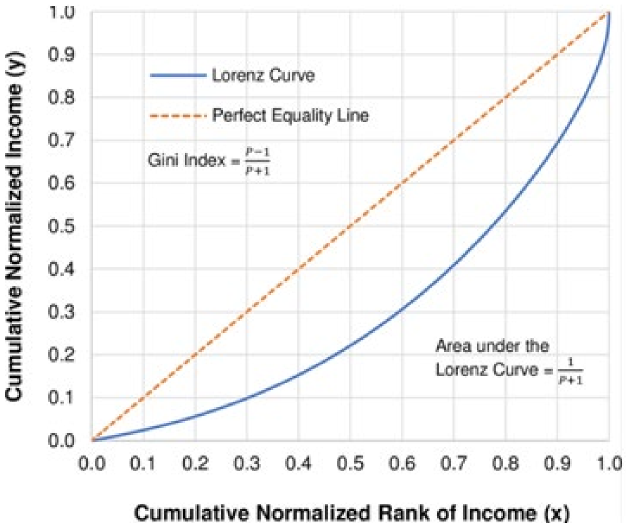

Figure 1. Lorenz curve (Sitthiyot and Holasut, 2021)

2.8. Justification for Index Selection

This study employs HHI, Gini, and Theil indices in combination to comprehensively capture different aspects of market concentration and inequality in port cargo distribution. The Herfindahl-Hirschman Index (HHI) is particularly sensitive to the dominance of large players and provides a clear indication of overall market concentration by squaring individual market shares, thereby giving more weight to leading ports. In contrast, the Gini coefficient measures the dispersion among all ports, making it more responsive to mid-level inequalities across the entire distribution, not just top-heavy dominance. The Theil index, based on entropy measures, adds a further dimension by being highly sensitive to variations across all segments and allowing for decomposition analysis, which facilitates the assessment of inequality within and between cargo types. By employing these indices together, the study ensures that both top-heavy concentration and broader distributional disparities are captured, offering a nuanced and multi-faceted understanding of port market structures that would not be achievable through a single metric alone.

3. ANALYSIS AND FINDINGS

This section presents the results of market share distributions and sectoral concentration analyses for Türkiye ports, categorized by cargo type: container, dry bulk, and liquid chemical. The findings are first evaluated separately for each cargo segment, followed by a holistic interpretation of the overall structural dynamics of the national port system.

3.1. Container Port Analysis

Container cargo transportation is one of the most dynamic segments of Türkiye's foreign trade and exhibits distinct structural characteristics in terms of sectoral competition and cargo distribution. In this section, container cargo data from 2017 to 2023 are analyzed using the Herfindahl-Hirschman Index (HHI), Gini coefficient, Theil index, concentration ratios (CR3 and CR5), and the Lorenz curve to evaluate market share distribution, competition intensity, and the level of inequality in cargo allocation (Table 1 and Table 2).

The HHI value calculated in this study is 0.0875. As one of the most widely used indicators for assessing sectoral concentration, the HHI provides a benchmark for market structure classification:

- A value between 0.01 and 0.15 indicates a competitive market,
- Between 0.15 and 0.25 indicates a moderately concentrated market,
- A value above 0.25 signals a highly concentrated market.

Accordingly, the HHI score of 0.0875 suggests that the container port market in Türkiye is characterized by low concentration and a competitive structure. Cargo volumes are not excessively concentrated in a few ports; instead, the data reflect a relatively balanced distribution of container handling across multiple terminals.

The Theil index was calculated as 0.5647 in this study. This index measures distributional inequality using a logarithmic approach:

- Values closer to 0 indicate lower inequality,
- Higher values signify greater inequality.

A Theil score of 0.56 suggests a moderate imbalance in the distribution of container cargo across Türkiye ports, with certain ports handling significantly larger volumes than others. However, this level of inequality is not considered extreme.

