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Araştırma Makalesi

Türkiye'de Konteynerleşmenin Gelişimi ve Hacimsel Yoğunluğunun Araştırılması

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ÖZET

Konteynerleşme limanlarda önemli yapısal, operasyonel ve stratejik değişikliklere neden olmuştur. Bir ülkenin kalkınmasında önemli bir rolü olan limanların kalkınmanın bölgesel dağılımı üzerinde etkileri vardır. Dolayısıyla, konteynerleşmenin sebep olduğu değişiklerin etkisiyle görülen liman çıktıları, pazar payları ve bölgesel yoğunlaşmalardaki değişimler limanların kalkınmanın bölgesel dağılımına etkilerini analiz etmek için önemli göstergelerdir. Böylece limanların bölgesel toparlanma ve gelişme hareketlerine, bölgedeki ticaret kalıplarına ve kargo akışlarına olan etkileri ortaya konulabilir. Bu makale, 2004-2022 yılları arasındaki Türkiye'deki liman başkanlıklarının konteyner hacmindeki değişimlerini ve konteynerleşmenin yoğunlaşma ve yayılım trendlerini incelemektedir. Bunun amacı, Türk limanlarının mevcut durumlarının tespit edilmesi neticesinde geleceğe yönelik kalkınma ve yatırım stratejilerinin belirlenmesinde karar vericilere bir bakış açısı sunmaktır. Bu çalışma da Gini Katsayısı ve Shift-Share analiz yöntemlerine kullanılmıştır. Bu çalışma için gerekli veriler Türkiye Cumhuriyeti resmî kurumlarından temin edilmiştir. Sonuçlar göstermektedir ki, devlet limanları, ağır ve dinamik olmayan yapıları nedeniyle yerini taleplere hızlı cevap verebilen ve gelişmiş teknoloji altyapıları sayesinde verimli konteyner operasyonları sunabilen özel limanlara bırakmaktadır. Elde edilen bulgular günümüzde Türk konteyner trafiğinin mevcut limanlar arasında daha dengeli dağıldığını göstermektedir. Ayrıca, konteyner hacimsel yoğunluğu Marmara bölgesinde hala daha baskın olsa da Akdeniz, Ege ve Karadeniz'de konteyner hacimsel yoğunluğunda önemli artışlar gözlemlenmiştir.

Anahtar Kelimeler: Konteyner limanları, konteyner taşımacılığı, liman gelişimi, Gini katsayısı, shift-share analizi

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Investigation of Containerization Development and Volumetric Concentration in Türkiye

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ABSTRACT

Containerization has caused significant structural, operational, and strategic changes in ports. Ports, which have an important role in the development of a country, also have an impact on the regional distribution of development. Therefore, changes in port throughputs, market shares and regional concentrations seen under the influence of changes caused by containerization are key indicators for analyzing the effects of ports on the regional distribution of development. Thus, the effects of ports on regional recovery and development movements, trade patterns and cargo flow in the region can be revealed. This article examines the changes in container volume of port authorities in Türkiye between 2004 and 2022 and the concentration and spread trends of containerization. The aim of this study is to provide a perspective to decision makers in determining future development and investment strategies as a result of determining the current situation of Turkish ports. In this study, Gini Coefficient and Shift-Share analysis methods were used. The necessary data for this study was obtained from the official institutions of the Republic of Türkiye. The results show that state ports, due to their sluggish and less dynamic structures, are being replaced by private ports that can respond to demands quickly and offer efficient container operations thanks to their advanced technology infrastructures. The findings show that today Turkish container traffic is more evenly distributed among existing ports. Moreover, although container volumetric concentration is still more dominant in the Marmara region, significant increases in container volumetric concentration have been observed in the Mediterranean, Aegean, and Black Sea regions.

Keywords: Container ports, container shipping, port development, Gini coefficient, shift-share analysis

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1. Introduction

Globalization of supply chains, technological transformation, and growing environmental concerns have increased the importance of ports in recent years. Popularity of containerization and intermodal transportation emerged as one of the main outputs of globalization of supply chains (Guerrero and Rodrigue, 2014; van Duin and van Wee, 2007). Contemporary developments in port technology aims to serve ships by meeting ever-growing ship capacities, reducing ships' port times, and speeding up efficiency of port-land interfaces (Ehlers et al., 2014; Kosiek et al., 2021). Increasing environmental pressures on businesses trigger more demand for maritime transportation due to its economy of scale advantages came to the fore with green port operations (Aregall et al., 2018; Kurt, 2023).

Containerization has pioneered the development of globalization and port technologies and has also become a part of corporate sustainability strategies to address environmental concerns. Containerization, which can be defined as a revolutionary development in terms of its contribution to maritime transportation and logistics systems, has also various effects on the structural, operational, and strategic development of ports and their spatial distribution. Reflections of these effects can be expressed as changes in the traffic volumes of ports and regional traffic shifts.

The increase in container traffic volume offers exceptional opportunities for capacity utilization existing ports and capacity planning of new ports investments. However, ports seek ways to gain an advantage by adapting the containerization through structural and operational adjustments to benefit from these opportunities and attract container flow to a port facility or region. On the other hand, while the strategic location of the ports is a vital criterion to attract the attention of container shipping liners, it has also a positive interaction with the structural operational developments. Developments resulting from containerization in Turkish ports also attract considerable attention, so there is a need to examine the effects of these developments on Turkish container shipping sector in detail. Especially after the second millennium, the privatization of Turkish ports, significant port investments, and the increase of Turkish container traffic volume are the important sources of motivation to examine the development in the Turkish port sector. Therefore, in this study, the distribution of container throughput of Turkish ports and the regional concentration of Turkish ports are discussed, in the light of the developments initiated by containerization. Gini Coefficient, which was developed to represent income or wealth inequality within a cluster, was used in this study to analyze the distribution of annual container throughput among Turkish container ports. However, since the Gini Coefficient method does not provide specific results for any port, the regional concentration change of port container throughputs over the years was analyzed by adopting the Shift-Share method.

This paper is formed as follows. The first section provides an introduction section to the study. The second section represents a literature review including key former studies on container shipping with its global context and containerization impacts on ports. The third section defines the methodology to analyze the concentration of Turkish container ports. The fourth section provides the extent of the concentration of Turkish container ports with the obtained results from the analysis. The fifth section represents a scientific discussion by considering port developments and clusters with containerization in Türkiye with evidence from the past and offers some future projections. The final section concludes the study with a concise summary including limitations and further implications of this research.

