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Analysis of the Competitiveness and Financial Development of the Port of Piraeus in the Containerized Maritime Transportation Market

by

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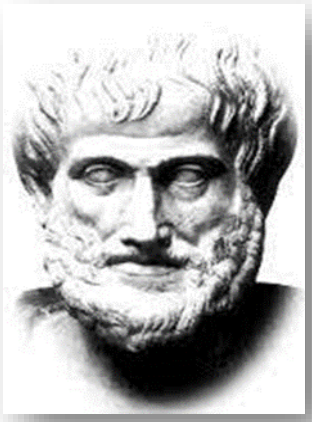
Abstract

Our thesis deals exclusively with the container handling/throughput in terms of volume (million TEU) for the port of Piraeus, Greece. We are investigating the competition between Piraeus and another 12 major port container terminals in the wide area of the Mediterranean Sea. Moreover, we assess the benefits which contribute to the development of the city where the Piraeus port operates. Studying maritime transportation market in Europe, the steady rise of the Mediterranean ports, is indicated due to their geographical location, which support hinterland transportation connecting to supplier's final destinations by train, road or waterway where it is applicable. After setting this framework, we delve into the port of Piraeus, analyze the container handling/throughput with numerical data, and study the destinations of the shipments as well as their origin, both for the China Ocean Shipping Company's (COSCO) Terminal and the Piraeus Port (Authority) Terminal (PPT). Carrying out a comparison analysis through figures and data tables for the port of Piraeus between other Mediterranean competitive ports in the area, such as Gioia Tauro (Italy), Algeciras (Spain), Marsaxlokk (Malta), etc. we conclude that the choice of the Piraeus as shipment center in the Mediterranean provides a lot of benefits in the investor COSCO, as well as in the affiliated city. Following the thesis's structure, in the literature we identify the crucial factors which influence the competitiveness of a container port and we discuss the available methodology for the identification and measurement the inter-port competition. We define the Mediterranean Sea maritime market and we select 13 ports (container terminals) to identify the port competition into the region from the year 2014 until 2020. Having in our mind that technical inefficiency prevails in the economic performance model of the ports of the region, in a quantitative approach we use the Concentration Ratio (CR4 & CR8), the Herfindahl–Hirschman Index (HHI), the Shift-Share Analysis and the Gini Index through Lorenz curves as benchmarking technique to determine the present leader port in the Mediterranean Sea. We use a number of variables from the most updated cargo volume data bases to make our calculations. All approaches for the port of Piraeus come to conclusion, that through the investment plans and strategies of both terminal operators, PPT Authority & COSCO the container terminals of Piraeus create the appropriate conditions for a continuous positive shift in competitiveness. For statistical & administrative approaches we use the inaugural edition of the Container Port Performance Index (CPPI 2020), which has been produced by the Transport Global Practice of the World Bank, in collaboration with IHS Market. Finally, we discuss the ability of the port of Piraeus to climb to a higher pedestal in the world in container handing/stack, something that is expected to be seen in numbers. For 2019 & 2020 the port of Piraeus was 1st largest commercial port in the Mediterranean as well as the 4th largest port in Europe in terms of TEUS according to dr. **Theo Notteboom**, (PortEconomics)**.**

Keywords: Hinterland, Piraeus, PPT, COSCO, Port product, Gioia Tauro, Algeciras, Marsaxlokk.



Άνευ αιτίου ουδέν έστιν.

Αριστοτέλης, 384-322 π.Χ., Αρχαίος Έλληνας φιλόσοφος

There is nothing without a cause.

Aristotle, 384-322 BC, Ancient Greek philosopher

THE MEDITERRANEAN REGION

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List of Abbreviations

ABP	Associated British Ports’
APL	American President Lines Ltd
BOPIS	Buy Online Pickup in Store
CAGR	Compound Annual Growth Rate
CITOS®	Computer Integrated Terminal Operations System
CMA CGM	Compagnie Maritime d'Affrètement and Compagnie Générale Maritime
COSCO	China Ocean Shipping Company
CPPI	Container Port Performance Index (2020)
DEA	Data Envelopment Analysis
DPW	Dubai Ports World
ECT	Europe Container Terminals BV
EU	European Union
EY	Ernst & Young
FDI	Foreign Direct Investment
GDP	Growth (rate of the real gross) domestic product
HHI	Herfindahl–Hirschman Index
HP	Hewlett-Packard
HPH	Hutchinson Pott Holdings
IMF	International Monetary Fund
MOL	Mitsui Osk Lines
MSC	Mediterranean Shipping Company
NVOCC	Non Vessel Operating Common Carrier
NYL	Nippon Yusen Kaisha

OBOR	One Belt, One Road
ONE	Ocean Network Express Pte. Ltd.
OOCL	Orient Overseas Container Line
PCDC	Piraeus Consolidation and Distribution Centre SA
PCT	Piraeus Container Terminal SA
PORTNET®	Nationwide Port B2B (Business to Business) shipping e-community
PPT	Piraeus Port (Authority) Terminal
PRPA	Philadelphia Regional Port Authority
PSA	Port of Singapore Authority
SSA	Shift Share Analysis
SWOT	Strengths Weaknesses Opportunities Threatens
TEN-T	Trans-European Transport Network
TEU	Twenty-Foot Equivalent Unit
UK	United Kingdom
USA	United States of America

PART

ONE

CHAPTER 1
INTRODUCTION

1 Introduction

Maritime transport is the most boundless mean for the distribution of products in international trade. Around 80% of the volume of international trade in goods carried by the sea, and the percentage is even higher for most developing countries. According to the Allied Market Research, a market research and advisory company of Allied Analytics LLP, the global shipping containers market was valued at $8.70 billion in 2019, and is projected to reach $12.08 billion by 2027, registering a CAGR of 4.3% for the forecast period 2020-2027.

Such a large development of the maritime trade could not be realized without the interconnection of the maritime means with the land (train, truck, etc.), i.e. the port. The port is no longer used exclusively as a “ship shelter” and a place for loading and unloading containers, and acquires a multidimensional usability. It includes all the various functions that are gathered in each area and through this set is achieved both the promotion of the various goods by land transport, storage and their distribution. Currently we are referring to third and fourth generation ports[1] which are a key link in the logistics chain, offering reliability to port user’s services.

In the context of globalization, maritime freight and the port industry has undergone major changes, due to the increase in the size of ships as well as the increase in the need of international trade, which has resulted in denser container traffic. New technologies were developed to achieve better container management, inside and outside the port. Ports, worldwide, have managed to be an important element of the economic development of the various countries. Those ports that could not keep up with these changes and the today’s rapid growth rates, were not a pole of attraction of the major shipping line companies, excluding themselves from the main sea routes.

Port competition is still very intense. Developed ports worldwide are trying to become strategically important for large shipping lines investing through public port administrations or private managers, in building a strong infrastructure and superstructure so they can handle more containers in less time. The geographical location, the number of calls and the number of the offered routs at the port, determined the three variables which influence the competitiveness of a port according **Itoh and Doi** (**2002**).

The present work aims to focus on the part of the handling/throughput in the port of Piraeus, which has seen a particular bloom in recent years and is expected to stimulate more and more the interest of various shipping companies in the line market. Opening we analyze, quantitatively and qualitatively the container handling/throughput has achieved in the port of

Piraeus so far, we compare it with competing ports in the Mediterranean, and through the benchmarking analysis based in general on Herfindahl-Hirschman Index (HHI)[2] calculations we reach our conclusions and we develop whether a port can be an attractive container handling/throughput center in Mediterranean region for a shipping line and under what conditions. This topic holds fascinating interest due to the rapid development of the Piraeus port continues with new investments from stakeholders.

1.1 Aim of the study

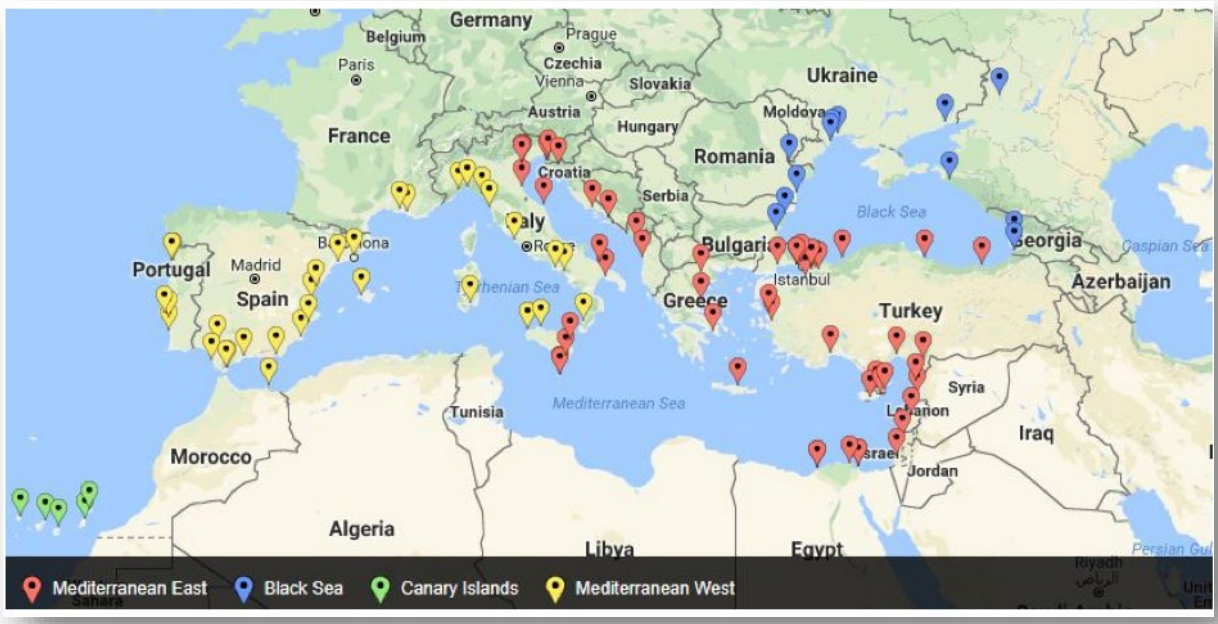


FIGURE 1 – Mediterranean Ports[3]

The moving force of all maritime businesses is the globalization of production and consumption. The world economic growth is in an increasing amount of trade flows, new trade routes and new players which are continuously emerging, even now when the pandemic COVID-19 make people hesitant on their activities. The former directly impacts the performance of the ports. At first our study measures the competitiveness of specific Mediterranean ports investigating the role of some qualitative and quantitative factors. More explicity, our study recognizes and measure the competitive position of the Piraeus container port in the Mediterranean region. In order to be close in this aim I exclude all the West Mediterranean Ports as well as the Black Sea ports, the Marmara Sea ports and of course the Atlantic (close Europe) Sea Ports (Canary Islands, etc.). All these are not **direct** competitors to the Piraeus container terminal. For purposes of our study concerning the recognition of the port competition we use the cargo volume handling (in TEUs) for a period of seven years.

1.2 Research questions

In order to analyze the Piraeus container port current competition in the Mediterranean region and do further research on the measurement of this competitiveness, it is important to answer the below questions. Our research is going to do an analysis of the mentioned competitiveness based on the ports users' perceptions.

1.2.1 Main research question

*Could the port of Piraeus be **leading transfer container center** in the Mediterranean Sea?*

To answer the question, we have to evaluate a number of parameters between the chosen different ports taking into consideration the inter-port/intra-port competition.

1.2.2 Indirect research questions

*a. Geopolitically is the **position** of the Piraeus port competitive into the Mediterranean region?*

In our study we define the position of the Piraeus port into the Mediterranean maritime trading market based on specific parameters and we justify our decision.

*b. Are the **rest** chosen ports more competitive than the Piraeus container port?*

In an affirmative and/or negative answer we have to specify which port is in a higher and/or lower position.

*c. Which port would be considered the **leader** in the container throughput in the Mediterranean?*

In order to answer an average ranking port from the selected Mediterranean ports defines the higher (above) or the lower (below) position in conjunction with others.

d. Which factors lower the position of Piraeus port?

The answer to the question presents missing elements in order to be filled in the future for a better new position of the examined mentioned port in the definitive rankings table.

*e. Could **COSCO** as investor and container terminals operator improve the competitiveness of the Piraeus container port?*

Our answer include data from the COSCO's investments in the Piraeus port with positive/ negative results. Piraeus port authorities and COSCO both, are focusing on significant infrastructure investments with the **aim at lowering operational costs and improving integral service quality**.

1.3 Data collection

The data collection was a very tough procedure because the information concerning the Mediterranean ports is very limited, the relative studies are very few and the data in the most of the cases were outdated. An important source was the Containerization International Yearbook 2019-2020. Nevertheless, data for our thesis were from Internet [Google Scholar, Web Sites from port authorities and Organizations (e.g. United Nations), international/national reviews/articles from recognized newspapers/magazines and e-books]. More detailed report for the bibliography and the internet sites providing in the end of the text.

1.4 Thesis overview

Our thesis consists of three parts with four chapters where we analyze all the collecting data from the several sources in order to conclude for the competitiveness of the Piraeus into the trade challenging region of the Mediterranean Sea.

In the first part we have the following two chapters.

Chapter 1 holds general information about the topic, the research questions and the data sources.

Chapter 2 includes the literature review and attempts to introduce the reader to the container market, emphasizing the role of Asia and presenting the major market alliances. The reasons for using larger ships are recorded and analyzed and the concept of repositioning of empty containers is presented. Following we talk about types of port competition and come up with a number of competitive criteria which we use for our benchmarking analysis.

The second part deals with the methodology of our research. In this part the unique **Chapter 3** presents the role of combined transportation today and makes reference to existing European policies. Port authorities in order to make attractive their installations started invested in their infrastructure, superstructure, cargo handling equipment (e.g. depth, storage area, cranes) and information systems as those investments was a necessarily step not only for the satisfaction of the customer needs, but also for the improvement of the port competitiveness. In this chapter mainly we perform the concentration benchmarking methodology using calculation of HHI^2, Cr_i, Gini coefficient, Lorenz curves as well as SSA, in

order to measure the inter-port competition for the ports of our survey. Moreover, we present the European market where incorporate the Mediterranean ports. We give a little bit specifically overview in Containerized Maritime Transportation Market for the Piraeus (Greece) port main competitors, the Mediterranean ports of Alexandria (Egypt), Algeciras (Spain), Ambarli (Turkey), Barcelona (Spain), Genoa (Italy), Gioia Tauro (Italy), Marsaxlokk (Malta), Mersin, Port Said (Egypt), Tanger Med (Morocco) and Valencia (Spain). The data cover the period from 2014 until 2020. Therefore, in this chapter we **discuss the main objective** of our study, which is to analyze the throughput of the above mentioned selected 13 container ports during the period 2014-2020 and to make all the proper calculations to identify the **rank** of the port of Piraeus among the other 12 Mediterranean ports and its effect in the wide area of the town. At the end of this chapter we perform a linear regression in excel using both modes linear as well as cubic polynomial (in 3 power/order) for the 13 Mediterranean ports for the above mentioned period 2014-2020 in order to make an estimation which port would be healthy and active and we make relevant comparisons.

In the third part of our thesis, in **chapter 4**, we conclude and discuss COSCO's investment in the port of Piraeus, the traffic in the COSCO terminal, the productivity and the development opportunities that exist for the port, such as the project of HP and the creation of shipping cluster and we use the regression to say for a positive and continues. Of course in this chapter we make references for DPW and PSA as global investor in ports market and we try a triangulating quantitative and qualitative data comparison between the Piraeus port (COSCO, Greece) and the ports of Mersin (PSA, Turkey,) and Izmir (DPW, Turkey).

In this day and age, the economic crises as well as the pandemic COVID-19 disease caused difficulties in the realization of ports investment plans due to the lack of liquidity. The ports are making deliveries in a more sluggish way. However, for the Piraeus Port, new opportunities derived from the installation of this global container terminal operator, COSCO with plenty of cash and know-how. In this point we attempt to investigate the evolution of Piraeus port as junction in the global shipping networks through an interesting and current newspaper article.

Lastly **chapter 4** prompts a research recommendation for a new era. The era where maritime trade specifications which comes from requirements of the transportation of the future energy forms and materials (hydrogen, composed materials, giant 3D working devices as printers for construction, etc.). This begs the question: Are TEU's enough to do this transportation? Or we need something beyond the innovation of Malcolm Purcell McLean who developed the modern intermodal shipping container?

At the end we are concluding with the answer to our main research question.

CHAPTER 2

LITERATURE REVIEW

2 Introduction

In this part after a qualitative pass through maritime container trade, focus on the competitiveness of the container ports taking under consideration the competition in inter-port level after leaving the intra-port level. In a more global overview for holistic measurement of port's competition containing both levels a selection of a benchmarking method includes a huge amount of variables, theoretically unlimited. Apart from the inter-port factors, there are intra-port factors, since terminals infrastructure differs, and the calculations become more complicated. This fact is outside of the scope of our survey. An overview is presented about maritime container transportation market, in the rest we discuss for the port competitiveness and conclude with the important remarks helpful for our benchmarking research method.