Table 1. Market Shares of Container-Handling Ports

Ports	2017 (%)	2018 (%)	2019 (%)	2020 (%)	2021 (%)	2022 (%)	2023 (%)
MIP	15.79	15.65	11.28	17.2	17.68	12.17	16.08
MARPORT	16.97	14.29	9.77	13.33	12.67	8.07	12.14
ASYA PORT	9.94	10.15	7.88	12.31	15.2	10.82	14.18
KUMPORT	10.54	11.43	7.46	10.36	10.21	7.08	10.51
DP WORLD	4.33	5.23	35.86	5.79	5.62	3.75	5.05
GEMPORT	4.7	4.77	3.18	4.88	5.75	4.08	4.81
IZMIR	6.34	5.88	3.53	4.55	0.0	0.0	0.0
YILPORT	4.95	5.01	3.29	4.49	4.78	3.29	5.28
EVYAP	3.67	4.22	2.91	4.36	5.05	4.1	4.95
NEMPORT	3.11	3.54	2.5	4.15	4.59	33.48	4.86
LIMAK ISKENDERUN	2.67	2.89	2.26	4.1	4.02	2.99	3.34
EGE GUBRE	2.85	2.71	2.22	3.94	4.12	3.08	4.66
SOCAR TERMINAL	1.48	2.52	1.81	2.63	3.01	2.5	3.56
ASSAN	1.87	2.05	1.45	2.09	1.81	1.07	2.11
BORUSAN	2.4	2.23	1.2	1.51	1.17	0.74	0.8
PORT AKDENIZ QTERMINALS AKDENIZ	1.98	1.69	0.87	1.06	0.98	0.56	0.7
MARDAS	3.54	3.2	0.81	0.98	0.19	0.53	3.64
SAMSUNPORT	0.69	0.67	0.51	0.84	0.86	0.64	1.03
RODA PORT	0.88	0.79	0.58	0.7	0.78	0.57	1.12
HAYDARPASA	0.86	0.51	0.27	0.36	0.0	0.0	0.0
LIMAS	0.16	0.15	0.1	0.15	0.0	0.0	0.0
CELEBI BANDIRMA	0.27	0.32	0.11	0.11	0.06	0.06	0.02
AKCANSA	0.0	0.1	0.15	0.11	1.41	0.1	0.09
BELDEPORT	0.0	0.0	0.0	0.0	0.0	0.3	1.06
ULUSOY CESME	0.0	0.0	0.0	0.0	0.03	0.02	0.02

Table 2. Analytical results of container-handling ports

Concentration Metric	Value
HHI	0.0875
Theil	0.5647
Gini	0.5693
CR3 (%)	37.99
CR5 (%)	58.12

The Gini coefficient was calculated as 0.5693. As a general rule:

- Values near 0 reflect equality,
- Values approaching 1 indicate inequality.

A Gini coefficient of 0.5693 indicates a moderate level of inequality in cargo distribution among ports. This means that a few major ports—such as MIP and MARPORT—handle a significant portion of the total container volume, while the remaining ports operate at relatively lower capacities. While this concentration enhances the strategic importance of large ports, it also allows smaller ports to maintain their operational diversity.

The CR3 ratio was calculated at 37.99%, indicating that the top three ports by volume—such as MIP, MARPORT, and ASYAPORT—collectively handled approximately 38% of the total container cargo. This suggests a noticeable concentration of cargo in a few key ports, but does not imply a strict oligopolistic structure. The market remains competitive, although a few dominant actors occupy leading positions.

The CR5 ratio was found to be 58.12%, meaning that the five ports with the highest throughput control more than half of the total container volume. This points to a partially concentrated market, where a small number of large ports capture the majority share. However, the remaining 42% of the market is distributed among a wider group of small and medium-sized ports, indicating the persistence of a polycentric port system in Türkiye.

This concentration pattern is largely driven by the Marmara Region's dominant role in Türkiye's manufacturing and export activities, coupled with its extensive hinterland connections, which naturally channel a substantial portion of container cargo through major terminals like MIP, MARPORT, and

ASYAPORT.

3.2. Analysis of Dry Bulk Cargo Ports

Dry bulk cargo transportation holds strategic importance in Türkiye ports, particularly for the trade of industrial raw materials and agricultural products (Şakar and Uzun, 2021). In this section, data from 2018 to 2023 are used to analyze market share distributions, competition intensity, and the degree of inequality among ports handling dry bulk cargo. The assessment is carried out using the Herfindahl-Hirschman Index (HHI), Gini coefficient, Theil index, concentration ratios (CR3 and CR5), and the Lorenz curve (Table 3 and Table 4).