2. Literature Review

Older ships were replaced by modern and large-capacity ships to ensure a faster and more efficient flow of goods (Baik, 2017), and ports turned into larger distribution nodes and more advanced facilities (Alderton and Saieva, 2013). Port numbers and capacities accepted as an important criterion in

determining the economic development levels of countries show the power and competitive capacity of countries in international transportation (Berkoz and Tekba, 1999; Dwarakish and Salim, 2015; Rodrigue and Notteboom, 2020). Ports were also seen as major economic multiplier in increasing the prosperity of countries and gateways of regional and international trade (Ducruet and Guerrero, 2022). Due to changing world dynamics, ports became not only an internal component of the transportation system, but also an important subsystem of broader production, trade, and logistics systems (Munim and Schramm, 2018). Extensive changes and developments were witnessed in port systems with the intramodality concept created by the introduction of containers. A significant part of the current literature on port systems paid particular attention to port structures that have changed and developed with containerization.

Guerrero and Rodrigue (2014) stated that K-waves associated with the technology time cycle fit functional and spatial diffusion of containerization. The K-wave of containerization was explained by a five-wave phase starting from developed countries (especially North America, Europe, and Japan, formerly known as the economic triad) and extending to developing countries. The development of containerization within these five-wave phases also affected ports, requiring them to adapt to global shifts in production and transportation. Notteboom (1997) stated that in response to the demand for technologically and economically competitive ports imposed by containerization, ports should focus on more advanced, efficient, and flexible services during their development and change processes. In this context, Haralambides et al. (2002) emphasized an increasing interest in dedicated container terminals operated by carriers, and in the emergence of global port operators to provide these advanced and special services. Although raising concerns about what the function of the port and the regulatory authority would be when dedicated container terminals were introduced, an intense interest in dedicated container terminals was seen as they increase the efficiency and development of ports by offering a higher service rate and faster response to demand (vertical integration) (Cariou, 2001; Hsu et al., 2015; Vacca et al., 2007). Baird (1996) concluded that the later phases of containerization necessitate a custom-built structural development of ports that can specifically serve mega container ships. Loo and Hook (2002) have attempted to draw four trends in shaping the development of one of the major container ports that is Hong Kong. These are the emergence of inland cargo centers, the high spatial concentration of container traffic, the ever-growing container ships, and the importance of hinterland connections.

In the nearly 70 years since its introduction, the containers established the operability of a globally standardized system where operational efficiency, speed, and high throughput came to the fore instead of heavy, labor-intensive, and expensive port operations. However, depending on the development levels of regions and countries, the diffusion, development, and growth of container ports were not at the same level as the advancement in global technology and economy. For this reason, up to now, several studies have addressed container port development of a country and regional basis. McCalla (1999) analyzed North American East Coast Ports with the help of queue size analysis and the Gini Coefficient, showing that container handling has concentrated from large ports to medium-sized ports, and regional container concentration has decreased according to the increase in container volume. Wang et al. (2004) applied the Herfindahl-Hirschman Index (HHI), Gini Coefficient, and Shift-Share Analysis (SSA) to measure the traffic concentration of the world's leading ports. It was concluded that ports in Southern China were much more concentrated than ports in Europe and the United States. Itoh (2012) discussed the cargo flow distribution and container traffic changes in Asian ports using the Gini Coefficient. González Cancelas et al. (2013) aimed to calculate the Lorenz Curve and Gini Coefficient for different types of cargo in Spanish Ports and propose future strategies. Nguyen et al. (2020) associated the concentration trend of container ports in the Southeast Asian region with port operation efficiency. For this purpose, the analysis based on the analysis based on HHI, Gini Coefficient,

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and SSA methods covered 10 major regional ports. Feng et al. (2020) proposed a comprehensive triple diagram method to investigate in detail the concentration gradient, inequality, and competition of The Yangtze River Delta multi-port system by combining HHI, Gini Coefficient, Aitchison Distance, and SSA. Other studies by Veenstra and Notteboom (2011) and Ziran et al. (2022) examined the development of the container port system in the Yangtze River Delta, with the Gini Coefficient method.

Studies in the literature showed that the Lorenz Curve, Gini Coefficient, HHI, and SSA methods were the most common procedures to determine container port developments and port concentration of containers. In addition, from the first studies in which these methods were used specifically for container port developments to the present day, it has been observed that the studies focus on a specific region and countries from wider geographies (for example, from the economic triad to the Yangtze River Delta or the Spanish port ecosystem). However, the lack of a comprehensive study in the literature addressing the concentration and development of Turkish container ports constitutes the main motivation of this study.

3. Methodology

3.1. Mathematical Model

In this study, a holistic approach integrating the Gini Coefficient and Share-Shift Analysis is utilized to establish the concentration of Turkish container ports by considering the cumulative and port-based annual throughput. Therefore, as the first step of this section, the concept of the Gini Coefficient and its mathematical model are introduced. The Gini Coefficient (also known as the Gini Index or Gini Ratio), an economic statistical measure of dispersion, is used to show the degree of inequality or concentration of a variable (e.g., income, wealth, and consumption; it is container throughput in this study) in a distribution of its elements.

The Gini coefficient is expressed as a number between 0 and 1. A Gini coefficient of 0 represents perfect equality where all values are the same. A Gini Coefficient of 1 (or 100%) represents maximum inequality, where a single unit (It is a port in this study) has all container throughput and the others have no container throughput. A general formulation of the Gini Coefficient can be shown as the equation below (Giorgi and Gigliarano, 2017).

$$G = \frac{1}{2\mu n^{2}} \sum_{i=1}^{n} \left(\frac{1}{n} \sum_{j=1}^{n} |t_i - t_j| \right) \quad (1)$$

Where:

n : the number of ports in a port range

μ : the average container throughput in the port range

i : i^{th} port in the port range $(i = 1, 2, \dots, n)$

t_i : the container throughput of i^{th} port

j : j^{th} port in the port range $(i = 1, 2, \dots, n)$

t_j : the container throughput of j^{th} port

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As the second step method of this study, a Shift-Share Analysis (SSA) was applied to understand the shift in the concentration of Turkish container ports. A typical SSA is done by obtaining a measurement/reference with the values taken at the beginning and end of an analysis period on a given variable (Container throughput) for certain regions (Türkiye) and industry (Container ports). The SSA to be applied for the regional shift (RS) in container concentration of Turkish ports can be formulated as follows (Artige and Van Neuss, 2014).

$$RS = e_k^{T+m} - e_k^T = NS_k + IM_k + LS_k \quad (2)$$

Where:

e : Container port throughput variable

k : Turkish container port industry

T : The first reference year

m : The time to the second reference year

NS : National growth effect on Turkish container port throughput

IM : Container port industry mix effect

LS : Local share effect

The beginning and ending values of the container throughput variable in the container port industry are e_k^T and e_k^{T+m} respectively. The three effects described above have a percentage impact on the container throughput concentration.

$$NS_k = e_k^T \times G^* \quad (3)$$

$$IM_k = e_k^T \times (G_k^* - G^*) \quad (4)$$

$$LS_k = e_k^T \times (g_k^* - G_k^*) \quad (5)$$

The total percentage change in the nationwide container throughput variable for the container port industry is G^*, while the national and regional industry-specific percentage changes are G_k^* and g_k^*, respectively. To express the change in container throughput at the second reference year for the Turkish container port industry, equations 3, 4, and 5 give the following equation.

$$e_k^{T+m} = e_k^T \times (1 + g_k^*) \quad (6)$$

3.2. Data Collection

Due to commercial confidentiality, it is difficult to obtain high-quality data on container cargo flow in Türkiye on a port or terminal basis. The annual cargo flow in Turkish ports is generally recorded in tons under the port authorities. However, since 2004, the container handling data of the port authorities have been disclosed by the General Directorate of Maritime Affairs of the Ministry of Transport and Infrastructure of the Republic of Türkiye. This article will contribute to the examination of the containerization development in Türkiye and the volumetric concentration of container cargo by using container throughput data in Turkish port authorities and other raw data supporting these data.