2.1 Maritime container transportation

Global container trade has reached 798 million TEUS by the end of 2020 from 545 million in 2010[4]. The rapid growth of containers is due to the role played by Asia in recent years, gaining the lead in all container exports feeding with supplies the rest of the product markets. Such an event could not leave unaffected the global capacity of containerships. The imbalance in trade from Asia created the need to move empty containers from shipping lines to meet Asia's export needs, creating high costs for them and a shortage of containers in other ports. The need to move large numbers of empty containers was one of the factors that led shipping lines to build larger ships to minimize voyages as much as possible.

2.1.1 The role of Asia

The role of Asia has been and is crucial for the development of container traffic. It is noteworthy that container traffic in Chinese ports was 21,5 times higher in 2020 than in 1990, while in other global ports increased only 6 times over the same period. The 'One Belt, One Road' (OBOR) initiative is a Chinese economic and strategic agenda by which the two ends of Eurasia, as well as Africa and Oceania, are being more closely tied along two routes–one overland and one maritime. The motives behind it and its importance for the European Union represents the impact of Chinese FDI in Europe. The significance of exchanges is strong however China holds a number of internal qualities which have contributed in attracting FDI and these should not be overlooked. From 2005 to 2019, Chinese companies invested $624.4 billion in North America and Europe, amounting to just over half (50.9 percent) of all Chinese FDI outflows during this period.[5]

TABLE 1 - Top 10 ports in the world[6]

PORT	COUNTRY	TEU(2020, 1H)	TEU(2021, 1H)	CHANCE %
SHANGHAI	CHINA	20.060.000	22.940.000	↑ 14,4%
SINGAPORE	SINGAPORE	17.837.000	18.730.000	↑ 5,0%
NINGBO-ZHOUSHAN	CHINA	13.250.000	16.070.000	↑ 21,3%
SHENZHEN	CHINA	11.070.000	13.760.000	↑ 24,3%
GUANGZHOU	CHINA	10.760.000	11.770.000	↑ 9,4%
QINGDAO	CHINA	10.340.000	11.660.000	↑ 12,8%
BUSAN	SOUTH KOREA	10.746.000	10.740.000	↓ 0,1%
TIANJIN	HONG KONG	8.580.000	10.300.000	↑ 20,0%
HONG KONG	CHINA	8.647.000	8.725.000	↑ 0,9%
ROTTERDAM	NETHERLANDS	7.002.800	7.612.000	↑ 8,7%
total		**118.292.800**	**132.307.000**	**↑ 11,,8%**

2.1.2 The largest alliances in the container market

The main shipping lines of container ships belong to a strategic alliance, in order to meet the growing needs for increased capacity and reliable services, applying horizontal integration. We could define horizontal integration[7] as «integration between companies belonging to the same industry, shall be achieved through alliances». Horizontal strategic shipping alliances aim at cooperation between members with a view to exploiting ships on specific routes, including ship type / size, navigation programs, the use of common terminals and the coordination of freight in a global level.[8]

The most important strategic alliances[9] in containers for fiscal year 2021 are the following:

- **2M Alliance (29%)**
  MAERSK LINE and MSC
- **Ocean Alliance (29%)**
  COSCO SHIPPING, CMA CGM, EVERGREEN and OOCL
- **Independents (20%)**
  APL, MITSUI OSK LINES, NIPPON YUSEN KAISHA.
- **THE Alliance (17%)**
  HAPAG LOYD, ONE, HUYNDAI MERCHANT MARINE and YANG MING

2.1.3 Tendency for using larger ships

One phenomenon that has been particularly noticeable in recent years is the gigantism of container vessels. Although large lines, such as Maersk, had implemented this policy by

building oversized ships[10], many other lines had not followed this practice because of the ambiguous financial results. Ships are one of the most spectacular inventions of all time, with thousands of pounds of wood and steel traveling on the surface of an ocean. As time passes, the designs have become much more complicated. And as engineers, shipbuilders became more knowledgeable, they began to make the size of ships even larger. There were a lot of complications when the ship's builders tried to build the world's largest ships. Containers vessels have been through various phases. These phases have been classified as generations. First generation from 1956 to 1970, second generation from 1970 το 1980, third generation from 1980 to 1988, fourth generation from 1988 to 2000, fifth generation from 2000 to 2005 and sixth generation from 2006 till now. Today the Ever Ace[11], owner Green Compass Marine S.A., is the World's largest containership (23.992 TEUs), when the same time ten containership with 24.004 TEUs capacity are under construction in Chinese shipyards[12].

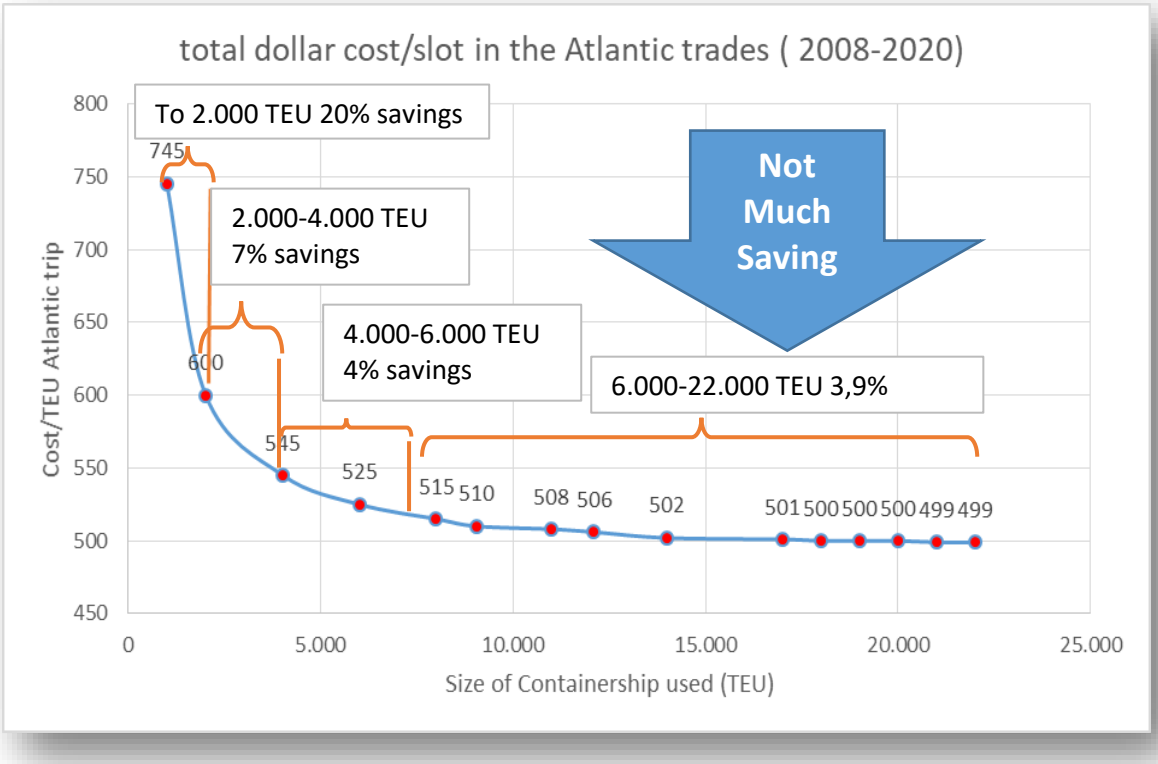


FIGURE 2 – Total cost ($)/slot in the Atlantic trades [Stopford (2008) - writer (2020)]

In the above figure 2 we have the result ratio for the total costs per slot in the Atlantic trading trip for the year 2008 according Stopford as adopted and expanded by the writer until the year 2020 with data from the Global Maritime Hub. We can see the unit cost curve starts from 745$ per TEU for an Atlantic trip with a 2.000 TEU containership, drops to 600$ per TEU and 7%

savings for the same trip with a 4.000 TEU containership as well as 4% - 3,9% savings for the same trip with up to a 22.000 TEU containership and a unit cost from 545$ to 499$. This is a result of ship's operations and propulsion. Mention that from 6.000 TEU to 22.000 TEU size of containership for the same trip during the fiscal years from 2008 to 2020 we don't have as much savings as we expected.

Oversized ships serve a certain number of ports in order to achieve maximum coverage of their tonnage. It is a fact that if we look at the port side, not all ports have the necessary infrastructure to receive and manage such large ships effectively. For this reason, the oversized ships unload the containers at ports of choice, selected by the respective shipping lines, and then supported by a network of feeder vessels, i.e. smaller ships, serving shorter distances and ports that are not on the basic shipping route of shipping lines.

2.1.4 Management of empty containers

A container moves empty either because it has been damaged or because it does not find a load while at the same time there is a demand for containers in another area. In both cases the container is moved to be reused either immediately or after maintenance and repair.

Moving and handling empty containers is one of the most important problems in the industry. Container enthusiasts know that the most expensive cargo is air. Moving an empty container is commonly referred to as "repositioning" as the container is moved to another location to search for cargo. In the diagram below we can conclude, in the form of percentages, that the most of the life of a container is occupied by moving it as empty equipment.

The phenomenon of gaps is mainly due to trade imbalances. As a rule, big cities import consumer products and show a surplus of containers, while industrial areas export goods and face a shortage of containers. At the same time, the needs for special types of containers, such as 40 feet, refrigerators (reefers), for liquefied loads (tank containers), open to the roof (open top containers), are usually one-sided, exacerbating the problem of empty containers. Container flows change over time for seasonal, economic and other reasons, so companies in the industry need to keep track of developments and adjust accordingly.

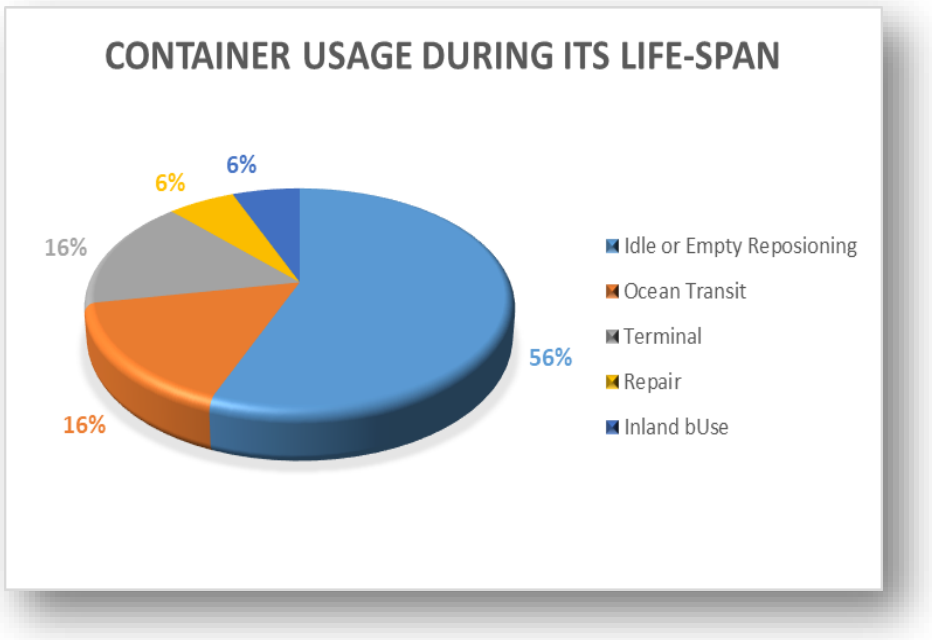


FIGURE 3 - Life stages of a container[13]

The issues of reuse containers need special attention and handling by regular companies and depots and, in general, companies in the industry, as they are considered crucial for their survival. Carriers are effective in managing the global container fleet, but they are less efficient in managing the global container fleet. It must be taken for granted that as competition increases, profit margins are compressed by falling fares, companies have to further reduce their costs and improve their services. This can be achieved by better managing the containers within the transport chain, the stages between unloading the goods in the container and reusing it.

2.1.5 The role of combined transport in our days

In trying to define what exactly combined transport is, we could mention that combined transport is carried out using at least two means of transport for the final delivery of the product to the recipient's door (door to door service). Combined transport is also an indicator of integration / cooperation of means of transport that complement each other towards a more efficient use of the transport system.

Thus it expands its activity apart from the sea transport and the land, having as a big competitor the freight forwarders[14], who provide these services. It is a given that if a shipping company does not offer door to door services and is limited to the maritime part, it does not offer solutions to the customer who will most often seek a complete combined transport to his door.

The shift from simple physical distribution or storage to complex systems of supply chain management brings about a fundamental transformation that is crucial in understanding the material dynamics of globalization. This process is relevant for a wide range of conditions and forces that go well beyond transportation, even if what a classic article by W. Bruce Allen[15] almost twenty-five years ago called 'the logistics revolution' had a strong impact first and foremost on transport.

FIGURE 4 - Map of the new Silk Road published on May 8, 2014. [16]

The main reason why the port of Piraeus was used as a gateway for transit cargo is the significant competitiveness which has to do with land transport (train / road) to the heart of Europe. In terms of quality, the existing infrastructure on the road and rail network is being renovated to competing the other Mediterranean ports. Below I quote a diagram (the Global Competitiveness Report 2019, by the World Economic Forum) which presents numerically the competitiveness index of infrastructure in Greece and its rank between other European and Asian countries.

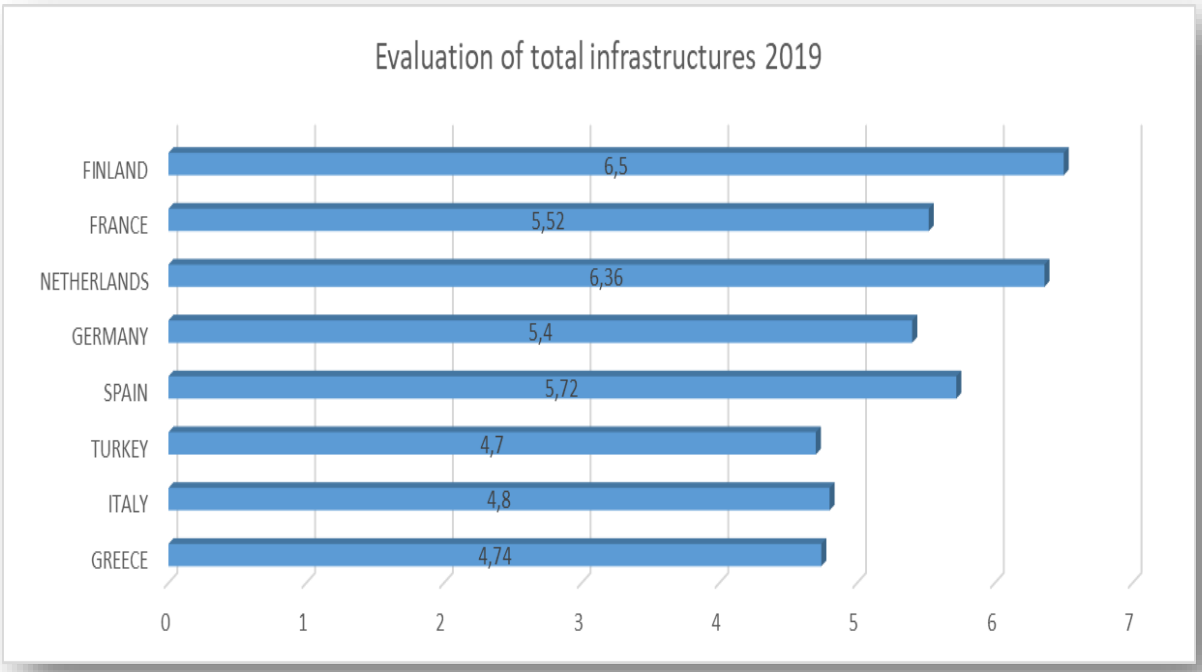


FIGURE 5 - Evaluation of total infrastructures[17]

In the last few years, with the rapid and continuous development of Piraeus as a port of transshipment and management of local as in transit cargo, the scene seems to be changing. Large companies are interested in transferring all their logistics work to the port of Piraeus, making it the main gateway to the markets of Northern and Central Europe and the Balkans. This idea starts to take place, with the conclusion of the agreement between Hewlett Packard, COSCO and TRAINOSE, for the forward of the first products through the port of Piraeus to the rest of Europe. In the next chapter we will report in more detail on the evolution of the port of Piraeus with figures.

2.1.6 European transport policy

Europe has around 130 container handling ports. Forty of these serve overseas transport services. This is one of the busiest port system in the world, with a total of 94.3 million TEUs were handled in 2020[18]. The quantities of goods passing through were certainly affected by the COVID-19 crisis that arose in 2020, however this was limited to the temporary cessation of the great growth that occurred in the handling of containers. In particular, the study of evolution over time from 1985 to the present shows that container handling in Europe has been growing steadily[18]. In particular, in the period 1985-1995 the container handling showed an increase of 6.8% per year[18], while in the period 2019-2000 the growth rate decreased by 2.4%

due to COVID-19 global conditions. In the wide area of Europe, the Mediterranean Sea is a crossroad of maritime corridors from Asia through Suez Canal to Europe. The port of Piraeus faces an ever-increasing international competition from ports with a favorable geographical position in the Mediterranean area. The type and origin-destination of the goods play an important role in this international competition. Intensified competitiveness is observed in the handling of containers with large Mediterranean ports such as those of Damietta, Gioia Tauro, Marsaxlokk (Malta). The ports of Italy (Taranto and Cagliari), Egypt (Port Said East) intend to increase competition. The port of Piraeus has a competitive advantage over other ports in the demand of shipping companies as it facilitates a large domestic market thus supporting the development of actions by shipping companies. Generally speaking, the geopolitical position of the port of Piraeus is very competitive into the Mediterranean Sea because provide an attractive interconnection from sea whenever to the European inland, up to the North Sea. Hence the answer in our first Indirect research question is positive. The European Union seems to have paid particular attention to the development of this inland transport throughout Europe. In an effort to develop a single transport network for the whole Europe, it focuses mainly on rail and maritime transport, which are environmental friendly means.