Table 3. Market Shares of Ports Handling Dry Bulk Cargo

Ports	2018 (%)	2019 (%)	2020 (%)	2021 (%)	2022 (%)	2023 (%)
ISDEMIR	13.94	12.31	10.75	11.75	11.04	10.04
ERDEMIR	9.39	7.98	8.73	9.53	8.38	8.79
ICDAS 1	9.73	8.1	8.48	8.31	5.51	5.87
EREN	8.27	9.12	8.16	7.33	8.78	9.42
MIP	6.62	7.25	6.46	6.99	7.61	7.14
MMK	6.2	5.94	5.5	6.32	5.71	5.34
ATAKAS	2.14	4.33	5.16	7.24	7.13	7.64
YESILYURT	4.5	4.49	4.61	4.75	4.86	5.36
COLAKOGLU	4.85	4.58	4.56	3.92	3.35	3.92
NUH CIMENTO	1.86	3.48	4.46	4.51	4.82	3.91
BATILIMAN	3.52	3.61	4.39	4.39	4.45	4.11
IDC	3.14	3.0	3.61	4.04	4.88	4.24
AKCANSA CANAKKALE	3.33	3.56	3.54	3.42	3.71	3.71
CELEBI BANDIRMA	3.15	4.02	3.3	3.72	3.82	3.85
TOROSPORT (CEYHAN)	3.23	3.26	3.16	2.1	2.96	3.76
CEYNAK SAMSUNPORT	2.58	2.18	2.88	2.44	2.81	2.98
EGE GUBRE	2.05	2.7	2.53	0.0	0.0	0.0
EKINCILER ISKENDERUN	3.43	3.12	2.45	3.06	3.63	3.38
MARTAS	2.53	2.38	2.44	0.0	0.0	0.0
BORUSAN	3.04	2.62	2.41	2.96	3.01	3.09
POLIPORT	2.48	1.98	2.41	0.0	0.0	0.0
YESILOVACIK	0.0	0.0	0.0	3.21	3.54	3.42

Table 4. Analytical Results of Ports Handling Dry Bulk Cargo

Concentration Metric	Value
HHI	0.0613
Theil	0.1667
Gini	0.3210
CR3 (%)	28.94
CR5 (%)	43.64

The HHI value calculated for dry bulk cargo is 0.0613, indicating a very low level of market concentration based on standard HHI classification thresholds. This result suggests that the dry bulk cargo market in Türkiye is characterized by intense competition, with no excessive clustering of cargo volumes at a few dominant ports. In other words, the market displays a polycentric port structure, free from monopolistic tendencies. The low HHI score reflects a competitive environment that contributes to enhanced operational efficiency and transport reliability across the sector.

The Theil index was found to be 0.1667. As a sensitive indicator of distributional inequality, the Theil index highlights disparities in cargo allocation across ports. The relatively low value obtained in this study indicates a fairly balanced distribution, where no single port dominates the cargo flow. Instead, the cargo is spread across a broader set of ports. This level of distribution supports the notion that maintaining a balanced infrastructure policy is a sound strategic approach for public authorities.

The Gini coefficient calculated in this study is 0.3210. This level is generally considered to reflect low to moderate inequality. The result indicates that the market shares of ports handling dry bulk cargo in Türkiye are relatively balanced, although some ports maintain a comparative advantage over others. Certain ports—such as ISDEMIR and ERDEMIR—act as market leaders, but their dominance is not absolute. Small and medium-sized ports continue to play a significant operational role in the sector.

The CR3 value was calculated at 28.94%, meaning that the top three ports—likely including ISDEMIR, ERDEMIR, and ICDAS—handle nearly one-third of the total dry bulk cargo. This ratio suggests that cargo volumes are not excessively concentrated, and other ports still command notable shares. A CR3 ratio below 30% typically reflects a market with strong inter-port competition, a pattern that appears consistent with the structure of Türkiye's dry bulk sector.

The CR5 value was found to be 43.64%, indicating that the top five ports control approximately 44% of the total cargo volume. This level points to moderate concentration but implies that oligopolistic pressure remains limited. Large ports maintain their leadership positions due to strong hinterland connectivity and investment capacity; however, the remaining 56% of the market is distributed among a larger group of medium and small-sized ports. This structure enables major ports to benefit from economies of scale, while smaller ports retain their relevance through flexibility and service diversity. In contrast to container and liquid chemical cargo, this more balanced distribution in the dry bulk segment can be attributed to the widespread production and consumption centers for commodities such as grains and iron ore across Türkiye, which prevents excessive concentration at specific ports.