The data needed to analyze the growth, concentration, and diffusion of container traffic volume of Turkish port authorities was obtained from the official data sets of the institutions of the Republic of Türkiye and the ports' data source. Not only the data obtained are presented in its raw form but are

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also processed with statistical tools and methods to be used in Gini Coefficient and SSA methods. In addition, the intermediate outputs obtained up to the stage of use in the Gini Coefficient and SSA methods are presented in the results section of this study, and what the processed data tries to describe is explained.

3.3. Data Analysis

The raw data obtained was processed with the help of SPSS and Microsoft Excel programs and made available for use in Gini Coefficient and SSA methods. The first raw container port data collected covered all Turkish ports that handled containers between 2004 and 2022. To evaluate raw data in different categories, such as container throughput and export figures, in the same category, a statistical approach was used, taking the year 2004 as a reference and based on the changes until 2022. On the other hand, when conducting Gini Coefficient and SSA analyses, it became crucial to eliminate meaningless or ignorable data. Therefore, the data of port authorities whose container flow was below 1000 TEU per year and which did not have a continuous container flow had been transferred to the nearest port authority. Preventing data loss was solved by transferring data to the nearest port authorities, considering regional concentration. Although statistically negligible data were transferred without loss, for the results obtained to be meaningful, data below 1% were disregarded in the graphical representation, even if they are included in the calculation. Only processed data were presented in the graphical representations in the results part of the study.

4. Results

The findings in this study show the concentration of Turkish container ports and their regional shifts over the years, based on the data of the Ministry of Transport and Infrastructure of the Republic of Türkiye between 2004 and 2022. Figure 1 provides a comparative analysis of the components that may affect the development of Turkish container ports and the total TEU throughput of the ports in the period to date. Accordingly, container transportation has shown a more stable and dynamic growth trend, differentiating from GDP with the effect of globalization. Türkiye's export figures showed a big jump after 2019 due to COVID-19 and high exchange rate policy, and similarly, the container throughput reached a growth rate of approximately 300% from 2004 to 2022. However, the growth rate in the container volume handled has been steadily upward, except for the negative outlook seen in 2009 due to the impact of the financial crisis in the last quarter of 2008. Although Türkiye's exports and Turkish ports' container outputs have achieved similar growth rates in the period until 2022, the growth trend of containerization has been less affected by the fluctuations in exports.

With the global trade contraction caused by the 2008 economic crisis, the rate of transit containers in the container throughput handled in Turkish ports decreased to 0.2% in 2009. As a response to the consequences of the 2008 economic crisis, an increasing interest in more efficient, and more economic container shipping has been seen. So, a significant increase was also recorded in the share of both transit and cabotage container traffic. From 2004 to 2022, in comparison with a TEU-based 300% growth rate of container throughput in Turkish ports, a growth rate of 2,077% and 1,055% was seen in cabotage and transit containers, respectively. This growth comparison between transit, cabotage, and total container throughput of Turkish ports is presented in Figure 2. Thus, while the rate of cabotage and transit containers in total containers handled was 1.2% and 5.6% in 2004, respectively, these rates reached 6.6% and 16.5% in 2022.

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The reasons for this increase in cabotage container traffic can be attributed to the better understanding and adoption of the benefits of containerization by companies engaged in trade and the introduction of inland container lines that enable cabotage container shipping. In addition to the economies of scale and scheduled regular voyages offered by containerization, the policies of shifting transportation from highways to short-sea shipping have increased the interest in cabotage container shipping.

Several growth factors were at play to explain the growth in transit container traffic. It could be said that behind the rapid increase in transit container traffic of Turkish ports especially after 2015 was the strategy of Asyaport under the Tekirdag Port Authority and the ports under the Ambarli Port Authority to serve transit cargo. So much so that 88% of the transit container traffic in 2022 was handled by ports under these two port authorities. This situation can be considered as a reflection of the development of transshipment hubs seen in the world in the 1990s and 2000s on Turkish ports. However, while the transit container traffic of ports in the Mediterranean basin was 43% in 2013 (Yetkili et al., 2016), the transit container traffic in Turkish ports was 12.5% in the same year, which is an indication that Turkish ports remain weak in terms of transit traffic.

Certainly, in addition to the factors considered to affect growth due to containerization, ports' ability to respond to this growth depends on their technical and operational development. Ports' investments in dedicated container terminals, equipping these terminals with appropriate cranes and equipment, sufficient port and stock areas, hinterland connections integrated with the port, and preparing suitable ground for third-party logistics (3PL) and fourth-party logistics (4PL) companies are important development parameters for ports.