2.1.7 Tendency privatization trend

There are many different activities that take place simultaneously in the port area, with the ships approaching, mooring and leaving, having completed their loading and unloading work. There is, therefore, the need to have a body (public or private) that will control and organize these activities.

Looking back to the post-World War II period, we see that the ports relied solely on public funding. This regime continued until 1980.

In the mid-1980s, the scene was reversed. State intervention is limited and the private sector participates in the port production process.

Port privatization was launched by the United Kingdom, a pioneering move for the Port Economy, which would make supply and demand forces more efficient[21].

2.1.8 The situation today

Line shipping is capital intensive due to the state-of-the-art and highly expensive projects required. In this context, the inability of the public sector to respond has contributed to the search for methods of attracting private capital[22]. In addition, the development of ports was hampered by some problems presented by the operation of public bodies, such as the bureaucracy, lack of organizational capacity, lack of adequate funding, strikes, etc.

The need for state-of-the-art ports to be able to accommodate large ships, acting as transshipment centers, has increased port competition with the result that many port terminals are being outsourced to private operators. It is estimated that 80% of terminals worldwide are privately owned. There are 5 main terminal operators worldwide (PSA INTERNATIONAL, CHINA COSCO SHIPING, APM TERMINALS, HUTCHISON PORT and DPWORLD,) who manage more than 30,6% of the container handling volume worldwide. It is worth noting at this point that in order to ensure a minimum level of profit, these managers enter into contracts with container shipping lines, which promise a certain number of containers per year (mainly cargo for transshipment). These agreements could not be absent from the time when the shipping industry is characterized by high concentration and shipping lines can easily change their transshipment center from one port to another.

In the figures below we present the most important terminal operators with the share that participate in the global container handling.

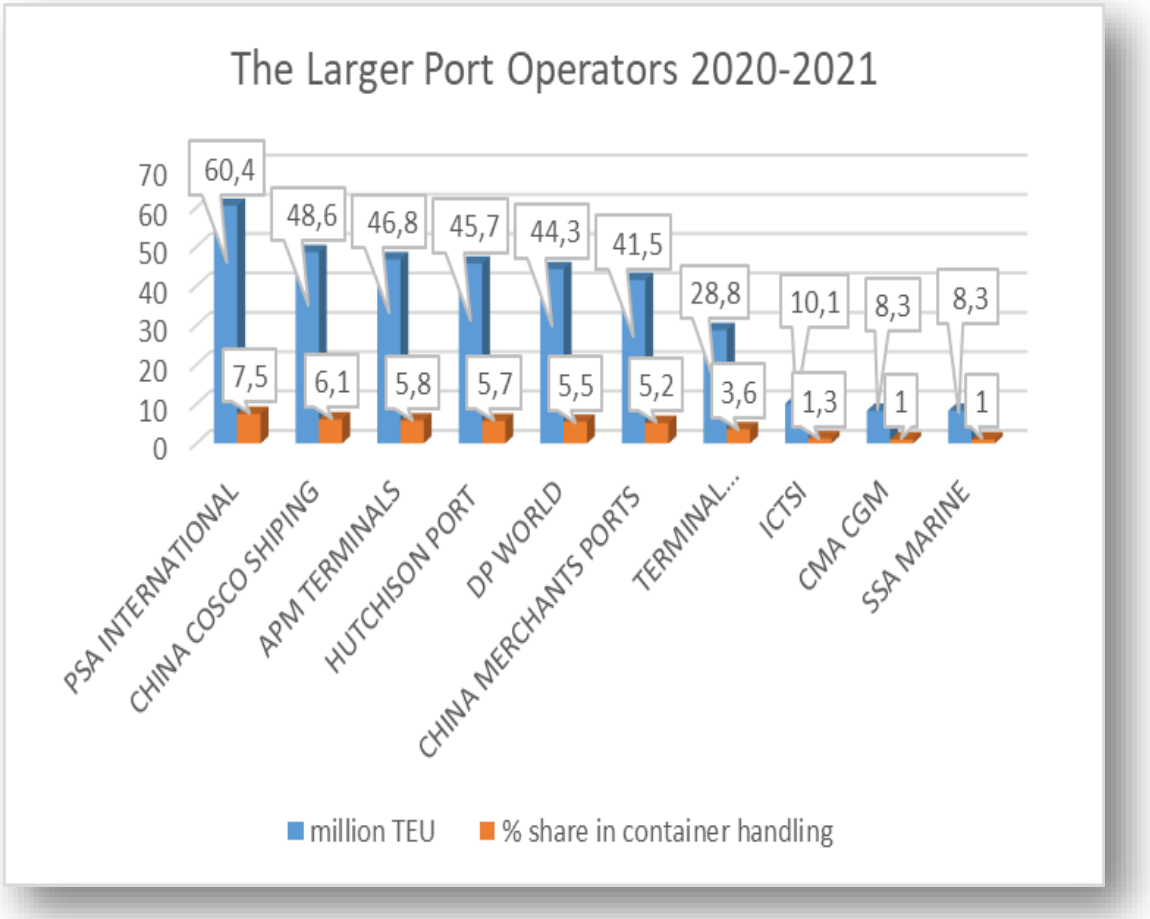


FIGURE 6 - The larger port managers[23]

2.1.9 Mediterranean ports conquer a market share

#	Port	Country	2018 TEUs	2017 TEUs	#	Port (cont.)	Country	2018 TEUs	2017 TEUs
1.	Valencia	Spain	5,104,000	4,832,136	11.	Port Said	Egypt	2,610,000	2,528,000
2.	Algeciras	Spain	4,772,000	4,380,849	12.	Alexandria	Egypt	1,757,000	1,589,000
3.	Marport	Turkey	1,591,983	1,711,357	13.	Haifa	Israel	1,464,000	1,343,000
4.	Piraeus	Greece	4,908,000	4,060,000	14.	Ashdod	Israel	N/A	1,525,000
5.	Gioa Tauro	Italy	2,301,000	2,448,570	15.	Beirut	Lebanon	1,300,000	1,305,038
6.	Marsaxlokk	Malta	3,310,000	3,150,000	16.	Marseille-Fos	France	1,400,000	1,362,204
7.	Genoa (Savona-Vado)	Italy	2,609,000	2,622,187	17.	Izmir-Alsancak	Turkey	610,908	610,908
8.	Barcelona	Spain	3,423,000	3,006,872	18.	Tanger-Med	Morocco	3,472,451	3,312,409
9.	Mersin	Turkey	1,723,000	1,591,983	19.	Damietta	Egypt	1,150,132	1,131,226
10.	La Spezia	Italy	1,543,000	1,473,571	20.	Koper	Slovenia	988,501	911,528

FIGURE 7 - Container port terminals operating 2017-2018 at the Mediterranean Sea[24]

The Mediterranean ports are in the middle of a vast network of trade lanes. And the competition to keep up with rising volumes and bigger ships commands more port investment. The growth of global container handling, particularly the Asia-Europe shipping line, has led European

ports, including the Mediterranean ports, to handle 94 million TEUS in 2020, comparing 95,4 million in 2019, 114 million TEUS in 2011 (!), up from just 23.7 million TEUS in 1990. This

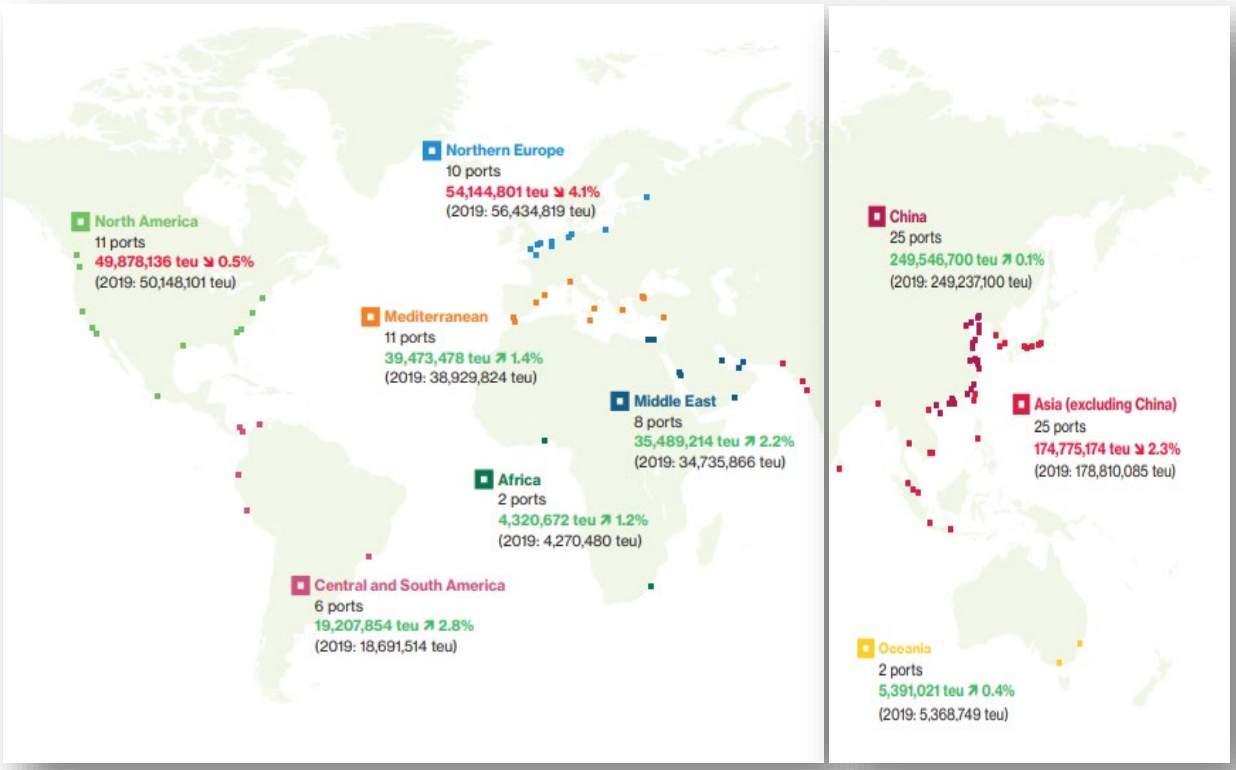


FIGURE 8 – Worldwide container port terminals [25]

increase was smaller from Asian ports, leading to a drop in the global container handling rate for European ports from 28% in 1990 to 19% in 2011 and 2,17% in 2020. Despite the decline, Mediterranean ports gained market share from Northern Europe ports, mainly due to the concentration of transshipment procedures. Indeed, as mentioned before, the main purpose of container shipping lines, especially in times of low freight, is to create sea lanes that will not deviate from the ship's quest to remain operating costs at low levels, and include ports capable of managing large ships, quickly and efficiently. It seems that many of the Mediterranean ports meet the above, so there has been a shift of cargo to the Mediterranean and their forwarding from there to Northern Europe. Characteristically, according to Containerization International, Piraeus and Gioia Tauro grew rapidly with the former jumping from 77th place, where it was in the world rankings in 2011, to 46th place in 2012, to 26th in 2019 and to 28th in 2020 when the second jumps from 58th place in 2011 to 47th in 2012, drops to 78th in 2019 and came back to 57th in 2020.

The diagram below shows the continuous increase in the percentage of Mediterranean ports compared to those of Northern Europe.

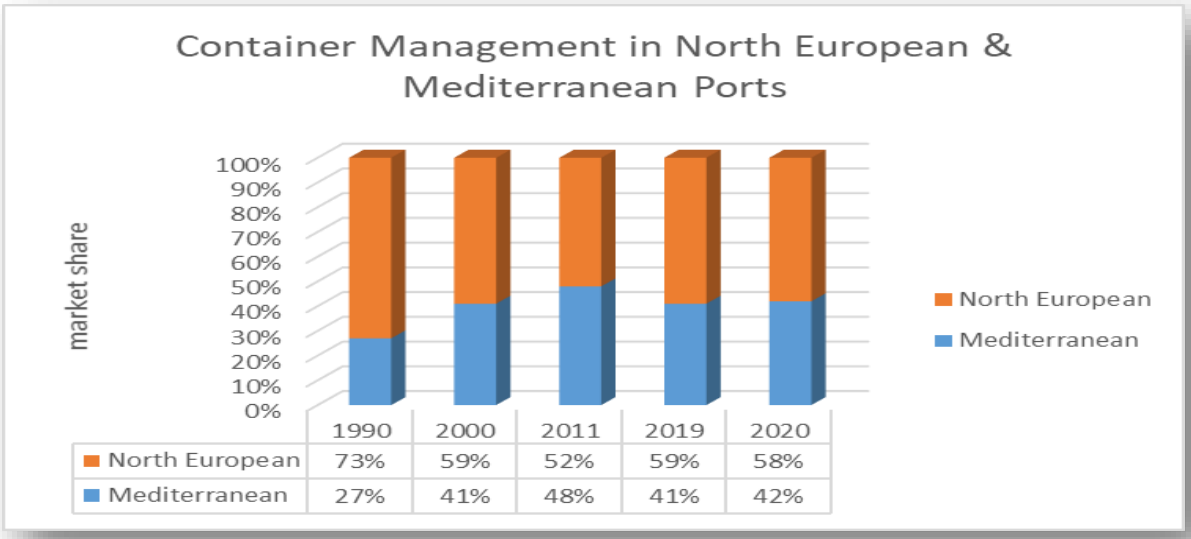


FIGURE 9 - Container management in North European and Mediterranean ports[26]

2.1.10 Distinction of the terms transshipment and in transit process

At this point it is useful to distinguish the difference between the terms transshipment and in transit process for the final destination of the cargo. Sometimes the cargo that arrives at a container handling port it is destined for the local market and sometimes has a destination at a different port to which reach either by another ship or by another mean of transport (except the initial ship). Therefore we have the following distinction:

- Ship Transshipment process: In this case, the port acts as an intermediate destination, where the container will be transshipped to another, usually smaller, ship and depart for its final destination. Many times we find in the various routings even 2 transshipment ports for the container to reach its final destination.

- In transit process: In this case, the port acts as a gateway so that the cargo reaches its final destination using land transport.

The procedures are points of intense competition for the various ports. Ports that manage to have the right infrastructure, quality of service and low costs of loading and unloading are an attraction pole for large shipping lines in the container market.

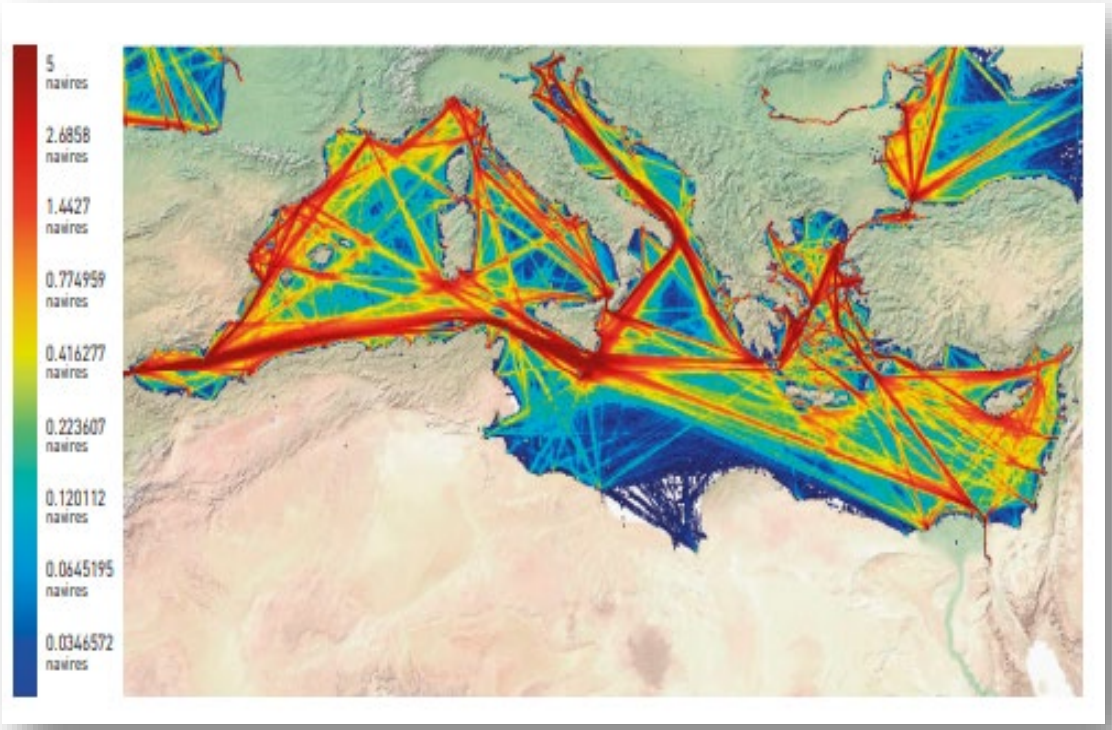


FIGURE 10 - Traffic density in the Mediterranean Sea Area [27]

The transshipment process has nothing to do with the import and export capacity of the country in which the transshipment port is located. It is mainly based on the geographical location of the area and the combination of cost and quality services offered by the port authorities. For the above reasons a recent factor has impacted the Mediterranean ports. Eastern Mediterranean ports have gained market share of those of the Western Mediterranean, as they managed 50 percent of the volume of containers in the Mediterranean in 2011, up from 28 percent in 1990. Nevertheless, the situation has changed as well as Western Mediterranean ports in 2017 managed 75% of the total containers' region volume, in 2018 the 74%, in 2019 the 68% and 2020 the 69%. The same time the Eastern Mediterranean ports managed the rest which was 25%, 26%, 32% and 31% respectively. The most favored ports are those of Piraeus (Greece), Valencia (Spain) and Algeciras (Spain) whereas Barcelona (Spain), Marsaxlokk (Malta) and Ambarli (Turkey) seem to have lost a significant share. To a large extent, this change in market shares is due to the development of Mediterranean ports as transshipment centers, gaining this title from significant investments they made in improving their infrastructure, for attracting large container shipping companies/vessels.