3.3. Analysis of Ports Handling Liquid Chemical Cargo

Liquid chemical cargo transportation plays a critical role in Türkiye ports, particularly in handling high-value-added products and supporting industrial production processes. Within this context, data from 2017 to 2023 were used to evaluate market share distributions, competition intensity, and distributional inequality among ports handling liquid chemical cargo. The analysis was conducted using the Herfindahl-Hirschman Index (HHI), Gini coefficient, Theil index, concentration ratios (CR3 and CR5), and the Lorenz curve (Table 5 and Table 6).

The HHI value calculated in this study is 0.0972. As a standard indicator of market concentration, this value reflects a highly competitive environment among ports handling liquid chemical cargo in Türkiye. Rather than being concentrated in a few dominant terminals, cargo volumes are dispersed across multiple ports.

The Theil index was measured at 0.5185, providing a sensitive indication of inequality in cargo distribution. This moderate-to-high value suggests that certain ports—such as PETKIM, TOROS TARIM, and LIMAS—handle substantial volumes of liquid chemical cargo, while others maintain relatively smaller shares. This distribution pattern highlights the emergence of economies of scale at some leading ports, yet also demonstrates that smaller ports continue to play a meaningful role in the market.

The Gini coefficient was calculated as 0.5520, indicating a moderate degree of inequality in cargo distribution among ports. While leading terminals such as PETKIM, TOROS TARIM, and LIMAS command significant market shares, other ports still maintain notable participation, contributing to a diversified structure.

The CR3 ratio was found to be 44.88%, meaning that the top three ports collectively handled approximately 45% of the total volume. Although this indicates a significant concentration of market power, it does not imply complete dominance, as a considerable number of ports remain competitive players within the sector.

The CR5 ratio was calculated at 60.15%, revealing that the top five ports control around 60% of the liquid chemical cargo market. While this figure confirms that a majority of the cargo is handled by a few leading ports, the remaining 40% is still distributed among various terminals, suggesting that the market retains decentralized characteristics despite the prominence of dominant actors. The dominance of PETKIM, TOROS, and LIMAS in this segment is closely linked to the geographic clustering of petrochemical plants and specialized industrial zones along the Aegean and Mediterranean coasts. While this configuration offers operational efficiencies, it also indicates a degree of structural vulnerability, as disruptions in these key hubs could disproportionately impact overall cargo flows.

Table 5. Market Shares of Ports Handling Liquid Chemical Cargo

Ports	2017 (%)	2018 (%)	2019 (%)	2020 (%)	2021 (%)	2022 (%)	2023 (%)
PETKIM	33.14	27.98	20.07	17.13	14.45	9.26	10.55
TOROS TARIM (CEYHAN)	8.06	9.49	11.6	11.41	14.55	16.93	17.22
LIMAS	11.26	11.42	10.95	11.26	16.47	16.07	14.09
POLIPORT	7.2	7.16	7.27	7.45	9.3	9.81	12.3
EVYAP	4.19	4.88	6.94	7.39	0.0	0.0	0.0
CELEBI BANDIRMA	5.67	6.14	5.18	7.01	6.7	8.99	8.57
SOLVENTAS	4.39	4.68	5.85	6.68	7.9	8.1	9.45
MESBAS	3.15	4.22	4.67	4.51	4.9	3.01	0.32
TOROS TARIM (SAMSUN)	5.09	7.23	6.26	4.42	6.58	7.47	4.87
ALTINTEL	1.73	3.63	4.24	4.28	2.88	3.2	3.56
AKSA	4.01	3.78	3.43	3.16	4.21	4.78	5.4
EGE GUBRE	2.43	2.3	2.51	2.67	3.59	2.66	2.76
IGSAS	0.66	0.55	1.26	2.2	1.82	1.61	1.62
MARTAS	1.66	0.39	1.38	1.86	1.8	0.16	0.25
KORUMA KLOR	1.39	0.9	1.74	1.46	1.67	2.39	3.15
SAVKA	1.45	0.72	0.88	1.45	0.0	0.0	0.0
AKTAS	1.57	1.7	1.68	1.45	1.16	1.03	1.09
YILPORT	1.23	1.03	0.74	1.43	0.0	0.0	0.0
ISDEMIR	1.09	0.85	1.16	1.39	1.1	0.88	1.35
CEYPORT TEKIRDAG	0.0	0.0	0.88	0.69	0.0	0.0	0.0
ERDEMIR	0.64	0.41	0.66	0.48	0.58	0.41	0.46
SAMSUNPORT	0.0	0.53	0.64	0.22	0.0	0.0	0.0
LIKIT PORT	0.0	0.0	0.0	0.0	0.34	3.23	2.99