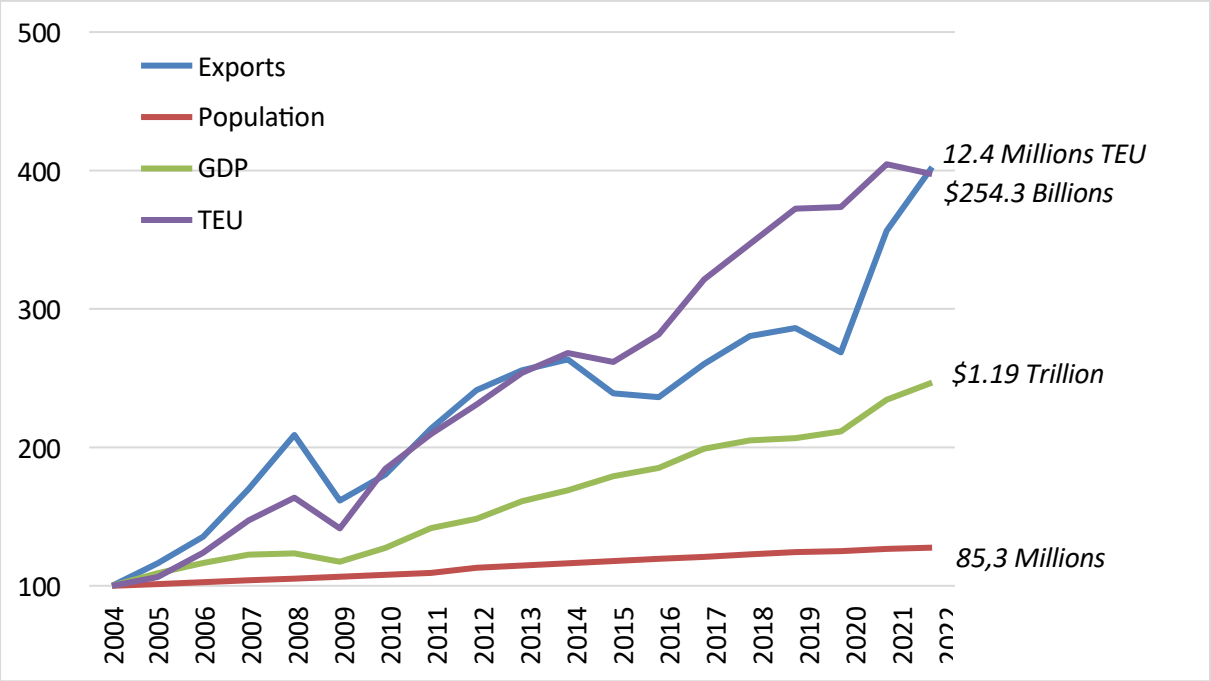

Figure 1. The relationship between economic growth of Türkiye and Turkish ports' container throughput, 2004-2022 (2004=100)

Source: Adapted from TIM (2023), TUIK (2023), UAB (2022), and World Bank (2023)

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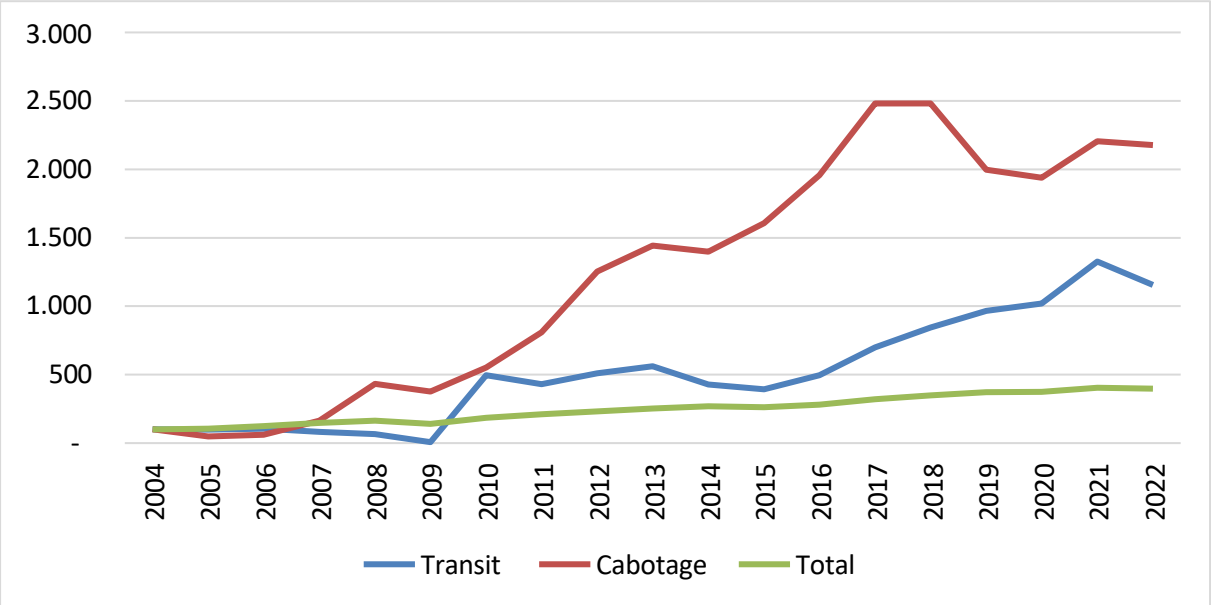

Figure 2. The relationship between transit, cabotage and total container throughput of Turkish ports, 2004-2022 (2004=100)

Source: Adapted from UAB (2022)

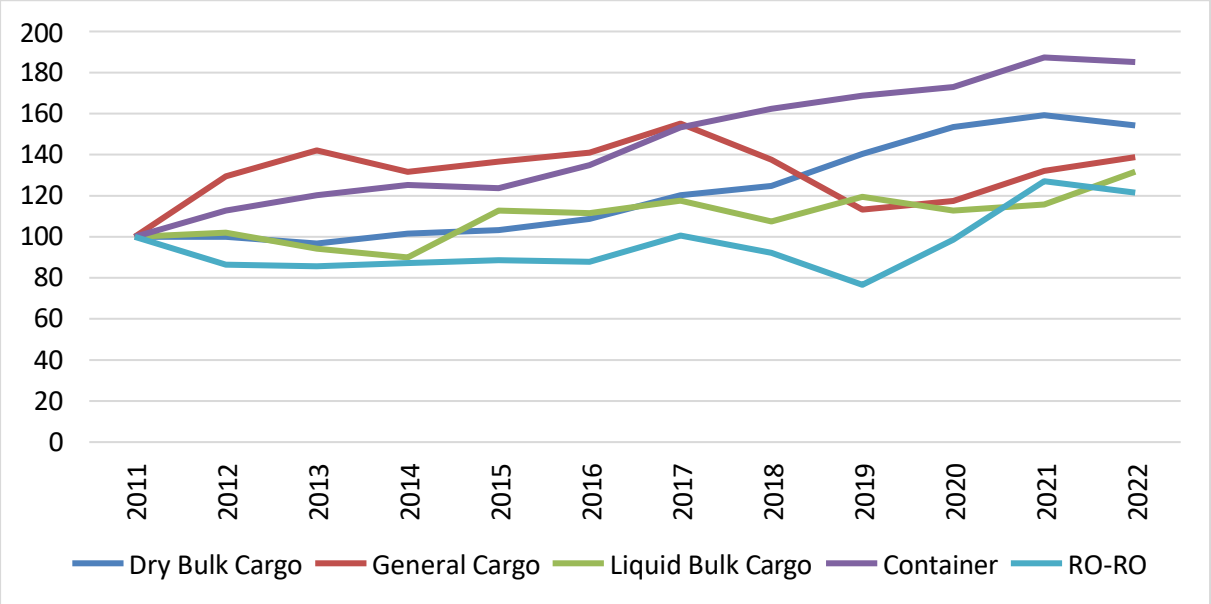

Figure 3. The ton-based comparison of containerized traffic with other maritime transportation modes, 2011-2022 (2011=100)

Source: Adapted from UAB (2022)

Although the increase in container traffic resulting from national and international economic growth is the most notable component, empty container traffic statistically contributes with additional container throughputs and port handlings. To understand whether the statistical data on the growth in container transportation is inflated by non-value-added operations, these growth rates are presented on a ton basis, and in comparison with other maritime transportation modes in Figure 3. Although 25% of the total handled containers consist of empty containers, according to the data of the Ministry of Transport and Infrastructure of the Republic of Türkiye, an 85% increase was recorded in

the total amount of container-ton handled between 2011-2022, with a higher acceleration than all other maritime transportation modes. The TEU-based containerization growth achieved during this period was 167%.