2.2 Review on port development

If we try to answer our (e) indirect research question "could COSCO as investor and container terminals operator improve the competitiveness of the Piraeus container port?" we can easily recognize that COSCO's global expansion has influenced the development of hosting ports and has capitalized the economic opportunities through seaborne moving trade. COSCO owns and operates 32 terminals around the world in 157 positions. The 2018 statistics show that the performance of COSCO Pacific Partnerships container terminals which cooperates with COSCO was 1st of the top 21 global terminal operators, throughput and capacity having the 17,8% of the 626,6 million global TEUs. (UNSTAD Review of maritime transport, and Drewry, 2019, Global Container Terminal Operators Annual Review and Forecast 2019). In order to move on our study, we summarize our thoughts in three research areas:

(a) The impact of port development on economic growth,

(b) The relationship between DT and port productivity, and

(c) PPIs and PE.

Let us briefly discuss every area:

2.2.1 Port development on economic growth

Ports occupy a substantial role in domestic and international trade since hold the of goods or passengers by sea [**Shan et al,** (**2014**) **in Ziaul & Schramm,** (**2018**)]. Moreover, harbor areas are where marine terminal facilities transfer cargo and passengers between ships and land transportation (**Rodrigue and Notteboom, 2021**). Many authors such as **Bottasso, A.; Conti, M.; Ferrari, C.; Tei,** (**2014**) referred to ports as an economic entity and **Talley (2017)** defined for the port as the engine for economic development. Furthermore, seaports can create new employment opportunities through the effects associated with their operations and logistic activities (warehousing, distribution, containerization etc.). Hence the port development is a keen driver towards economic growth in a rapidly changing competitive market. **Jouili, T.A,** (**2016**) studied the positive impact of port infrastructure and logistics performance on economic growth. **Munim et al,** (**2018**) in **Mudronja et al.** (**2020**) analyzed the effects of seaports on regional growth. To sum up seaports have a critical impact on regional economic growth.

2.2.2 DT and port productivity

Within literature for the port dwell time (DT), **Ioanna Kourouniotia, et al, (2016)** defined as "*the total time a container spends in one or more terminal stacks*". Earlier **Ottjes et al.,** (**2007**),

following by **Notteboom et al** (**2021**) after 15 years, in their studies defined that DT is the amount of time a cargo or ship spends within a port and indicate the efficiency levels of a seaport. DT impacts port productivity and efficiency; thus, reducing DT will improve port productivity. Several authors studied the relationship between DT and port productivity and have illustrated that improvement on information regarding trucks' arrivals to pick-up import containers could result in an important reduction of unproductive moves [**Goodchild and Noronha,** (**2010**)]. To the best of our knowledge, although there is a substantial literature focusing on factors affecting freight mode and route choice, limited scientific interest is presented regarding to the factors that affect the containers' DT. Hence, the average DT plays a crucial role in determining the overall terminal capacity (**Chu et al., 2005**). Nowadays, the increased container volumes in combination with the new massive container vessels are demanding bigger terminal capacities. Port productivity is used frequently to measure and compare the performance of a firm's ratio of output over input, while PE analyses the ability of a port to obtain the maximum result under a given amount of input [**Suarez-Aleman et al.** (**2016**) **inTalley** (**2017**)].

2.2.3 PPIs and PE

PPIs measure the port operation (**Kashuina Miller**) when PE analyses the ability of a port to obtain the maximum output under a given amount of inputs (**Tetsuro Hyodo**). The weight of PPIs may vary based on location, throughput volumes, nature of cargoes, port infrastructure, equipment, and facilities [**Melalla et al.** (**2016**) **inTalley** (**2017**)]. PPI's also measure the port's performance by monitoring activities, checking their efficiency, and comparing the present with past performance [**Notteboom et al.** (**2021**)]. Port performances require a set of measures related to vessel dwell time, cargo throughput volumes, berth area, harbor depth, quality storage, and inland transport [**Shetty and Dwarakish** (**2018**)]. However, not all measurements are related to a port's physical infrastructure.

2.3 Port Competition

In the modern port industry the calculation of the port productivity is very crucial. The productivity of a port is determined by its competitiveness and consequently the number of customers it can attract. However, calculating productivity is a process with many challenges and is accomplished with a variety of indicators. The appropriate factors are determined each time according the purposes of each research, but also from the availability of the calculation data. The port productivity is a quantity that is affected by many factors, both endogenous and exogenous. Generally speaking a port to be extra productive need to handle more and larger ships and hinterland transport modes faster. This specific requirement defines the type of the

port, the cargo group, and the distinction between the large load centers or main/hub ports and the smaller regional or feeder ports. The comparison among the ports productivity raise the port competition[28].

2.3.1 Definition[28]

According to **dr. Theo Notteboom** [Port Economics(2022)]"*Port competition is competition for trades, with terminals as the competing units, logistics, transport, and industrial enterprises as the chain managers of the respective trades with port authorities and port policymakers as co-developers. Can be defined as competition for trades, with terminals as the competing units, logistics, transport, and industrial enterprises as the chain managers of the respective trades and port authorities and port policymakers as co-developers of the broadly defined port complex."*

2.3.2 Types of port competition[28]

To begin with this complex and multi-faceted concept such as the port competition focusing on the container ports we have to determine some characteristics/criteria. These port competitiveness criteria which define how the port is cost-effective are port costs, handling efficiency, hinterland connectivity, and the quality of infrastructure and services (**Parola et al. 2017**). A competitive port is more efficient and cost effective in providing operations. Moreover the geographical and functional levels of port competition define its types (**Dr. Theo Notteboom, 2022**) as follows:

2.3.2.1 Intra port competition, when different companies (often compete) at operator level, operate different terminals in the same port. In such a way, the local and national economy are affected positively. An example of an outstanding intra port operation is the Port of Hong Kong.[29] The port is financed, owned and operated by the private sector. The container terminals are operated by five companies, namely MTL, HIT, COSCO Information & Technology, DPW International Terminals and ACT.

2.3.2.2 Inter port competition within a multi-port getaway region, when many companies are expanding their activities over more than one port in the same maritime range or port region (e.g. Dutch ports against Belgian ports or the port of Singapore against Malaysian ports).

2.3.2.3 Inter-port competition within a port range, when a group of several main ports situated in different countries sharing the same long transnational seashore in a similar hinterland [e.g. the ports in the Hamburg-Le Havre range where the ports are spread over different countries (Belgium, Germany, the Netherlands, and France), each following their own port policy].

2.3.2.4 Inter-range competition which involves the competitiveness between ports ranges (e.g. competition in Europe between ports in the Mediterranean region in south and the Hamburg-Le Havre range in the north).

2.4 Review on criteria of port competitiveness

Contemporarily, ports have become key elements for the national economic development of the countries. This fact raises the competitiveness of the ports based on political, technological, geographical, social and ecological factors. The shipping liners (**Van de Voorde & Winkelmans, 2002**) and the shippers (**Robinson, 2002**) are the most important decision key points in the determination of the port of choice for the container maritime trade. In the present financial status the economy of scale requires vertical and horizontal integrations for the transport industry. Shippers all over the world needs better supply management as well as dense geographic coverage (**Haralambides, 2002**). However in many times the choice of the port of call based on the lowest cost for the demanding level of services. On the other hand shipping liners have developed joint ventures, mergers and alliances with the respective port terminals. In the Mediterranean region an important example of vertical integration is the COSCO agreement with the Piraeus container terminal. At this point we overview factors which influence the containerized port competitiveness and they are strongly correlated with the port selection criteria (**Yeo et al., 2008, Grosso and Monteiro, 2008**).

❖ **Fageda, Xavier, 2000** in his Conference Paper "*Load centers in the Mediterranean port range. Ports hub and ports gateway*" mention that competition among main Mediterranean ports for becoming the dominant port of the system, called Load centers, is under the consideration of his research. The broadening of container use has involved deep changes in the maritime transport, especially with regard to port competition. Different ports shares the same hinterland whose borders depend on the development of intermodal transport corridors and not on exclusive market areas of each port, so it takes places a direct competition between ports far away one of each other. Port competition is not only referred to widen the neighboring influence area but as well to its transshipment function, that is, attracting those throughput whose origin or destination is not the own port. In fact, in his paper the author analyze the competition between main Mediterranean ports for becoming load centers as maritime hubs as well as gateways. The distinction allows a better approach to the study of competition between main Mediterranean ports. The total shift shows the total container number (in this case TEU) each port has lost or won from the intra-range port competition, with expected container throughput (share effect) as point of reference. Regarding port competition in order to reach gateway status, port of Geneva, according the writer is so far port with the best results and it is also the winner of the intense competition between ports of Barcelona, Valencia,

Marcella and Geneva for becoming southern Europe gateway with regard to traffic between Far East and North Europe.

❖ **Itoh et al, 2002**, in another study "*An analysis of cargo transportation behavior in Kita* Kanto *(Japan)*" the following variables have been used to determine the port choice behavior. At first based on the **port** characteristics: **(1)** Ship calls, **(2) Total vessels' capacity (DWT)**, **(3)** TEU per berth, **(4) TEU of Crane**, **(5)** Average handling volume per meter and **(6)** Port and Loading Charges. Subsequently based on the **shippers** own characteristics: **(1)** Distance of shipper from port, **(2) Time of travel to the shipper from port**, **(3)** Type of trade, **(4) Municipality output** and **(5) Shipper's facilities variable** whereas the bold are the most important variables.

❖ **Wen-Chih Huang et al, 2003** in their study "*Port Competitiveness Evaluation by Fuzzy Multicriteria Grade Classification Model*" follows the FMGC model measured the competitiveness of eight East Asian container terminals. Moreover their evaluation include the following categories of research quantitative methods: DEA, OCRA, game theories, productivity analysis and MCDM. Their research include 31 variables shared in two categories, 11 refers to the *terminal efficiency* and the rest 21 refers to terminals effectiveness. (The *italics* marks the category *terminal efficiency*).The 31 variables of competitiveness are: **(1)** *Labor quality*, **(2)** Customs service impact, **(3)** *Operational efficiency*, **(4)** *Liberalization of operation*, **(5)** Operation cost of carriers, **(6)** Port services charge, **(7)** Ship mean time in port, **(8)** *Machinery loading/unloading efficiency*, **(9)** *Container terminal movement capability*, **(10)** Port location, **(11)** Sailing points, **(12)** Schedule, **(13)** In-bound / out-bound container, **(14)** Number and ratio of transshipment containers, **(15)** Rail/ highway transport, **(16)** Waterway transport, **(17)** *Number of deep-draft wharves*, **(18)** *Number of operational machinery*, **(19)** *Operational land for container terminals*, **(20)** *Container automation*, **(21)** *EDI*, **(22)** *Shipping information*, **(23)** Land of warehouse / logistics, **(24)** Investment plan, **(25)** Investors of wharves, **(26)** Operator, **(27)** Political stability, **(28)** Social stability, **(29)** Hinterland productivity, **(30)** Economic stability, **(31)** Financial liberalization.

❖ **Lirn et al, 2003** in their study "*Transshipment port selection and decision-making behavior: Analyzing the Taiwanese case*" studies the importance of different factors affecting Taiwanese seaport competitiveness using the AHP model. From almost 50 factor of the research, in conclusion the following 15 factors are the most important: **(1)** Cargo volume, **(2)** Accessibility (land and sea), seaport infrastructure (including water depth of the terminal, number of available berths and length of berths) and intermodal links (includes highway, rail), **(3)** Port facilities and equipment (superstructure), **(4)** Size of terminal, **(5)** Logistic services, **(6)** Geographical advantage and proximity of competitive ports, **(7)** Security and seaport safety,

(8) Terminal operation and risk management, **(9)** Loading / unloading rate and berthing delay, **(10)** Customs regulations and port administration, **(11)** Ownership of terminal and port, **(12)** Loading and discharging cost, **(13)** Privileged carrier terms, **(14)** Proximity to feeder ports, and **(15)** Deviation from main navigation routes.

❖ **Sheila Farrell, 2011** in her article "*The ownership and management structure of container terminal concessions*" examines **(1)** The impact of concessioning on the balance between public and private sector control, **(2)** The use of competitive tendering to assign concessions, **(3)** The structure of the Special Purpose Vehicles (SPVs) to which concessions were originally awarded, and **(4)** The way in which the ownership of these SPVs has changed over time through merger and acquisition activity. In her research examines **(1)** Geographical differences in concessioning processes, **(2)** The growth of competitive tendering, **(3)** The reasons for multi-company ownership of many terminal concessions, **(4)** The dominant role of shipping lines and global terminal operators, and **(5)** The sale and purchase of stakes in terminal concessions after they have been awarded.

❖ **Maria Rosa Pires da Cruz et al, 2013** in an equal study with the title "*Key factors of seaport competitiveness based on the stakeholder perspective: An Analytic Hierarchy Process (AHP) model*" from the perspective of Iberian seaports stakeholders using the same AHP model, demonstrates that seaport users and seaport service providers differ in their understanding of the key factors of seaport competitiveness. The evaluation of the results from the seaport authorities and terminal operators' perspective, gives that **(1)** Seaport facilities and equipment is the most important factor followed by **(2)** Channel depth, **(3)** Intermodal links, **(4)** Vessel turnaround time and **(5)** Proximity to import/export areas. **(6)** Vessel turnaround time is considered by ocean carriers as the most influential factor to competitiveness, followed by **(7)** Intermodal links, **(8)** Seaport facilities and **(9)** Equipment, proximity to import/export areas.

❖ **Sami Bensassi et al, 2015**, in their paper "*Relationship between logistics infrastructure and trade: Evidence from Spanish regional exports estimates that Geographical factors and transport infrastructure*" estimates that Geographical factors and transport infrastructure are two of the key determinants that influence international competitiveness. The findings show that logistics is indeed important for the analysis of trade flows in goods and they highlight the importance of logistics measures at the regional level. In particular, the number, size and quality of logistics facilities positively influence export flows.

❖ **Ancor Suárez-Alemán et al, 2016**, in their paper "*When it comes to container port efficiency, are all developing regions equal?*" they examine the evolution and drivers of productivity and efficiency changes across developing regions. Their analysis indicates that

(1) Private sector participation, **(2)** The reduction of corruption in the public sector, **(3)** Improvements in liner connectivity and **(4)** The existence of multimodal links increase the level of port efficiency in developing regions.

❖ **Nils Kemme, 2020** in the chapter "*State-of-the-Art yard crane scheduling and stacking*" from his book "*Design and Operation of Automated Container Storage Systems*" points out that the container yard plays a vital role for the performance and competitiveness of container terminals as the interface between waterside and landside transport chains. Most terminals of relevant size nowadays deploy gantry cranes for container stacking operations, which are therefore key elements of modern terminal planning. The creation of an efficient terminal design therefore requires a profound understanding of the capabilities and performance of gantry cranes, which is in turn largely determined by the rules and strategies defining the way these machines are deployed in operation. All this data cover the container stacking and yard crane schedule and finally explains the strategical implications for terminal planning.

❖ **Dimah H. Alahmadi et al, 2021** from King Abdulaziz University of Jeddah in their research "*Comparative analysis of blockchain technology to support digital transformation in ports and shipping*" says that blockchain can support digital transformation in industries in many aspects as this sophisticated technology can provide a decentralized, transparent, and secure environment for organizations and businesses. In other words their study gives insight analysis how incorporate blockchain technology into ports and shipping processes globally to support digital transformation, not only integrated into the current ports and shipping ecosystem such as financial and document workflow.

❖ **Qifei Ma et al, 2021**, in their study "*Port integration and regional economic development: Lessons from China*" they adopt through the DID model to analyze the effect of PInt. They stated that PInt has positive effects on the rationalization of port resources and allocation among regional ports, promoting, in this way urban economic growth. In China, in particular, the country's Pint strategy has effectively driven the development of numerous ports, and it has successfully contributed to the development of the country's strong transportation network.