Table 6. Analytical Results of Ports Handling Liquid Chemical Cargo

Concentration Metric	Value
HHI	0.0972
Theil	0.5185
Gini	0.5520
CR3 (%)	44.88
CR5 (%)	60.15

3.4. Analyzing Cargo Distribution Inequality Using the Lorenz Curve

To visually assess the degree of equality in cargo handling across Türkiye ports, a Lorenz curve was constructed based on total cargo volumes—including container, dry bulk, and liquid chemical cargo. This graphical analysis complements the inequality findings obtained through the Gini and Theil indices and highlights a tendency toward high cargo concentration within the Türkiye port system.

The Lorenz curve presented in Figure 2 illustrates the extent of inequality in the distribution of total cargo volumes—comprising container, dry bulk, and liquid chemical cargo—handled by Türkiye ports between 2017 and 2023. The curve's significant deviation from the 45-degree line of perfect equality reveals that cargo flows are heavily concentrated in a small number of ports, with major ports occupying a dominant position in overall traffic. Notably, the first 20% of ports account for only a small fraction of the total cargo, while the top 20% handle a disproportionately large share.

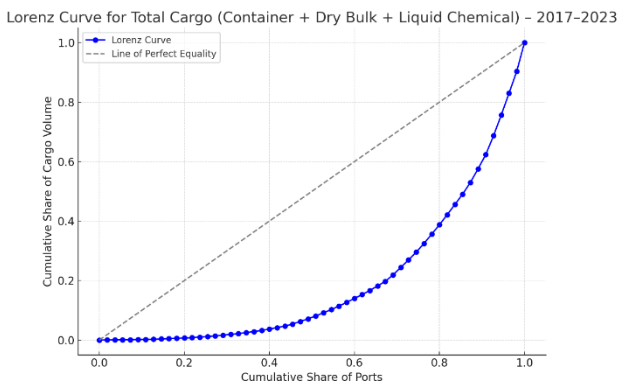

Figure 2. Lorenz curve

This observation is consistent with the high Gini coefficient values obtained in the study and reflects a port system that, despite its high inequality, still retains a polycentric structure. The findings suggest that while strategic investments in major ports can effectively enhance the sector's overall handling capacity, the continued support of small and medium-sized ports is essential for preserving system-wide flexibility and resilience.

Moreover, the pronounced curvature of the Lorenz curve underscores how Türkiye's port system, while polycentric in nature, relies heavily on a limited number of hubs. This implies that disruptions at these critical nodes could have cascading effects across national cargo flows, highlighting the need for policy frameworks that both strengthen major ports and bolster the capacities of smaller terminals to mitigate systemic risks.

4. CONCLUSIONS AND DISCUSSIONS

This study conducted a multi-dimensional analysis of market concentration and cargo distribution inequality across Türkiye ports between 2017 and 2023, focusing on container, liquid chemical, and dry bulk cargo segments. Utilizing the Herfindahl-Hirschman Index (HHI), Gini coefficient, Theil index, concentration ratios (CR3 and CR5), and the Lorenz curve, the findings reveal that the Türkiye port system is generally competitive but exhibits notable disparities in cargo distribution.

In the container segment, the HHI was found to be 0.0875, indicating a highly competitive market structure. However, the CR5 ratio of 58.12% and the Gini coefficient of 0.5693 point to significant inequality in cargo distribution, with major ports such as MIP, MARPORT, and ASYAPORT holding dominant positions. This apparent discrepancy stems from the fact that while HHI reflects the average concentration across all ports in the market, measures like CR3 and CR5 specifically highlight the extent to which the largest players dominate. Thus, despite a generally competitive market suggested by the HHI, the high CR ratios reveal that cargo flows are substantially concentrated in a few key ports.