Container port investments in Türkiye were first made in Haydarpasa Port in 1979, and the first private dedicated container terminal was Marport under Ambarli Port Authority in 1996 (Limar in 1996). In light of the data received from UAB and based on Turkish ports with traffic of more than 10,000 TEU, the number of ports increased from 7 in 2004 to 17 in 2022 (see Figure 4). The number and capacity increase in Turkish ports have been provided with the recent year investments of Asyaport (Tekirdag Port Authority -2015), DP World Yarimca (Kocaeli Port Authority -2016) and Socar Terminal (Aliaga Port Authority -2018). The number of ports is seen as the primary indicator to explain the growth in container traffic. Although a similar curve trend is observed when comparing the increase in container traffic with the number of ports, there are no new container port investments to be commissioned in the near future in Türkiye, other than investments in capacity increase. This may indicate that there would not be a sudden acceleration in the increase of container traffic.

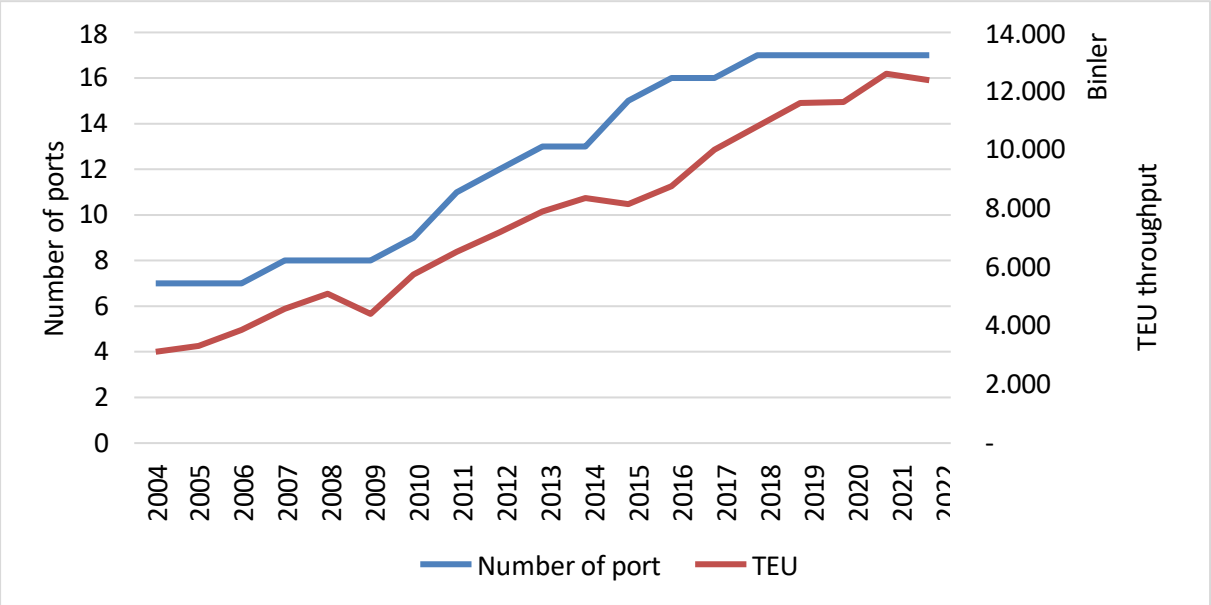

Figure 4. The comparison of the number of ports and TEU throughputs, 2004-2022

Source: Adapted from Türklim (2023), and UAB (2023, 2022)

The analysis of Turkish container ports shows that container concentration has changed significantly between 2004 and 2022 (see Figure 5). The Gini Coefficient mainly points to two periods in which the strategies of concentration in existing conventional ports and incorporating industrial regions into the port hinterlands came to the fore. The first period can be described with a concentration trend in Türkiye's main ports (Haydarpasa Port, Alsancak Port, and Mersin Port), which were already located close to industrial centers and started container handling in the 1980s, and in the Ambarli Port (GC= 0.7 in 2004 and GC= 0.64 in 2014). The second period is expressed by the Gini Coefficient of 0.55, which characterizes the diffusion of container traffic, especially in responsibility of Mersin, Gemlik, Aliaga, Kocaeli, and Tekirdag port authorities, which have a hinterland that covers Türkiye's industrial centers.

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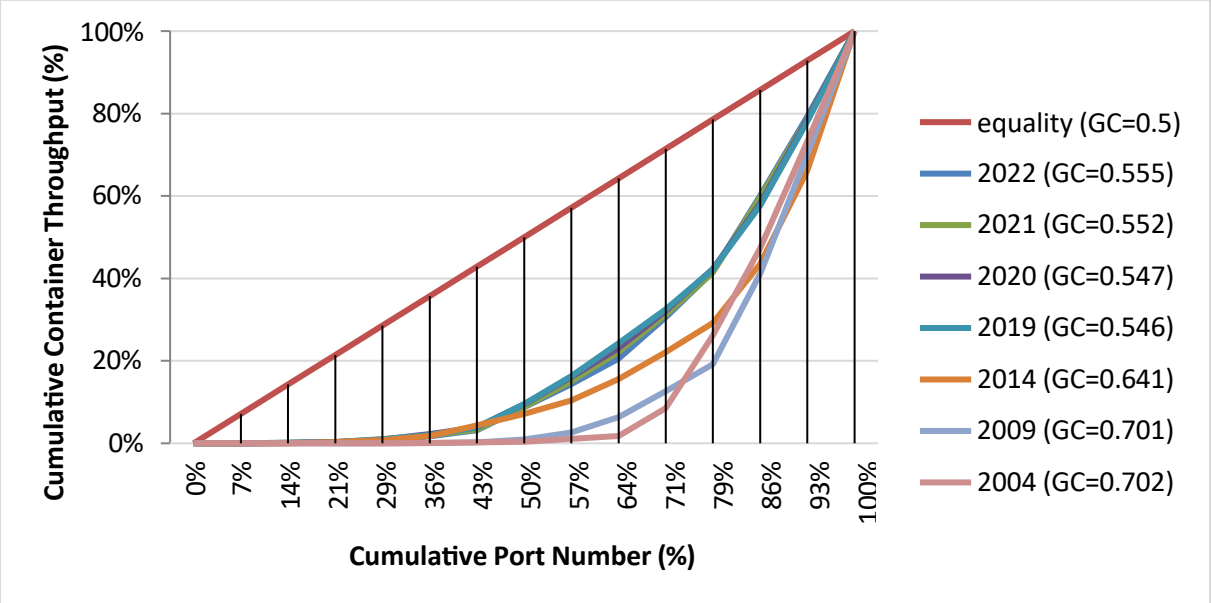

Figure 5. The concentration of Turkish container ports, 2004-2022

The concentration trend in Turkish container ports is presented in Figure 6. In 2004, 7% of all ports handled 25% of the total container volume. In 2022, 14% of all ports handled the same share of traffic, while 21% of ports handled 50% of container throughput. As of 2019, the trend, as shown by the Gini coefficient, was that approximately 21% of all ports handled 50% of Türkiye's container throughput, while 36% of ports handled 75% of container output. Therefore, between 2004 and 2022, Türkiye's container traffic concentration shifted and spread to newly built ports and terminals during this period. This situation reveals that the concentration in major ports, which already have a certain infrastructure, tends to spread with new investments.