❖ **Adam Kaliszewski et al, 2021**, published the study "*Key factors of container port competitiveness: A global shipping lines perspective*" aiming to examine factors of global competitiveness of container ports as perceived by shipping lines through a quantitative primary non-random social research sampling model. They evaluated the importance of this three factors: **(1)** Container terminal service quality, (**2)** Social harmony with labour and **(3)** Adequate nautical accessibility corresponding with growing size of container ships, which

require deep water container terminals and reliable port services. As a result shipping lines' decision makers need services of a high standard and with a low risk of labour-related disruptions to maintain their own high level of service quality. Also they mentioned that the factors' relative importance depends on the location of the port, the situation in the market and it can be perceived differently by different groups of stakeholders.

❖ **Desmond Ighravwe et al, 2021,** in their study "*Adoption of a multi-criteria approach for the selection of operational measures in a maritime environment*" proposes a framework for selecting operation measures for the maritime industry. It uses stakeholders' expectations for operational criteria and fuzzy logic to design the framework. Nine criteria were considered in this framework. During the process, (**1)** Hinterland traffic diversion, **(2)** Congestion pricing, **(3)** Off-dock container yards, **(4)** Fast rail shuttles and **(5)** Expanded rail connections were considered as alternatives for seaport operational measures. The study's insights show that mathematical models can be used to help seaports decisions.

❖ **Sedat Başтuğ et al, 2022** in a latest survey with FAHP (Fuzzy) method having the interesting title *Port competitiveness:* "*Do container terminal operators and liner shipping companies see eye to eye?*" identifies that the factors port operators consider important for the competitiveness of their port are not necessarily of equal importance for shipping companies when selecting a port. For port operators, the most important criterion for competitiveness is **(1)** Port location, followed by **(2)** Service level, **(3)** Port tariffs, and **(4)** Port facilities (total cargo volume handling and berthing). In contrast, the most important criterion for carriers is (port) **(5)** Operational efficiency. The least important criteria for both groups of actors are the institutional framework of the port and its **(6)** Ownership status, respectively.

❖ **Enrico D' Agostini et al, 2022** in their research "*Q-method and its application in clustering Hong Kong shippers' selection criteria of ocean carriers*", through a mix of qualitative and quantitative analyses, investigate shippers' choice behavior regarding ocean carriers in Hong Kong. Three are the unique clusters of shippers with different needs when considering the ocean carrier selection process: **(1)** Reliability and flexibility of service achiever, **(2)** Long-term shipper-carrier relationship builder and **(3)** Customer service and cost-saving seeker.

❖ **Wen-Kai K Hsu et al, 2022**, in their empirical study "*Assessing the investment environment in container terminals: A knowledge gap model*" for the TIPC based on an improved fuzzy AHP approach, the results indicate that evaluation criteria include: **(1)** Intra-port coopetition, **(2)** Number of shipping carriers, and **(3)** Business tax.

❖ **Meifeng Luo et al, 2022**, in their dense study "*Relationships among port competition, cooperation and competitiveness: A literature review*" through a collection of 210 papers from

1970 to 2019 and overlapping topics identified on the relationship of port competition and competitiveness, that intra-port competition can increase port competitiveness whereas both inter-port competition and cooperation are found to have positive or negative impacts, depending on the perspective of the study and the geographical location of the ports in examination.

❖ **Kahuina Miller et al, 2022**, publishers of the study "*Assessment of port efficiency within Latin America*" among the four (4) port performance indicators [**(1)** Berth length, **(2)** Port area, **(3)** The number of cranes (STS gantry and mobile), and **(4)** The number of berths], the number of STS gantry cranes and berth length had the largest and most significant impact. Some ports with high technical efficiency experienced TEU losses despite port infrastructural development and privatization. The findings also revealed that the increased competition among regional ports has negatively impacted some Mediterranean ports' TEU volumes due to port proximity.

❖ **Jurate Liebuviene et al, 2022**, authors of the study "*Comparative Analysis of Ports on the Eastern Baltic Sea Coast*" mention that the increase in the number and specialization of terminals in seaports, the improvement of machinery and the growing volume of cargo from distant countries show that port countries are increasingly inclined to invest in maritime transport, as its benefits to both the state and the population are enormous.

❖ **Ziaul Haque Munim et al, 2022**, the results in their research "*A port attractiveness assessment framework: Chittagong Port's attractiveness from the users' perspective*" indicate that the port users' find the port's connectivity most attractive and green port management practices least attractive. They also observe that port users with a high frequency of port usage find Chittagong Port less attractive compared to less frequent users. These findings have significant policy implications for the port authority and policymakers to enhance the port's attractiveness.

❖ **Vítor Caldeirinha et al, 2022**, in their study "*Port Community Systems: Accelerating the Transition of Seaports toward the Physical Internet—The Portuguese Case*" mention that in supply chains, physical and information flows have strict service quality requirements, namely transparency conditions and traceability. Port community authorities invest in electronic platforms to foster communication and integration with the companies that interact with the seaport, guiding the digitization of the seaport business. In main European and world ports, the PCS is the platform that supports the creation of a network composed of shipping agents, shippers, freight forwarders, transporters, terminals, logistics platforms, and public entities. The PI is an innovative concept that seeks new logistics solutions requiring integration

and interoperability between partners in the supply chain, including maritime and land transport.

The above mentioned review is the identification of port attractiveness measurement factors define the competitiveness criteria based on the relevant researches. There is limited literature on transshipment port choice, factors affecting port choice in general and factors affecting the general competitiveness of Mediterranean Sea container ports. Due to this shortage there are not papers to measure competitive position of the Piraeus/COSCO container port but only fiscal yearly statistical data. Even so, numbers are very optimistic for the Piraeus/COSCO cooperation. In order to simplify later benchmarking calculations the initial large number criteria was by being further classified into the following major criteria: **(1)** Port connectivity (port transportation network), **(2)** Port facilities (local infrastructure), **(3)** Port costs, **(4)** Port service quality (water depth of the port and area of the container yard and of marshalling yard), **(5)** Port policy and management, and **(6)** Green port management.

❖ **Notteboom (1997) and (2009)** evaluating the concentration ratio factors: the HHI, the Gini Coefficient, the Lorenz Curve and the SSA, concludes that developments in the European container port system caused the decrease of power of port concentration. In 2009 the same author in a similar study but in α wider prospect covers in general cargo traffic for 78 European ports evaluating HHI, Net Shifts and Market Share for the period 1985-2008 he resulted that the European container market remains more concentrated in comparison to other handling segments. He also observed that the European container port system is becoming more diverse, growth of traffic has benefited slightly the largest ports, leading to an increased concentration of container flows in a limited number of ports.

In the table 2 below, we are qualitative categorizing 26 **criteria** into four general criteria units affecting the port competitiveness, using outlines from the previous mentioned researches. Attempts to investigate the concentration in the 13 major Mediterranean ports of our study in order to discuss for competition, we find the following main points. **(1)** We have 34 references from researches in the category of port facilities. We can explain this number because facilities for a port is a necessary team of factors for a proper port working activity/duty. **(2)** We have 28 references in the category of port policy and management, another important team of factors. **(3)** In the third position we have the Port connectivity with 24 references. Here the team of factors refer to an easy port access, in/out. **(4)** The port costs with 18 references and (**5)** the green port management only with 6 references are the last teams of factors for an outstanding operation of a port.

To sum up, cost, quality of hinterland connections, capacity, reliability, port location (at sea or inland) and cargo base, are the most important criteria for shipping companies when the same time flexibility, customer service quality, location in port, total door-to-door transport time and feeder frequency are criteria of a lower importance.

We can call these criteria as Port's Attractiveness Assessment.

TABLE 2 – Factors affecting the competitiveness of the container ports

a/a	Criteria	Fageda, Xavier, 2000	Itoh et al, 2002	Wen-Chih Huang et al, 2003	Lirn et al, 2003	Sheila Farrell, 2011	Maria Rosa Pires da Cruz et al, 2013	Sami Bensassi et al, 2015	Ancor Suárez-Alemán et al, 2016	Nils Kemme, 2020	Dimah H. Alahmadi et al, 2021	Qifei Ma et al, 2021	Adam Kaliszewski et al, 2021	Desmond Ighravwe et al, 2021	Sedat Başţuğ et al, 2022	Enrico D' Agostini et al, 2022	Wen-Kai K Hsu et al, 2022	Meifeng Luo et al, 2022	Kahuina Miller et al, 2022	Jurate Liebuviene et al, 2022	Ziaul Haque Munim et al, 2022	Vítor Caldeirinha et al, 2022
Port connectivity																						
1	Connection to the mainline navigational route	**X**	**X**		**X**			**X**	**X**				**X**		**X**			**X**			**X**	
2	Service coverage of the major import/export areas of the country	**X**	**X**		**X**																	
3	Feeder shipping network		**X**		**X**									**X**								**X**
4	Inland waterway connectivity	**X**	**X**	**X**	**X**		**X**			**X**				**X**						**X**		

a/a	Criteria	Fageda, Xavier, 2000	Itoh et al, 2002	Wen-Chih Huang et al, 2003	Lirn et al, 2003	Sheila Farrell, 2011	Maria Rosa Pires da Cruz et al, 2013	Sami Bensassi et al, 2015	Ancor Suárez-Alemán et al, 2016	Nils Kemme, 2020	Dimah H. Alahmadi et al, 2021	Qifei Ma et al, 2021	Adam Kaliszewski et al, 2021	Desmond Ighravwe et al, 2021	Sedat Başţuğ et al, 2022	Enrico D' Agostini et al, 2022	Wen-Kai K Hsu et al, 2022	Meifeng Luo et al, 2022	Kahuina Miller et al, 2022	Jurate Liebuviene et al, 2022	Ziaul Haque Munim et al, 2022	Vítor Caldeirinha et al, 2022
Port facilities																						
5	The maximum water draft			**X**			**X**	**X**					**X**		**X**				**X**			
6	Resource for moving special cargo/shipments			**X**																		**X**
7	Number of berths at the port		**X**	**X**	**X**		**X**	**X**		**X**			**X**	**X**	**X**		**X**		**X**	**X**		
8	Sufficiency and security of storage facilities		**X**	**X**	**X**		**X**	**X**		**X**									**X**			
9	I.T. and advanced technology			**X**		**X**	**X**			**X**	**X**								**X**	**X**		**X**

a/a	Criteria	Fageda, Xavier, 2000	Itoh et al, 2002	Wen-Chih Huang et al, 2003	Lirn et al, 2003	Sheila Farrell, 2011	Maria Rosa Pires da Cruz et al, 2013	Sami Bensassi et al, 2015	Ancor Suárez-Alemán et al, 2016	Nils Kemme, 2020	Dimah H. Alahmadi et al, 2021	Qifei Ma et al, 2021	Adam Kaliszewski et al, 2021	Desmond Ighravwe et al, 2021	Sedat Başţuğ et al, 2022	Enrico D' Agostini et al, 2022	Wen-Kai K Hsu et al, 2022	Meifeng Luo et al, 2022	Kahuina Miller et al, 2022	Jurate Liebuviene et al, 2022	Ziaul Haque Munim et al, 2022	Vítor Caldeirinha et al, 2022
Port costs																						
10	Container/cargo handling fee		X	X	X									X	X	X	X					
11	Storage fees			X		X																
12	Reliability of the berth schedule																					
13	Slot exchange facility with cooperating shipping line			X			X	X	X													
14	Ability to handle large volume shipments			X																		
15	Reliability of cargo/container handling at the port			X			X	X								X						

a/a	Criteria	Fageda, Xavier, 2000	Itoh et al, 2002	Wen-Chih Huang et al, 2003	Lirn et al, 2003	Sheila Farrell, 2011	Maria Rosa Pires da Cruz et al, 2013	Sami Bensassi et al, 2015	Ancor Suárez-Alemán et al, 2016	Nils Kemme, 2020	Dimah H. Alahmadi et al, 2021	Qifei Ma et al, 2021	Adam Kaliszewski et al, 2021	Desmond Ighravwe et al, 2021	Sedat Başţuğ et al, 2022	Enrico D' Agostini et al, 2022	Wen-Kai K Hsu et al, 2022	Meifeng Luo et al, 2022	Kahuina Miller et al, 2022	Jurate Liebuviene et al, 2022	Ziaul Haque Munim et al, 2022	Vítor Caldeirinha et al, 2022
Port policy and management																						
16	Custom clearance procedure		X	X											X							
17	Support from the Port staffs		X	X		X							X									
18	Port authority policy and regulations				X	X			X							X						
19	Public reputation of the port		X	X	X	X							X									
20	Efficiency of administrative procedure			X	X	X		X	X					X	X	X	X	X				
21	Urban economic growth											X								X		

a/a	Criteria	Fageda, Xavier, 2000	Itoh et al, 2002	Wen-Chih Huang et al, 2003	Lirn et al, 2003	Sheila Farrell, 2011	Maria Rosa Pires da Cruz et al, 2013	Sami Bensassi et al, 2015	Ancor Suárez-Alemán et al, 2016	Nils Kemme, 2020	Dimah H. Alahmadi et al, 2021	Qifei Ma et al, 2021	Adam Kaliszewski et al, 2021	Desmond Ighravwe et al, 2021	Sedat Başтuğ et al, 2022	Enrico D' Agostini et al, 2022	Wen-Kai K Hsu et al, 2022	Meifeng Luo et al, 2022	Kahuina Miller et al, 2022	Jurate Liebuviene et al, 2022	Ziaul Haque Munim et al, 2022	Vítor Caldeirinha et al, 2022
Green port management																						
22	Environmental sustainability of the economic activities linked to the port										**X**										**X**	
23	Reward/punishment of port operators over/under performing against specific environmental goals																				**X**	
24	Waste reception facilities within the port																				**X**	
25	Communication of information on green activities of the port, e.g., environmental report																				**X**	
26	Implementation of national/regional/global environmental regulations										**X**											

2.5 Conclusion of the literature review

The dynamism of the maritime sector, especially containerization, requires ports to implement value-added services and logistics centers in tandem with port performance indicators to remain sustainable and competitive in the maritime industry.

Apart from that let us focus on the main objective of our paper, the Piraeus port. No one in the Greece can imagine the city of Piraeus without the Port of Piraeus! Through over the years, on the historic route of the city, the port was directly connected to the local economy but also to the society. It is known that in times of port's decline the city virtually did not exist. The course of the city and the port, historically appears common. In other words, we are talking about a port city. Today, being a modern 4th generation and beyond port, contributes financially and developmentally throughout the country and its scope escalates from local, regional, national and from there to supranational and global level.

But in this new, constantly changing, international and globalized environment, its development role becomes even more important and its contribution in local development more relevant than ever. The local level must be protected, the port's relationship with the urban fabric and the local community it is necessary not to disturb. Thus it can contribute to the sustainable approach to development, mediating into economic growth, contributing in various ways to its growth business and employment, serving the needs of the local society and reducing, by taking appropriate measures, for environmental problems and negative consequences that it causes.

To study the contribution of the port effects to the local development of its wider area Piraeus, it was deemed necessary to investigate the influence of the port towards the four municipalities of Piraeus that are directly connected to the port were defined, not only with socio-economic criteria, but also spatial planning, since in the specific municipalities all the facilities and the parts that make up its whole are spread around the perimeter.

Following our research and based on the previous literature we will investigate more specifically through figures and tables, where the comparison it is easy, the major part of the criteria as well as the socio-economic and the environmental factors that determine the local development of the port of Piraeus and the port competition among 13 major Mediterranean ports.

PART TWO

CHAPTER 3

METHODOLOGY

3 Introduction

Based on literature, in this chapter we intend to develop in a first section our research methodology. We define the Mediterranean Sea maritime market and we select 13 major ports (container terminals) to identify and evaluate the port competition into the region for the period 2016-2020. As we see these ports are: Alexandria (Egypt), Algeciras (Spain), Ambarli (Turkey), Barcelona (Spain), Damietta (Egypt), Genoa (Italy), Gioia Tauro (Italy),Haifa (Israel), Izmir (Turkey), Marsaxlokk (Malta), Mersin (Turkey), Piraeus (Greece), Port Said-West (Egypt), Port Said-East (Egypt), Tanger Med (Morocco) and Valencia (Spain). Having in our mind that technical inefficiency prevails in the economic performance model of the ports of the region, in a qualitative, quantitative approach we use the Market Share Analysis, the Herfindahl–Hirschman Index (HHI), the Concentration Ratio (CR4 & CR8), and the Shift-Share Analysis as methods for benchmarking technique to determine the present leader port in the Mediterranean Sea. We use a number of variables from most updated cargo volume data to make our calculations. However our study focused on comparing also the performance and efficiency of these container ports. It is interesting that the Mediterranean ports achieved efficient utilization of berths, cranes and total areas, while in terms of timeless, labor and tug utilization are far away from a proper situation management. But it is more interesting that many ports can increase both their throughput and their performance by developing other aspects of the port, mainly the infrastructure. So it is not far away from truth to say that the **ports and terminals of the Mediterranean region do not face size problem, but management problem**! Nevertheless an exogenous factor such China's trade greatly affects the prosperity of Mediterranean stations port and terminal traffic.**[Notteboom, Coeck and Van den Broeck (2000), Cullinane and Song (2003, 2006), Tongzon and Heng (2005), Sun, Yan and Liu (2006), Tovar and Trujillo (2007)., SFA [Tongzon and Heng (2005), Cullinan et al (2005)] and DEA [Roll et Hayuth (1993), Liu (1995), Tongzon (2001), Valentine et Gray (2001), Cullinan et al (2004, 2005)]**, In the second section, we seek to understand the determinants of performance of the economy in the port sector. We will evaluate the TEU performance for the Mediterranean container ports, with main port / terminal the Piraeus port. To do this, we use the panel of the mentioned 13 ports in a wide range of calculations and diagrams as answers which are more understandably. The performance is a relative concept, as is efficiency and should be determined in comparison to a basic report. Our model seems sufficient to establish this benchmarking by calculating border scores representing best practices in the market, so the performance of the leading port will be compared to this limit as

well as the total scores. We present and describe the models and discuss in brief the empirical results in the context of Mediterranean ports.