For dry bulk cargo, the HHI value was 0.0613, representing the lowest concentration level among the segments. This indicates a well-balanced market structure and a strongly competitive environment. The relatively low Theil and Gini values support the conclusion that small and medium-sized ports capture a meaningful share of this market. These results highlight the importance of pursuing inclusive infrastructure policies in strategic planning.

In the liquid chemical cargo segment, the HHI was calculated as 0.0972, again reflecting the presence of competition. However, the Gini coefficient (0.5520) and the CR5 ratio (60.15%) suggest that this segment is more concentrated compared to the others, with ports such as PETKIM, LIMAS, and TOROS emerging as dominant players. This implies a delicate balance between economies of scale and competitive dynamics within the liquid chemical market.

Taken together, the findings indicate that the Türkiye port system is competitive in structure, yet uneven in distribution. Although HHI scores point to a non-monopolistic market, the relatively high inequality measures such as the Gini and Theil indices highlight a trend of cargo centralization around certain major ports. This structure reflects a tendency toward centralization, yet also demonstrates the resilience of a polycentric port system, with small and medium-sized ports continuing to play active roles (Ducruet and Notteboom, 2023). Their ongoing contribution enhances the resilience of the Türkiye port network, particularly in the face of external shocks (Ju *et al.*, 2023; Kammoun and Abdennadher, 2023).

Furthermore, when comparing these findings with previous national and international studies, a similar pattern emerges. Feng *et al.* (2020) highlighted how the Yangtze River Delta multi-port system demonstrates overall competitiveness while still concentrating cargo flows around dominant hubs, mirroring the trends identified in this study. Similarly, Solak Fiskin (2024) found that although European port systems maintain balanced competition, certain major ports continue to hold substantial influence. These parallels suggest Türkiye's port market dynamics—characterized by both competitive structures and centralization pressures—are not unique, but rather align with broader global patterns. This emphasizes the importance of strategic planning to balance efficiency with equitable distribution across ports.

In conclusion, the analysis demonstrates the varying degrees of market concentration and inequality across different cargo segments in Türkiye ports. These findings are particularly insightful considering Türkiye's strategic position between Europe and Asia and its substantial growth in port capacities (Zeybek, 2021). Therefore, selecting Türkiye as the case study offers a meaningful perspective on evolving competitive dynamics within multi-cargo port markets. Moreover, the inequality patterns highlighted by the Lorenz curve reaffirm the need for balanced port development strategies that not only strengthen the capacities of dominant hubs but also ensure the continued vitality of smaller ports, thereby safeguarding the resilience of the entire system.

5. RECOMMENDATIONS

The concentration and competition analysis conducted for the period 2017/2018–2023 reveals that while the Türkiye port system is broadly competitive, it also exhibits varying levels of inequality and centralization depending on cargo type. This underscores the need for national port policies to address not only high-capacity ports but also small and medium-sized ports. The findings of this study highlight the importance of balanced infrastructure investment, stronger hinterland connections, and cargo-specific strategic interventions. Within this framework, the following recommendations offer a multi-layered policy approach to sustain the current level of competition and to strengthen Türkiye's logistics capacity on both regional and global scales.

5.1. Strategic Recommendations

Balancing Cargo Distribution: The pronounced inequality observed in container and liquid chemical cargo handling calls for infrastructure investments to be directed toward ports located in the Anatolian hinterland to ensure a more geographically balanced cargo flow.

Supporting Small and Medium-Sized Ports: To preserve the sustainability of competition, small and medium-sized ports should receive support in areas such as digital transformation, logistics service diversification, and connectivity infrastructure.

Cargo-Specific Policy Development: Tailored strategies should be formulated for each cargo segment, taking into account their unique structural characteristics. For instance, in the liquid chemical segment, terminal safety, storage capacity, and environmental management should be prioritized.

5.2. Policy Recommendations

These policy recommendations are directly informed by the findings of the concentration and inequality analysis, which reveal relatively high CR5 and Gini values in container and liquid chemical segments, suggesting the need for strategies to encourage more balanced cargo distribution.