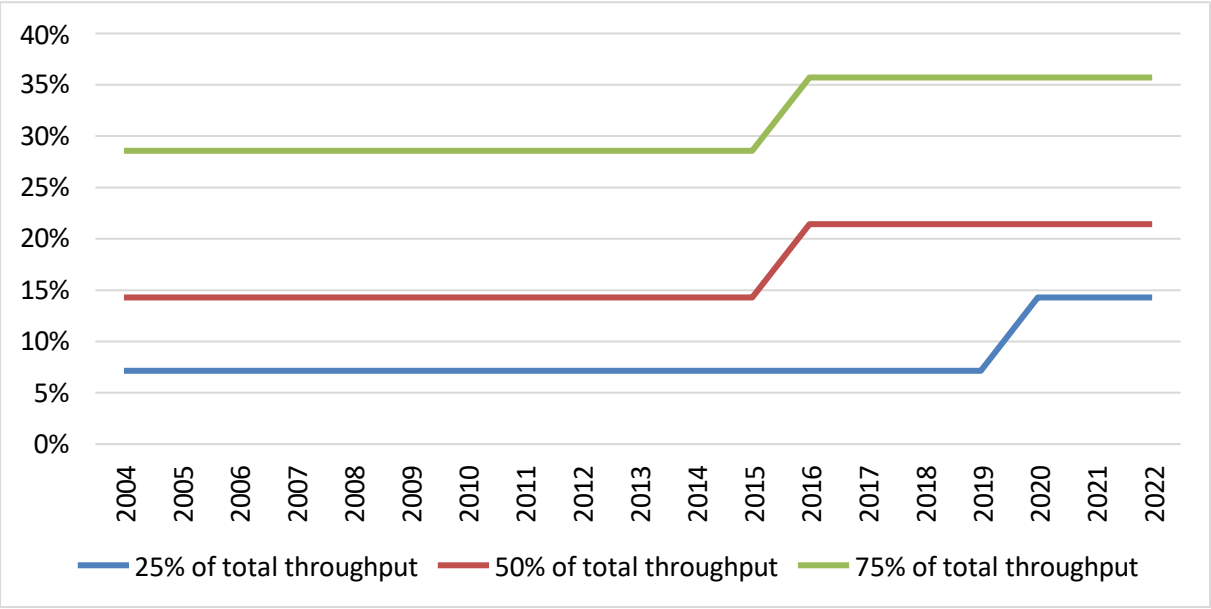

Figure 6. The rate of ports handling 25%, 50%, and 75% of Turkish container throughput, 2004-2022

Source: Adapted from UAB (2022)

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Using SSA, shifts in share distribution in Turkish container ports are obtained as in Figure 7. In the analysis, data of port authorities that recorded a container throughput of 1% or more between 2004 and 2022 were taken into account. Compared to 2004, significant decreases were observed in the shares of Ambarli Port Authority (from 37.9% to 23.2%), Izmir Port Authority (from 18.2% to 3.2%), and Istanbul Port Authority (from 14.4% to 0.1%), which have dominated the Turkish container port market. Despite this decrease, Ambarli Port Authority continues to be the largest actor in the Turkish container port sector even today. The shares of Mersin and Gemlik Port Authorities, which were completing the top 5, in total traffic showed a moderate decrease. Aliaga Port Authority increased its share in the pie from 0% to 12.1%, Tekirdag Port Authority from 0.2% to 14.3% and Kocaeli Port Authority from 1.3% to 16.7%, forming the new top 5 together with Ambarli and Mersin Port Authorities. Between 2004 and 2022, all ports except Istanbul and Izmir Port Authorities recorded an increase in their container throughput as the Turkish container port market grew, even though their share of the pie decreased.

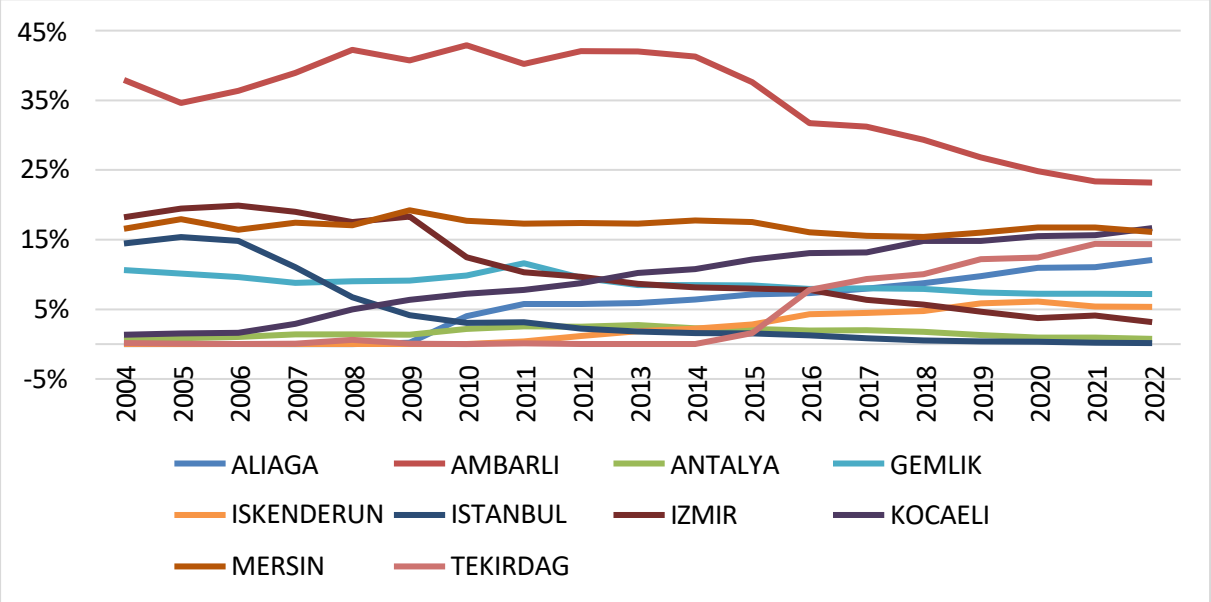

Figure 7. The share of Turkish port authorities in percentage[1]

Source: Adapted from UAB (2022)

Figure 8 shows the shares of Turkish Port Authorities in the growing Turkish container market. Thanks to this graph, it becomes clear that containerization has a specific temporal growth pattern. A decrease or increase in the share of a port authority does not indicate that the port authority has less container throughput than in previous periods. However, it enables the direction of the momentum gained by the port authority to become clear with the growth trend in the container market. In total, the growth in Turkish container traffic is high, but each port authority has a different growth dynamic in line with its own specific development and regional factors. The explanations in this section are not valid as the Izmir Port Authority shows a decrease and the Istanbul Port Authority almost disappears in container market.