3.1 Methodology, discussion and results

Since 1988 many researchers used the concentration ratio analysis to determine the relationship between the number and the utilization of the container ports in a specific region. **Hayuth** in **1988** studies the **US ports**, **Herfindahl–Hirschman** in **1995 & 2010** study the **East Mediterranean** region using the HH Index as well as shift – share analysis and **Notteboom** in **1997** & **2010** studies the relationship between concentration and terminal development in the **European** port cluster.

3.1.1 Data

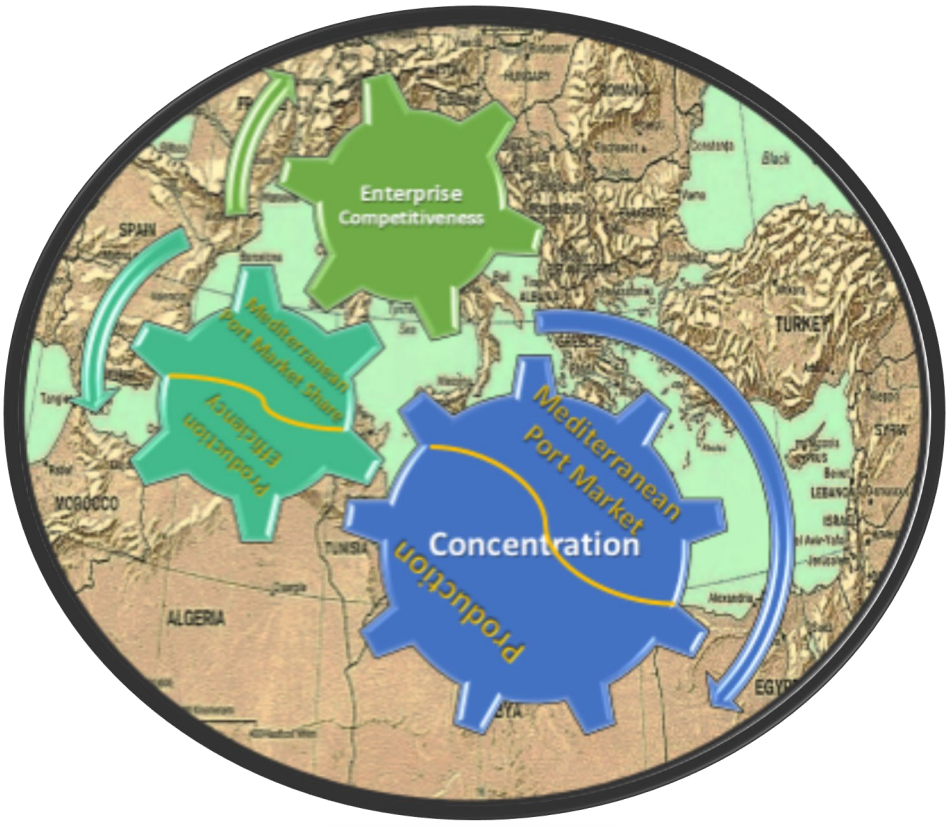


FIGURE 11 – Market concentration vs enterprise competitiveness in the Mediterranean region (2014-2020) [31]

In the table 3 below we can show in which areas of the Mediterranean region belong the 13 ports of our study, the 10-year, 5-year, 3-year Compound Annual Growth Rate from 2011 to 2021 as well as the Growth (rate of the real gross) domestic product. An important element of the table is that the source determines validity level for the country's growth rate. The data will help us later below, to compare region's growth periods in relation to the development of the relative port.

TABLE 3 - Larger ports/Region in Mediterranean Sea and GDP from 2011 to 2021[30]

REGION	PORT	GDP Data Quality	CAGR 10 YEAR 2011-2020	CAGR 05 YEAR 2016-2020	CAGR 03 YEAR 2018-2020	Global GDP Share %
Egypt	Alexandria	C	4,6%	6,1%	4,6%	1,1%
	Port Said					
Greece	Piraeus	A	-1,0%	0,1%	-1,0%	0,2%
Italy	Genoa	A	-0,3%	0,0%	-0,8%	1,9%
	Gioia Tauro					
Malta	Marsaxlokk	A	0,4%	0,1%	-1,5%	1,4%
Morocco	Tanger Med	B	2,8%	2,5%	1,8%	0,2%
Spain	Barcelona	A	0,4%	0,1%	-1,5%	1,4%
	Algeciras					
	Valencia					
Turkey	Izmir	B	5,2%	5,0%	4,9%	2,1%
	Mersin					
	Ambarli					

Key:

Data Quality Grade definitions:

A: As good as it gets;

B: Use with caution;

C: Unreliable for many purposes

D: Extremely poor quality.

Furthermore in figure 12 below we have the annual TEU throughput per year from 2014 to 2020. It is easy to understand from the figure that we can divide the ports for this period into

three categories. The first with total throughput from 25 million to 35 million TEU's with the ports of Tanger Med, Piraeus, Valencia, Algeciras and Port Said, the second from 20 million

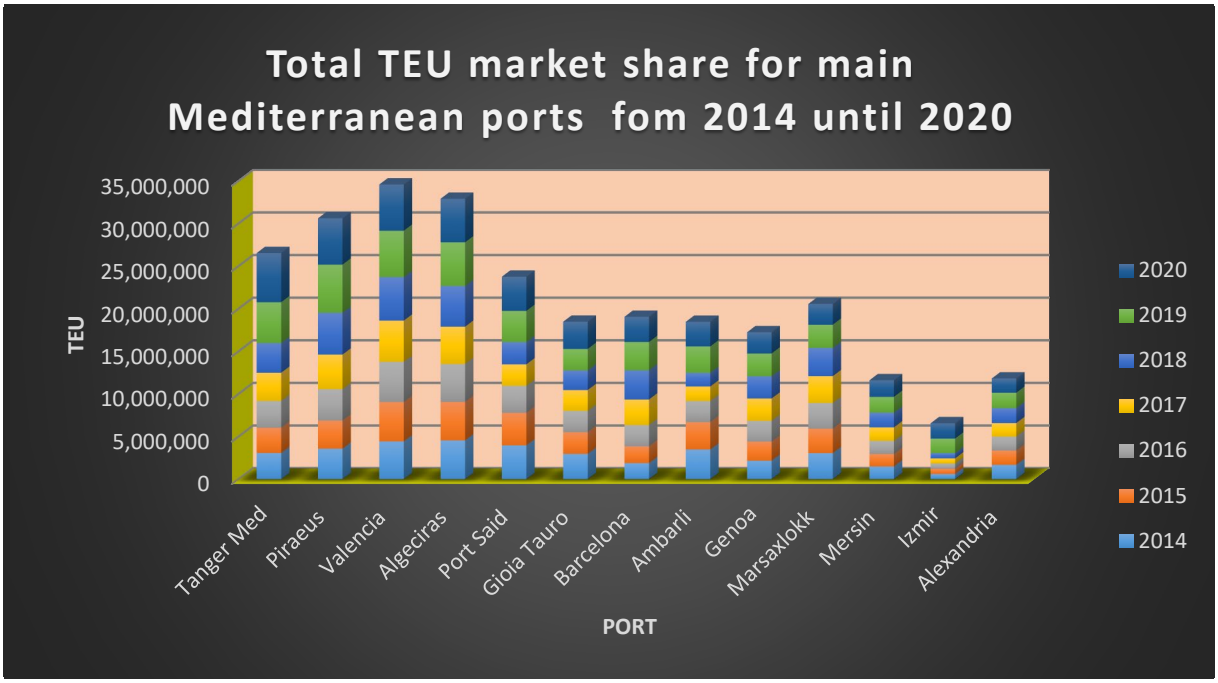


FIGURE 12 – Total TEU market share for main Mediterranean ports (2014-2020)[32]

to 25 million TEU's with the ports Gioia Tauro, Barcelona, Ambarli, Genoa and Marsaxlokk and in the third, the last one from 5 million to 10 million with the ports of Mersin, Izmir and Alexandria. In the named period 272,25 million TEU's (approximately 4 billion tones) of goods moved to and from these ports.

The following diagrams from 13 to 25 show the annual container throughput of our study ports from 2014 to 2020. I would like to mention that I have emailed an official paper in every port's administration (of the chosen 13) and requested TEU annual traffic data for each port from 1994 to 2014, with no further response except the authorities of the port of Barcelona which responded replying. I would like to thank the Barcelona's port administration once again for their deep professionalism. Therefore, I only have complete data for this port from 1994. From the comparative study of the diagrams we can conclude the period from 2014 to 2020 as the period which in-depth statistical study will give us reliable data on port's competitiveness and operation.

3.1.2 Analysis

Our primary research consideration and objective of the paper is to examine concentration/de-concentration tendencies of container volumes within the 13 selected major Mediterranean ports for the period 2014-2020.

For the purposes of this study we will employ:

- The n-firm concentration ratio [**Bikker and Haaf (2002), Varan and Cerit (2014)**], given by the formula:

$$CR_n = \sum_{i=1}^{n} S_i \quad \textbf{(1)}$$

Where CR_n refers to n number of firms concerned (here 13 ports), while S_i signifies the market share (here TEU) of the i^{th} firm (port) taken into account.

- Another concentration ratio, the Hirshmann-Herfindahl Index (HHI), [**Notteboom (1997) and (2009)**], given by the formula:

$$HHI = \sum_{i=1}^{n} S_i^2 \quad \& \quad \frac{1}{n} \leq HHI \leq 1 \quad \textbf{(2)}$$

Where n is the number of firms concerned (here 13 ports), while Si signifies the market share (here TEU) of the i^{th} firm (port) taken into account.

The HHI is a common measure of market concentration and is used to determine market competitiveness taking into account the relative size distribution of the firms in a market. The lower the HHI is, the more power consumers hold in that industry. Thus, prices are usually lower, and company margins compressed. This index accepted by the **USA Department of Justice and the USA Federal Trade Commission**. The Horizontal Merger Guidelines issued August 19, 2010 from this department based on the utilization of this index.

- The Gini coefficient, [**Hayuth (1988)**, **Wang and Cullinane, (2004)**], given by the formula:

$$G = 0,5 * \sum_{i=1}^{n} |X_i - Y_i| \quad \& \quad 0 < G < 1 \quad \textbf{(3)}$$

Where n is the number of firms concerned (here 13 ports), X_i is the cumulative percentage of the number of firms (ports), Y_i is the cumulative percentage of market shares of all firms (TEU throughput from all the 13 ports). The value of Gini coefficient ranges between 0 (perfect equality) and 1(perfect inequality). When all ports, are of equal size, the value of Gini coefficient

is 0. On the opposite, when one port only has a very excessive TEU throughput, Gini's value reaches 1, denoting full concentration of TEU traffic within the market. In our research we use Lorenz curve to compare the distribution of TEU port throughputs with the uniform distribution that represents equality, shown by a diagonal line (egalitarian line).

- The Lorenz curve is a popular statistical measurement of incomes, which as stated [**Sys (2009)**] serves for the measurement of market concentration. In our research Lorenz curve represents variations in TEU throughput of all 13 Mediterranean ports. The relationship between Lorenz curve and Gini coefficient, is that the Gini index is the ratio of the area between the line of equality and the Lorenz curve (inequality line).

- The SSA [**Notteboom (1997)**], given by the following formulas:

$$\mathrm{SHARE_i} = \left(\frac{\sum_{i=1}^{n} \mathrm{TEU_{it1}}}{\sum_{i=1}^{n} \mathrm{TEU_{it0}}} - 1\right) * \mathrm{TEU_{it0}} \quad \textbf{(4)}$$

$$\mathrm{SHIFT_{it1}} = \mathrm{TEU_{it1}} - \frac{\sum_{i=1}^{n} \mathrm{TEU_{it1}}}{\sum_{i=1}^{n} \mathrm{TEU_{it0}}} \mathrm{xTEU_{it0}} \quad \textbf{(5)}$$

$$\mathrm{ABSGR_i} = \mathrm{TEU_{it1}} - \mathrm{TEU_{it0}} = \mathrm{SHARE_i} + \mathrm{SHIFT_i} \quad \textbf{(6)}$$

Where $\mathrm{SHARE_i}$ is the share effect in TEU of the i^{th} container port for the period t_1-t_0, $\mathrm{SHIFT_{it1}}$ is the shift effect in TEU of the i^{th} container port for the period t_1-t_0, $\mathrm{ABSGR_i}$ is the absolute growth in TEU of the i^{th} container port for the period t_1-t_0, $\mathrm{TEU_i}$ is the throughput volume of the i^{th} container port, n is the number of container ports (13 for our paper).

3.1.3 Market Share Analysis

The following table 12 gives us the TEU throughput for the 13 major ports of the Mediterranean region for the period from 2014 to 2020 as well as the percentage of handling in each of them. Initially, we observe that the minimum container traffic took place in 2014 in the port of Izmir with 610.908 TEU, 1,6% of the annual total traffic, while the highest occurred in 2020 in the port of Tanger Med with 5.771.200 and 12.8% of the total traffic. Every year the amount of TEU throughput is 37 million for 2014, 36 million for 2015, 2016, 2017, 38 million for 2018, 44 million for 2019 and 45 million for 2020. The port of Piraeus is located in the first 5 Mediterranean ports, from where 53% of the annual cargo is handling. More specifically, it was 4th in 2014 and 2015 with 9,68% and 9,22% respectively, climb in the 3rd position in 2016 with 10,27% and 2017 with 11,3%, reach the 1st in the 2019 with 12,72% and drop 2nd in 2020 with 12,04%. There is a strong competition between Valencia and Algeciras the Spain ports and Piraeus,

each of them have market share 12,02% ,11,31% and 12,04% of fiscal's year 2020 Mediterranean containers market. However there is no clear leader in this competition.

The Piraeus port operated by Piraeus Container Terminal (PCT), a subsidiary of COSCO, the port of Valencia by APM Terminal Valencia's Multipurpose Terminal the port of Algeciras by Cámara de Comercio de El Campo de Gibraltar and the 1st port for 2020, the port of Tanger Med, Morocco operated by APM Terminal

The significant improvement of the market share of the Piraeus from 2016 was mainly the result of the investment of COSCO shipping line in the port. In table 10 we show the operators of the ports. It is obvious that the agreement for the port of Piraeus between the Greek government and COSO, has provided many benefits for the wider region, such as the new jobs and combined transport, thus upgrading its geostrategic role and making it very competitive in Northern Europe as well as Global Transportation Center.