These recommendations align with Türkiye's current national strategies. Both the 2053 Transport and Logistics Master Plan and the Coastal Structures Master Plan (2010) emphasize the need to diversify port investments geographically, relieve operational pressures in the Marmara Region, and develop hinterland logistics through dry ports and improved rail connectivity. Thus, the proposed tax incentives, infrastructure upgrades, and diversification policies directly support these strategic priorities.

5.2.1. Container Cargo Policies

Regional Distribution Incentives: Given the relatively high market shares of MIP, MARPORT, and ASYAPORT, which indicate a concentration of container flows in the Marmara region, tax incentives and public subsidies could be provided to support mid-sized container ports in the Aegean, Black Sea, and Mediterranean regions. This would help achieve a more balanced regional distribution of cargo, consistent with the concentration patterns identified in this study.

Logistics Zones and Rail Connections: In regions with strong hinterland potential but weak port access, logistics industrial zones should be developed, and their connectivity to maritime transport should be enhanced through rail integration.

Digitalization and Logistics Technologies: Automation systems and data-driven operation platforms currently used in major ports should be extended to small and medium-sized terminals to reduce efficiency gaps across the network.

5.3. Dry Bulk Cargo Policies

Technical Investment for Small Ports: Given the balanced competition in this segment, the operational capacity of small ports should be supported through crane modernization and storage infrastructure upgrades to maintain market balance.

Climate-Sensitive Investment Incentives: Ports handling dry bulk cargo should be encouraged to implement dust suppression systems, enclosed storage solutions, and sustainable transport practices through dedicated incentive programs.

Integration with Inland Regions: Road and rail links should be improved to strengthen the connection between Central Anatolian industries/agriculture and dry bulk ports, thereby reducing transport costs and boosting accessibility.

5.4. Liquid Chemical Cargo Policies

Technical Safety and Storage Capacity: Ports outside the dominant players should be supported in obtaining safety certifications, hazardous material management, and the construction of standard-compliant tank storage facilities.

Coordination with Petrochemical and Chemical Clusters: Strategic coordination plans should be developed between ports like Toros, Solventaş, and Poliport and the industrial zones in their hinterlands to align port–industry logistics.

Risk Diversification and Disaster Preparedness: The current concentration of liquid chemical cargo at a few ports poses risk management challenges. Alternative ports should be designated as backup service providers, with emergency handling scenarios established in case of disruption.

5.5. Cross-Cutting Policy Priorities

Preserving a Polycentric Port System: National authorities should ensure that Türkiye's existing polycentric port structure is maintained, preventing the excessive concentration of cargo in a single geographic region (Ducruet and Notteboom, 2023). This would enhance resilience against crises and promote optimal utilization of national logistics capacity (Notteboom and Rodrigue, 2005).

Developing a National Port Competitiveness Index: A country-specific Port Competitiveness Index (PCI) should be developed and published annually to support evidence-based investment planning and policy formulation.

Enhancing Sectoral Data Transparency: Access to port statistics in Türkiye remains limited. More detailed, timely, and publicly accessible data should be made available by TÜRKLİM and the Ministry of Transport, which would significantly enhance the quality of academic and institutional analyses.

These priorities also resonate with national master plans that call for balanced regional development and resilience-focused port planning.

5.6. Limitations and Future Research

This study has several limitations. First, the analysis is based on a relatively short time frame (2017-2023), which may not fully capture long-term market dynamics. Second, the study focuses exclusively on Türkiye ports, limiting the geographic generalizability of the findings. Finally, the use of only cargo handling data does not account for other important aspects such as pricing, service quality, or operational efficiency. Future studies could address these limitations by incorporating longer time series data, expanding the geographic scope to include cross-country comparisons, and integrating additional variables such as port tariffs, hinterland connectivity, and customer service metrics. Such extensions would provide a more holistic understanding of port competition and concentration dynamics.

AUTHORSHIP CONTRIBUTION STATEMENT

Muhammed TURGUT: Conceptualization, Methodology, Validation, Formal Analysis, Resources, Writing - Original Draft, Writing-Review and Editing, Data Curation, Software,

Visualization, Supervision,

CONFLICT OF INTERESTS

There is no conflict of interest.

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ORCID ID
Muhammed TURGUT:
https://orcid.org/0000-0002-0868-7041

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