[1] Port authorities with more than 1% container share in total container traffic are included.

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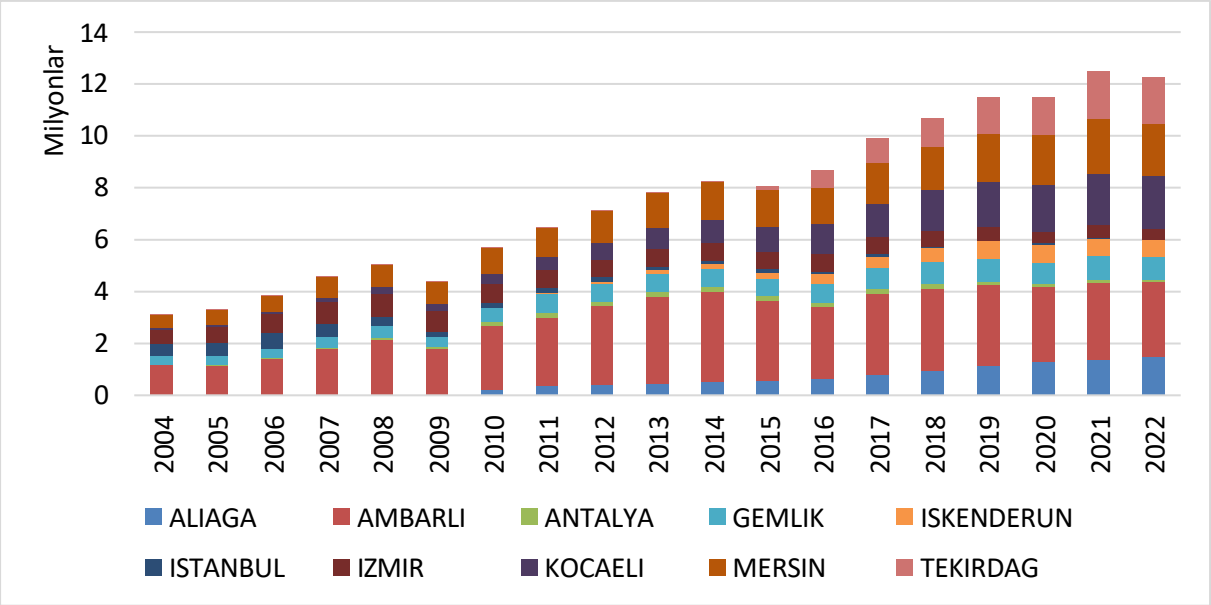

Figure 8. The volume of Turkish port authorities in TEU with the growth of Turkish container market[2]

Source: Adapted from UAB (2022)

The maps presented in Figures 9 and 10 show container traffic volumes in 2004 and 2022, respectively. These visuals are important to better understand the size of port authorities and the spatial distribution of Turkish container ports between the years when the analysis started and ended. Ports with container throughput over 10,000 TEU are included in these map representations.

Figure 9. Major Turkish container port locations in 2004

[2] Port authorities with more than 1% container volume in total container traffic are included.

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At first glance at Figures 9 and 10, it is clearly seen that while containerization has been focused on the Marmara and Aegean regions, container traffic volumes of Mersin, Iskenderun, Samsun, and Trabzon Port Authorities have increased in 2022 compared to 2004.

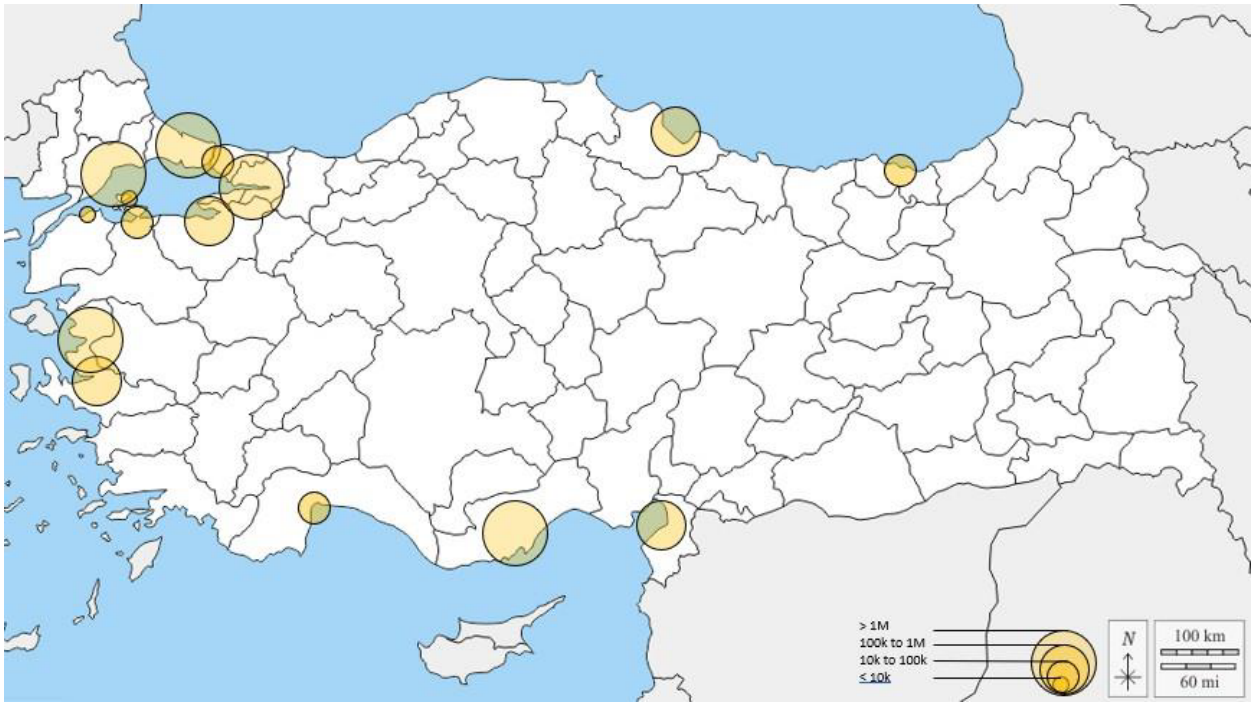

Figure 10. Major Turkish container port locations in 2022

Table 1. Analysis of port share shifts, 2004-2022

PORT AUTHORITY	2004-2022
Kocaeli	15.3%
Tekirdag	14.2%
Aliaga	12.1%
Iskenderun	5.3%
Samsun	0.9%
Antalya	0.2%
Bandirma	0.1%
Karabiga	0.0%
Marmara Island	0.0%
Trabzon	0.0%
Mersin	-0,5%
Gemlik	-3.4%
Istanbul	-14.3%
Ambarli	-14.7%
Izmir	-15.0%