[33]**TABLE 4**–Container throughput market share in Mediterranean region ports (in TEU)

PORT	REGION	2014		2015		2016		2017		2018		2019		2020			
		Total TEU	% Market Share	Total TEU	% Market Share	Total TEU	% Market Share	Total TEU	% Market Share	Total TEU	% Market Share	Total TEU	% Market Share	Total TEU	% Market Share	Global Ranking	Mediterranean Ranking
Tanger Med	Morocco	3.080.000	8,3	2.964.324	8,3	3.138.367	8,8	3.312.409	9,2	3.472.451	9,1	4.801.713	10,8	5.771.200	12,8	25	1
Piraeus	Greece	3.585.155	9,7	3.300.000	9,2	3.680.000	10,3	4.060.000	11,3	4.908.000	12,9	5.648.056	12,7	5.437.477	12,0	**28**	**2**
Valencia	Spain	4.441.949	12,0	4.615.196	12,9	4.723.666	13,2	4.832.136	13,5	5.104.000	13,4	5.439.827	12,3	5.428.307	12,0	**29**	**3**
Algeciras	Spain	4.556.465	12,3	4.515.768	12,6	4.448.309	12,4	4.380.849	12,2	4.772.000	12,5	5.125.385	11,5	5.107.873	11,3	**33**	**4**
Port Said	Egypt	3.975.747	10,7	3.810.437	10,6	3.169.219	8,8	2.528.000	7,1	2.610.000	6,8	3.658.159	8,2	4.009.672	8,9	**46**	**5**
Gioia Tauro	Italy	2.970.000	8,0	2.547.000	7,1	2.497.785	7,0	2.448.570	6,8	2.301.000	6,0	2.523.000	5,7	3.193.000	7,1	**57**	**6**
Barcelona	Spain	1.893.836	5,1	1.965.240	5,5	2.486.056	6,9	3.006.872	8,4	3.423.000	9,0	3.324.650	7,5	2.958.040	6,6	**64**	**7**
Ambarli	Turkey	3.487.677	9,4	3.220.506	9,0	2.465.932	6,9	1.711.357	4,8	1.591.983	4,2	3.104.882	7,0	2.887.800	6,4	**66**	**8**
Genoa	Italy	2.172.944	5,9	2.242.902	6,3	2.432.545	6,8	2.622.187	7,3	2.609.000	6,8	2.669.917	6,0	2.498.850	5,5	**73**	**9**
Marsaxlokk	Malta	3.064.005	8,3	2.869.131	8,0	3.009.566	8,4	3.150.000	8,8	3.310.000	8,7	2.722.889	6,1	2.441.589	5,4	**76**	**10**
Mersin	Turkey	1.498.850	4,0	1.466.119	4,1	1.529.051	4,3	1.591.983	4,4	1.723.000	4,5	1.854.312	4,2	1.948.700	4,3	**90**	**11**
Izmir	Turkey	610.908	1,6	610.908	1,7	610.908	1,7	610.908	1,7	610.908	1,6	1.715.193	3,9	1.800.642	4,0	**97**	**12**
Alexandria	Egypt	1.688.301	4,6	1.677.986	4,7	1.633.493	4,6	1.589.000	4,4	1.757.000	4,6	1.800.391	4,1	1.677.017	3,7	**99**	**13**
	Total	**37.025.837**	100,0	**35.805.517**	100,0	**35.824.897**	100,0	**35.844.271**	100,0	**38.192.342**	100,0	**44.388.374**	100,0	**45.160.167**	100,0		

3.1.4 Herfindahl–Hirschman Index (HHI)

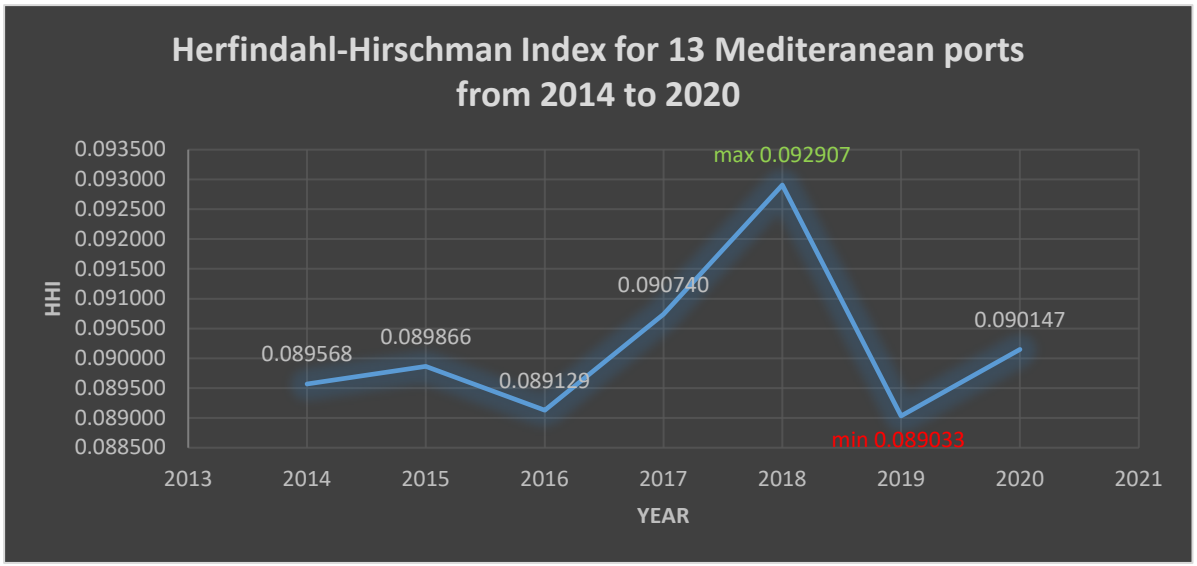


FIGURE 28 – Herfindahl-Hirschman Index for 13 Mediterranean Ports (2014-2020)[32]

At this point in our research we will look at the HHI index. We have reported that with this index we measure the concentration of values in market entities in order to have a first and fairly clear picture of market competitiveness. In the present study we have to approach the competition in the annual handling of containers from the 13 major ports in the Mediterranean. The mathematical formula of the HHI is mentioned in paragraph 3.1.2 hereof as (2). The requirement must be met the relationship $\frac{1}{n} \leq \mathrm{HHI} \leq 1$. So, for n=13 ports must be $0{,}076923 \leq \mathrm{HHI} \leq 1$, which applies to the table 6. From our check in figure 28 it appears that minHHI=0,089033 and maxHHI=0,092907. Always is HHI>0,076923 and the Table 6 contains the HHI value limits which determine the classification of the market concentration as **Un-concentrated – Effective competition**.

[34]**TABLE 5** – Market concentration based on Herfindal – Hirschman Index (HHI)

HHI	Market concentration
HHI < 0,1 (or 1.500)	Un-concentrated – Effective competition
0,1 (or 1.500) ≤ HHI ≤ 0,18 (or 2.500)	Moderately Concentrated – Monopolistic competition
0,18 (or 2.500) < HHI	Highly Concentrated – Oligopoly, dominant firm with competitive fringe or monopoly

In the diagrams 27 and 28 we have the graph of the annual TEU throughput during the period from 2014 to 2020 in number of containers and in percentage distribution in the whole specific market (13 major Mediterranean ports). In figure 28 of the annual percentage distribution of

container handling we show a trend of market equilibrium (curves without engagement with each other), but I will address the issue below in another section. The port of Piraeus occupying the 2nd position in the evaluation of 2020 after 1st port Tanger Med (Morocco) and before the 3rd port of Valencia (Spain) and 4th port Algeciras (Spain) shows a distinct percentage of annual service without vague compressions, as seen in 12th port Izmir.

The HHI is fluctuated between 0,089033 and 0,092907 over the period 2014 to 2020. Following the HHI fluctuations, HHI first rises from 0,089568 (in the year of 2014) to 0,089866 (in 2015) then falls to 0,089129 (in 2016), before re-rise to 0,090740, max=0,0922907 (in 2017 and 2018), then drops to min=0089033 (in 2019) before re-rises again to 0,090147 (in 2020). In the entire period the HHI is smaller than 0,1, indicating that the containers market in Mediterranean region tends to a degree of Un-concentrated – Effective competition.

The results demonstrate that the 1st port for 2020, the port of Tanger Med (Morocco) has an increase 2% from 2019 (in TEU market share), as well as the port of Gioia Tauro (Italy) has 1,5% increase. All other ports has almost flattened with close annual values as 2019.

The same time port of Piraeus keeps a continuing growth rate having 9,7% of the total TEU throughput for 2014 and takes the 4th position as well as 2015 with 9,2%, 10,3% for 2016 and 3rd as well as 2017 with11,3%, 12,9% for 2018 and 2nd , 12,7% for 2019 and 1st and 12,0% for 2020 and 2nd position. It is expected that further growth of container throughputs of Piraeus, Valencia and Algeciras ports, the figure of HHI index of the port cluster will further increase. The port competition in Mediterranean region tends to centralize.

All the above commends show that the port of Piraeus is a very competitive port. Always is between the leader European/Mediterranean ports. Hence the answer in our second Indirect research question is negative.

[33]**TABLE 6** –Herfindal – Hirschman Index (HHI)

PORT	REGION	2014		2015		2016		2017		2018		2019		2020			
		% Market Share	SI_i^2	% Market Share	SI_i^2	% Market Share	SI_i^2	% Market Share	SI_i^2	% Market Share	SI_i^2	% Market Share	SI_i^2	% Market Share	SI_i^2	Global Ranking	Mediterranean Ranking
Tanger Med	Morocco	8,32	0,00692	8,28	0,008683	8,76	0,01064	9,24	0,012811	9,09	0,01517	10,82	0,017738	12,78	0,02050	2	1
Piraeus	Greece	9,68	0,00937	9,22	0,008494	10,27	0,01055	11,33	0,012830	12,85	0,01651	12,72	0,016190	12,04	0,01449	2	2
Valencia	Spain	12,00	0,01439	12,89	0,016614	13,19	0,01738	13,48	0,018174	13,36	0,01785	12,26	0,015019	12,02	0,01444	2	3
Algeciras	Spain	12,31	0,01514	12,61	0,015906	12,42	0,01541	12,22	0,014937	12,49	0,01561	11,55	0,013333	11,31	0,01279	3	4
Port Said	Egypt	10,74	0,01153	10,64	0,011325	8,85	0,00782	7,05	0,004974	6,83	0,00467	8,24	0,006792	8,88	0,00788	4	5
Gioia Tauro	Italy	8,02	0,00643	7,11	0,005060	6,97	0,00486	6,83	0,004666	6,02	0,00363	5,68	0,003231	7,07	0,00499	5	6
Barcelona	Spain	5,11	0,00261	5,49	0,003013	6,94	0,00481	8,39	0,007037	8,96	0,00803	7,49	0,005610	6,55	0,00429	6	7
Ambarli	Turkey	9,42	0,00887	8,99	0,008090	6,88	0,00473	4,77	0,002280	4,17	0,00173	6,99	0,004893	6,39	0,00408	6	8
Genoa	Italy	5,87	0,00344	6,26	0,003924	6,79	0,00461	7,32	0,005352	6,83	0,00466	6,01	0,003618	5,53	0,00306	7	9
Marsaxlokk	Malta	8,28	0,00684	8,01	0,006421	8,40	0,00705	8,79	0,007723	8,67	0,00751	6,13	0,003763	5,41	0,00292	7	10
Mersin	Turkey	4,05	0,00163	4,09	0,001677	4,27	0,00182	4,44	0,001973	4,51	0,00203	4,18	0,001745	4,32	0,00186	9	11
Izmir	Turkey	1,65	0,00027	1,71	0,000291	1,71	0,00029	1,70	0,000290	1,60	0,00025	3,86	0,001493	3,99	0,00159	9	12
Alexandria	Egypt	4,56	0,00207	4,69	0,002196	4,56	0,00207	4,43	0,001965	4,60	0,00211	4,06	0,001645	3,71	0,00137	9	13
	Total	100,0		100,0		100		100,0		100,0		100,0		100,0			

3.1.5 Concentration Ratio (CR_i)

In this section we determine the market concentration through a simple factor [according to **Bikker and Haaf (2002)**], which give immediate results, the concentration ratio. It refers to sum factor of the concentration of the companies with the highest concentration (for our study ports with the highest number of container handling). Ports with a low concentration factor are expected to compete with each other and a high ratio port means no competition and indicates oligopolistic or monopolistic tendencies (**Pavic, et al, 2016**). The mathematical formula of the CR_i is mentioned in paragraph 3.1.2 hereof as (1). In the table 7 below we have the concentration ratios over the 13 major ports in Mediterranean region for the top three [CR_3 (%)], top four [CR_4 (%)], top five [CR_5 (%)], top six [CR_6 (%)], top seven [CR_7 (%)] and top eight [CR_8 (%)], ports every year from 2014 to 2020. As per year 2020: **CR_3** includes the ports of Tanger Med 1st (Morocco), Piraeus 2nd (Greece) and Valencia 3rd (Spain), **CR_4** includes the ports of Tanger Med 1st (Morocco), Piraeus 2nd (Greece), Valencia 3rd (Spain) and Algeciras 4th (Spain), **CR_5** includes the ports of Tanger Med 1st (Morocco), Piraeus 2nd (Greece), Valencia 3rd (Spain), Algeciras 4th (Spain) and Port Said 5th (Egypt), **CR_6** includes the ports of Tanger Med 1st (Morocco), Piraeus 2nd (Greece), Valencia 3rd (Spain), Algeciras 4th (Spain), Port Said 5th (Egypt), Gioia Tauro 6th (Italy), **CR_7** includes the ports of Tanger Med 1st (Morocco), Piraeus 2nd (Greece), Valencia 3rd (Spain), Algeciras 4th (Spain), Port Said 5th (Egypt), Gioia Tauro 6th (Italy) and Barcelona 7th (Spain) and **CR_7** includes the ports of Tanger Med 1st (Morocco), Piraeus 2nd (Greece), Valencia 3rd (Spain), Algeciras 4th (Spain), Port Said 5th (Egypt), Gioia Tauro 6th (Italy), Barcelona 7th (Spain) and Ambarli 8th (Turkey). From all these factors we use CR_4 as well CR_8 to judge the port concentration. **Gwin (2001)** attempted, the classification of CR4 values, as in Table 8. According this classification and taking into account that $40 \leq CR_4 < 60$ (middle down), because min CR_4=42,304429% and maxCR_4=48,150524% , our Mediterranean port concentration is in middle down level which means **loose oligopoly**

[33]**TABLE 7** – Concentration ratios over larger ports in Mediterranean region

TOP MEDITERRANEAN PORTS	2014	2015	2016	2017	2018	2019	2020
CR_3 (%)	29,998252	30,385038	32,217910	34,048802	35,306688	35,796752	36,839952
CR_4 (%)	42,304429	42,996972	42,996972	46,270697	47,801339	47,343435	48,150524
CR_5 (%)	53,042193	53,639010	53,481134	53,323428	54,635170	55,584690	57,029304
CR_6 (%)	61,063619	60,752439	60,453338	60,154561	60,659938	61,268611	64,099694
CR_7 (%)	66,178523	66,241091	67,392802	68,543272	69,622468	68,758522	70,649803
CR_8 (%)	75,598099	75,235531	74,276094	73,317694	73,790798	75,753331	77,044376

[34]**TABLE 8**– Market concentration according to CR_4 values

CR_4	Market concentration
$CR_4 = 0$ (minimum)	Perfect Competition
$0 < CR_4 < 40$ (low)	Effective or Monopolistic Competition
$40 \leq CR_4 < 60$ (middle down)	Loose Oligopoly or Monopolistic Competition
$60 \leq CR_4 < 90$ (middle up)	Tight Oligopoly or dominant firm with a competitive fringe
$90 \leq CR_4 < 100$ (up)	Approaching monopoly (the dominant firm with competitive fringe or effective monopoly)
$CR_4 = 100$ (max)	

or monopolistic competition. These values indicating lesser concentration and more competition. Judging the CR_8 values we have [Durukan and Hamurcus (2009), Yasar and Kiraci (2017)] that a 48% of CR_4 has equal value with 77% CR_8 level which mean in table 12 from the year 2014 until 2019 we are in loose oligopoly when the year 2020 we are in monopolistic competition with the port of Tanger Med. The Piraeus port is always inside into the CR_4 as well as into the CR_8 and follows the loose oligopoly with the port of Valencia. In the figure 29 we have all the lines refer the CR_4 until CR_8 for the period from 2014 until 2020.

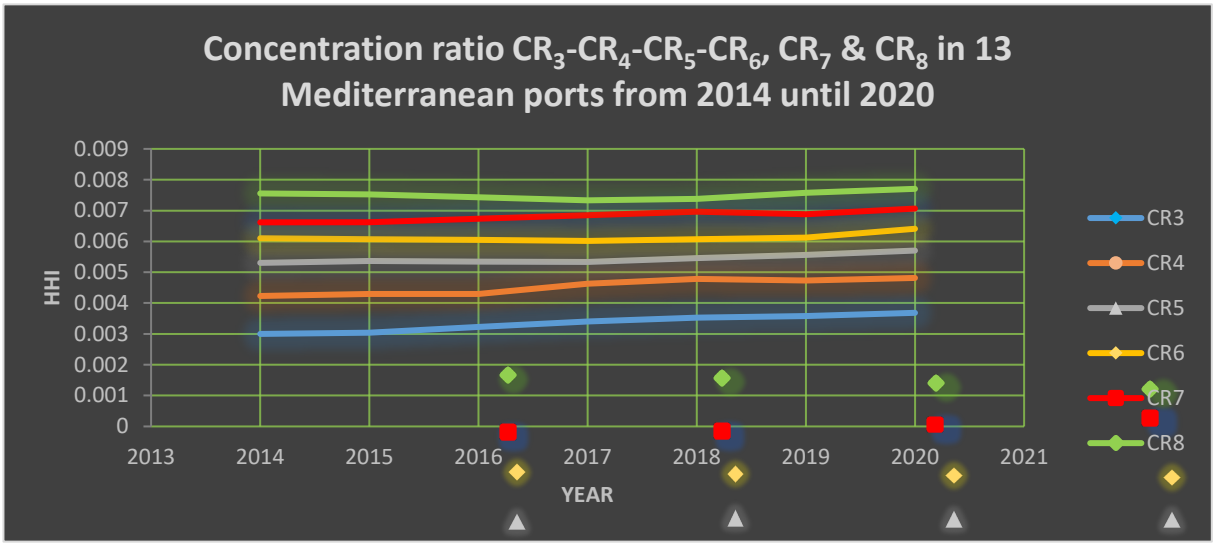


FIGURE 29 – Concentration ratio CR_3-CR_4-CR_5-CR_6-CR_7-CR_8 over 13 larger Mediterranean ports from 2014 until 2020[32]

3.1.6 Lorenz curves

In this section we talk about TEU throughput inequality in a graphical representation as in figures 31 to 37. The graph plots percentiles of the TEU throughput on the vertical axis according to total and plots cumulative total TEU throughput on the horizontal axis, so that (e.g. figure 31) a y-value of 0,744984439 and a x-value of 0,846153846 would mean that the bottom 84,614% of the TEU throughput controls 74,498% of the total TEU throughput. In other words we can say Lorenz curve in our paper represents the distribution of TEU throughput within the population of 13 Mediterranean ports. Lorenz curves in mentioned figures present analogous results which means that the inequality has very close values for every port.