The shifts in shares in the Turkish container market within all port authorities that handle containers are given in Table 1. This underlines the increasing divergence in the dynamics of containerization. The most important example of these share shifts was experienced by the Izmir and Istanbul Port Authorities, which took over the responsibility of the two state ports that dominated the market, and the Ambarli Port Authority, which dominated the market by offering the advanced port infrastructure and the wide container network. Ambarli Port Authority, whose container traffic was 1.2 million TEU

in 2004 and reached 3 million by 2022, is responsible for the port complex with the largest container volume in Türkiye, even though it lost its share of the pie in this period.

5. Discussion

As mentioned in the literature review, containerization has resulted in extensive changes and developments in port structures, operational practices, and strategic plans. Moreover, various reports have shown that container traffic is increasing day by day (Feng et al., 2021). The continuity in the increase in container traffic has also been seen in Turkish ports (Oztemiz and Vatansever, 2023). This study was designed to determine the effects of changes and developments in ports due to containerization and increasing traffic volume on Turkish port concentrations.

The results of this study showed that container throughputs are now more evenly distributed compared to 2004 and there is a significant increase in the number of container ports and port areas. As Tunalı and Akarçay (2022) highlighted that the developments in ports have an important relationship with the economic growth and development of countries. Therefore, the results of this study also support that ports and port regions help the development of the geography. One of the reasons for the port privatization policy carried out by the Turkish government is the desire to benefit the development of the country by using the resources allocated for state ports more efficiently (İnce and Güngör, 2021). It can be seen from examples around the world that governments play a significant role in the development of ports through the policies they develop (Loo and Hook, 2002b; Monios and Wilmsmeier, 2014; Tae-Woo Lee and Flynn, 2011). The development of Turkish container ports, the quadrupling of container traffic volume and the emergence of many container port regions can be shown as supporting investment plans with incentives, privileges, and procedural conveniences.

On the other hand, the sustainable development of Turkish ports depends on how well they can take advantage of emerging opportunities and adapt to developing technology. Especially due to its strategic location, the fact that the transit container traffic of Turkish ports is below the world average should be considered as a weakness for Turkish port industry (Yetkili et al., 2016). The increase in the transit cargo volume of Piraeus port with the Chinese state's investment in Greece within the scope of the One Road One Belt initiative is enough to understand how big the missed opportunity is (Bo et al., 2018; Van der Putten et al., 2016). In terms of technology, the sustainable development of Turkish ports can be achieved by adaptation to possible structural, operational, and strategic developments that may arise with digitalization, automation, and autonomous ships (Del Giudice et al., 2022; Gasparotti et al., 2023; Kon et al., 2021; Kurt and Aymelek, 2024, 2022).

6. Conclusion

This study aimed to examine the development of Turkish container ports in terms of their container traffic volume, spatial diffusion, and shares in the container market. For this analysis, Gini coefficient and Shift-share analysis methods which are used in many studies to examine the development of ports, were carried out. The investigation of Turkish ports showed that ports have experienced significant structural, operational, and strategic developments with the introduction of containerization. The heavy and non-dynamic structures of state ports which dominated the Turkish container sector before the millennium, brought to light the need for rapid and efficient container ports. This need has been tried to meet by privatizing state ports and new container port/terminal investments. The proliferation of containerization and the increase in container volume have also attracted port operators to invest in the Turkish port sector. This trend has caused the Turkish container sector to be dominated by

private ports. Only, a few state ports (Haydarpasa Port and Alsancak Port) currently continue their operations but are losing their share in the market day by day.

The findings obtained in this study show that the container throughputs are shared more evenly among the existing container ports today. The fact that the Lorenz curve approached the equal distribution in the period from 2004 to 2022 shows that the increasing container volume is directed to different port facilities as a result of the privatization of Turkish ports and new port/terminal investments. Thus, it can be said that Turkish container handling is carried out by a wider portfolio of ports. While this situation intensifies the competition among Turkish ports, the Turkish port sector, which can offer alternatives, gains a significant advantage against its international competitors. In addition, a more balanced distribution of container throughput among ports will allow ports to focus more on operational efficiency, enabling a faster and more effective response to demand. The balanced distribution also supports efficiency in resource use by preventing excessive capacity use in certain ports and reducing possible idle capacity problems in new port investments. The inequality reduction in the distribution of container throughput prevents traffic congestion in port and hinterland connections by redirecting the traffic to different regions.

This study indicates that although the Marmara region is the busiest region of container traffic, significant increases in the concentration of container volume in other regions (Mediterranean, Aegean, and Black Sea) have also been seen. The percentage shift in volume to other regions can be explained as the increasing container traffic opportunity being turned into an advantage by privatized or new ports. While container throughput has increased in almost all regions, Kocaeli, Tekirdag, and Aliaga port areas have become more prominent due to their intertwined with industry and strong hinterland connections.

This study also reveals the weaknesses of the Turkish container port system. Due to its location, Türkiye has the potential to serve as a transfer hub on the Asia-Europe mainline route. However, while the average transit cargo rate of ports in the Mediterranean basin is 43% and this rate is around 30% in the world, the rate of transit containers handled in Turkish ports is only 14%. This rate has reached this level with Asyaport's transit container handling of up to 70%, whose purpose of establishment is to serve transit cargo. It is important for the development of Turkish container ports to include a strategic plan to increase the transit container volume in the future projection, especially due to their strategic location.

The biggest limitation of this study is the period of analysis had to be restricted due to the unreliability of the data before 2004. Due to data limitations, the period from the first investment in containerization at Haydarpasa Port in 1979 to 2004 could not be included in the analysis. Therefore, examining the development of Turkish container ports before the millennium requires consideration in future studies. In addition, the policies to be produced to improve the transit cargo volume, which is the weakness of the above-mentioned Turkish container ports, and the academic studies that will play a guiding role in these policies will add great value to the Turkish container sector. On the other hand, shaping the future of the Turkish container industry is possible by adapting to developing advanced technology. Examining the effects of autonomous ships on ports, and studies on ensuring operational adaptation of Turkish container ports with autonomous ships should be considered as future studies on Turkish container ports.

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