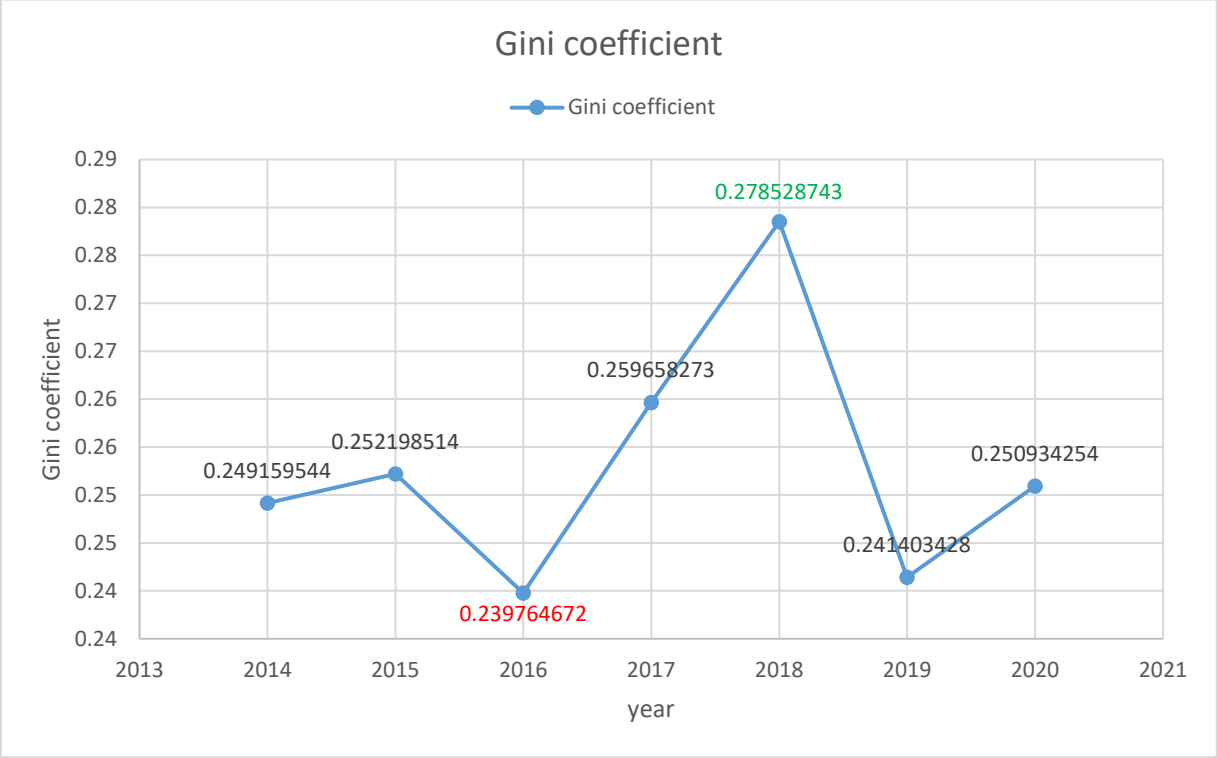
3.1.7 Gini coefficient

Furthermore, as far as the Gini coefficient is concerned, the results for the Mediterranean ports are shown in the figure 38 as well as in the table 9 below. The results illustrate a slight increase in the Gini values over 2014-2015 from 0,249159544 to 0,252198514, a drop to min 0,2397644672 for 2016 a continues increase passing 0,259658283 for 2017, peek max 0,278528743 for 2018, a decline at 0,241403428 for 2019 increasing again at 0,250934254 for 2020.

Despite these fluctuations however Gini values are considered relatively low, indicating un-concentration and hence effective competition within the range.

TABLE 9 – Gini Coefficient[33]

Year	GINI coefficient
2014	0,249159544
2015	0,252198514
2016	0,239764672
2017	0,259658273
2018	0,278528743
2019	0,241403428
2020	0,250934254



[32]**FIGURE 37** – Gini coefficient for 13 larger Mediterranean ports (2014-2020)

3.1.8 Shift – Share Analysis

Figure 39 illustrates in one chart the results of Shift Share Analysis over the 13 major ports of our research for three consecutive periods 2014 to 2015, 2016 to 2017, 2018 to 2020 and the total for 2014 to 2020. Table 10 below presents the values from our calculations for the above mentioned time periods. Moreover in following figures 40 to 43 we have a chart for every period presenting the share effect, the absolutely growth and the net shift. More specifically the port of Piraeus for the 1st period 2014-2015, lost potential volumes of more than 118.000 TEU's, as well as all the other ports. The less TEU volume lost the port of Izmir, about 20.000 TEU's. The following period, gains 2016-2017 all the ports recuperate their losses with small amounts of TEU volumes. Piraeus gains only 1.990 TEU's and after COSCO's investment at 2016, the period, 2018-2020 gains approximately 895.000 TEU and took the 2nd place over the major ports in the Mediterranean Sea. The same time the port of Valencia took the 1st place with volume of 931.000 .TEU's. The entire period from 2014 to 2020 the port of Algeciras was 1st with a volume about 1 million TEU's, Port of Valencia 2nd with 975.000 TEU's Port Said, 3rd with 873.000 TEU's and the port of Piraeus 4th with 788.000 TEU's. The competition among

the ports it is obvious. Specifically from the figure 43 we can see that the ports of Barcelona Genoa, Marsaxlokk and Alexandria lost considerable amount of volume to their rivals, while on the contrary ports of Tanger Med, Piraeus, Valencia. Algeciras, Gioao Tauro, Ambarli, Mersin and Izmir increased their market shares. Generally speaking the majority ports in the Mediterranean Sea illustrated an increase in market share over the 2014-2020 period.

[33]**TABLE 10** –Share effects-Absolute growth-Net shift effect for 13 larger Mediterranean ports (in TEU)

PORT	REGION	2014-2015			2016-2017			2018-2020			2014-2020		
		Share Effects	Absolutely Growth	Net Shift	Share Effects	Absolutely Growth	Net Shift	Share Effects	Absolutely Growth	Net Shift	Share Effects	Absolutely Growth	Net Shift
Tanger Med	Morocco	-101.512,5	-14.163,5	-115.676,0	1.697,2	172.344,8	174.042,0	633.515,2	1.665.233,8	2.298.749,0	676.655,5	2.014.544,5	2.691.200,0
Piraeus	Greece	-118.161,7	-166.993,3	-285.155,0	1.990,1	378.009,9	380.000,0	895.417,3	-365.940,3	529.477,0	787.634,7	1.064.687,3	1.852.322,0
Valencia	Spain	-146.400,5	319.647,5	173.247,0	2.554,5	105.915,5	108.470,0	931.175,6	-606.868,6	324.307,0	975.866,6	10.491,4	986.358,0
Algeciras	Spain	-150.174,7	109.477,7	-40.697,0	2.405,6	-69.865,6	-67.460,0	870.605,4	-534.732,4	335.873,0	1.001.025,0	-449.617,0	551.408,0
Port Said	Egypt	-131.035,1	-34.274,9	-165.310,0	1.713,9	-642.932,9	-641.219,0	476.169,4	923.502,6	1.399.672,0	873.445,2	-839.520,2	33.925,0
Gioia Tauro	Italy	-97.887,1	-325.112,9	-423.000,0	1.350,8	-50.565,8	-49.215,0	419.795,3	472.204,7	892.000,0	652.489,2	-429.489,2	223.000,0
Barcelona	Spain	-62.418,2	133.822,2	71.404,0	1.344,5	519.471,5	520.816,0	624.493,4	-1.089.453,4	-464.960,0	416.063,2	648.140,8	1.064.204,0
Ambarli	Turkey	-114.949,0	-152.222,0	-267.171,0	1.333,6	-755.908,6	-754.575,0	290.442,0	1.005.375,0	1.295.817,0	766.219,4	-1.366.096,4	-599.877,0
Genoa	Italy	-71.617,2	141.575,2	69.958,0	1.315,5	188.326,5	189.642,0	475.986,9	-586.136,9	-110.150,0	477.381,3	-151.475,3	325.906,0
Marsaxlokk	Malta	-100.985,3	-93.888,7	-194.874,0	1.627,6	138.806,4	140.434,0	603.877,6	-1.472.288,6	-868.411,0	673.141,5	-1.295.557,5	-622.416,0
Mersin	Turkey	-49.400,0	16.669,0	-32.731,0	826,9	62.105,1	62.932,0	314.344,8	-88.644,8	225.700,0	329.287,4	120.562,6	449.850,0
Izmir	Turkey	-20.134,7	20.134,7	0,0	330,4	-330,4	0,0	111.454,3	1.078.279,7	1.189.734,0	134.212,4	1.055.521,6	1.189.734,0
Alexandria	Egypt	-55.644,0	45.329,0	-10.315,0	883,4	-45.376,4	-44.493,0	320.547,7	-400.530,7	-79.983,0	370.908,5	-382.192,5	-11.284,0

TABLE 11 –Input and output data for 13 larger Mediterranean ports for the year 2020[35]

PORT	REGION	Input			Output	Operated by
		Berth length (m)	Number of cranes	Total Area (m^2)	Container Throughput (TEU)	
Tanger Med	Morocco	1.200	12	360.000	5.771.200	APM Terminals at Med Port Tangier
Piraeus	Greece	2.485	40	700.000	5.437.477	Piraeus Container Terminal (PCT), a subsidiary of COSCO
Valencia	Spain	1.660	12	450.000	5.428.307	APM Terminal Valencia's Multipurpose Terminal
Algeciras	Spain	1.200	27	970.000	5.107.873	Cámara de Comercio de El Campo de Gibraltar
Port Said	Egypt	600	2	919.698	4.009.672	Port Said Container Handling Co
Gioia Tauro	Italy	3.391	23	1.600.000	3.193.000	Terminal Investment Limited Sàrl(TIL)
Barcelona	Spain	1.500	13	790.000	2.958.040	Hutchison Ports BEST
Ambarli	Turkey	4.550	21	540.000	2.887.800	ALTAS Ambarli Liman Tesisleri Ticaret AS, Mardas Marmara
Genoa	Italy	1.350	7	316.000	2.498.850	Messina Group Intermodal Marine Terminal (IMT)
Marsaxlokk	Malta	2.140	23	680.000	2.441.589	Malta Freeport
Mersin	Turkey	2.280	11	993.908	1.948.700	PSA International and Akfen Holding
Izmir	Turkey	895	6	460.000	1.800.642	DP World Yarimca
Alexandria	Egypt	732	44	89.896	1.677.017	General Authority for Alexandria Port

Memorandum

	First of 13 larger Mediterranean Port in TEU for 2020
	Second of 13 Mediterranean Port in TEU for 2020, & COSCO's investment
	Mutual PSA's International and Akfen's Holding investmend
	DP World Yarimca investmend
	Last of 13 larger Mediterranean Port in TEU for 2020

[35]**TABLE 12** –Data sources for 13 larger Mediterranean ports for the year 2020

PORT	REGION	Sources/information (accessed 10-04-2022)
Tanger Med	Morocc	https://www.apmterminals.com/en/medport-tangier/about/our-terminal
Piraeus	Greece	https://www.oocl.com/greece/eng/localinformation/terminalsandfacilities/Pages/default.aspx?print=true&ooclite=true
Valencia	Spain	https://www.apmterminals.com/en/valencia/about/our-terminal
Algeciras	Spain	http://www.industrialalgecirasbay.com/en/resource/algeciras-port
Port Said	Egypt	http://www.seapace.com/e_ports/e_ports_144.htm
Gioia Tauro	Italy	https://www.tilgroup.com/terminal/port-gioia-tauro
Barcelona	Spain	https://www.best.com.es/en/the-terminal/
Ambarli	Turkey	http://www.worldportsource.com/ports/commerce/TUR_Port_of_Ambarli_2079.php
Genoa	Italy	https://www.portsofgenoa.com/components/com_publiccompetitions/includes/download.php?id=548
Marsaxlokk	Malta	https://www.yilport.com/en/ports/detail/Marsaxlokk-%7C-Services/178/146/0
Mersin	Turkey	https://www.google.com/search?q=mersina+berth+length%2C+cranes%2C+area&oq=&aqs=chrome.0.69i59l8.136555638j0j7&sourceid=chrome&ie=UTF-8
Izmir	Turkey	https://oevz.com/en/dp-world-yarimca-opens-as-turkeys-newest-port/
Alexandria	Egypt	https://dlca.logcluster.org/display/public/DLCA/2.1.1+Egypt+Port+of+Alexandria

3.1.9 Regression

In addition, to the above, following are the figures of the regressive lines for every Mediterranean port from the chosen through. With this attempt we would like to perform a simple linear as well as a more complicated regression to see how well the measures of throughput, of every port's TEU's can predict the throughput TEU's at least for the following next 2 years. It is obvious that as many data we have from previous handlings it is better and the corresponding curve it is more accurate. For calculations we use two types of regression, (**1**) the simple linear and (**2**) the polynomial. The first one it is for simple approaches and smooth curve, as well as the polynomial curve it is for more complicated approaches and a curve with chances and peek points (incline to decline and vies-versa). For the polynomial regression I use the 3rd order (power of 3) because bigger it is out of the scope of our paper. The linear regression it is suitable when we don't have additional influences and the situation is the same as previous years. The power of 3 interprets that for our estimation we are taking into account a new number positive and/or negative influences (e.g. number of cranes, sea depth, and berth length). From our study we have the value for the Pearson correlation R that tell how strong the linear relationship is. Moreover, we have the value for the coefficient determination R^2 that tell how much variance the dependent variable can be accounted for by the independent variable. A percentage (%) of the variance in market share can be accounted for by the yearly measures. Adjusted R^2 takes into account the number of independent variables in the analysis and corrects for bias. Stand and Error of the regression is the average distance that the observed values fall from the regression line. The smallest the standard error the more precise the linear regression model is. Let see now the average value between linear and the polynomial regression, **we find out that they are very close to the real values.** Apply the analysis for the Port of Piraeus, figure 40. The curve in continues blue line represents the fluctuation of TEU container handling from the Piraeus port. The dot curve (line) in magenta represents the linear regression and the dot curve in red represents the polynomial regression (in power of three). We know from the entire research that port of Piraeus under the COSCO's investments is in a positive development without operational problems (so far there are no positive or negative situations). From the table 5 above for the Piraeus I have 12,4% TEU market share. The estimation for 2021 is for linear regression 13,50% and for the polynomial 9,60% (take into account we calculate values for the same 13 Mediterranean ports). The average value is 11,55%. From [28]PPC SA authority for the year 2021 we have: "Terminal Capacity: Pier II: 3,2 M TEU - Pier III: 3 M TEU - TOTAL:6,2 M TEU", or 12,82%. (real data). Those numbers [11,55% the average (estimation) and 13,08% the reality] are very close into a total of million TEU's. It is very interesting the factor Δφ, how small is it for some other ports

of our research. Moreover, the total Δφ equals zero, which mean we don't have additional or hidden deviations from our calculations.

[33]**TABLE 13** –Estimation vs real data for 13 larger Mediterranean ports for the year 2021 for the percentage of TEU market share

Port	Estimation Linear a	Estimation Polynomial b	Average $\frac{a+b}{2}$	Real Data 2021	Δφ= Average – Real Data 2021
Tanger Med	13,10	16,00	14,55	14,84	-0,29
Piraeus	13,50	9,60	11,55	12,82	-1,27
Valencia	12,50	11,00	11,75	11,61	0,14
Algeciras	11,15	9,00	10,07	9,92	0,15
Port Said	6,35	13,00	9,68	8,07	1,61
Gioia Tauro	6,10	8,10	7,10	6,51	0,59
Barcelona	8,00	3,50	5,75	7,30	-1,55
Ambarli	5,00	10,00	7,50	6,14	1,36
Genoa	6,00	4,50	5,25	5,29	-0,04
Marsaxlokk	6,00	2,60	4,30	6,18	-1,88
Mersin	4,60	4,20	4,40	5,38	-0,98
Izmir	4,00	5,50	4,75	2,82	1,93
Alexandria	3,70	3,00	3,35	3,10	0,25
total	100,00	100,00	100,00	100,00	0,00

PART

THREE

CHAPTER 4

CONCLUSION

4 Discussion

The ports of the Mediterranean are the gateway for maritime freight from Asia to Europe. Europe's industry needs raw materials from Asia to move through an intermodal transport system dominated by the container. Given the development of maritime transport, major shipping investors are investing in Mediterranean port terminals to reduce transport time from production to raw material processing, achieving economy of scale, risk reduction and indirect production growth. This development as developed quantitatively and qualitatively in our paper illustrating analytical methods for the data analysis, price tables and relational diagrams shows for the period 2014-2020 for the Mediterranean region the phenomenon for major ports to increase their share in the volume of traffic by weight of the smallest. We observed the ports of Valencia, Algeciras and Piraeus monopolizing the movement of containers but without developing an oligopoly trend since the mentioned ports meet due to their location specific transport requirements of the Western and Central European hinterland and there is no concentration. COSCO's investments in the port of Piraeus has given and continue to give a clear leading presence in the field. All these elements are intervened positively (or negatively) by the existing equipment, the area, the facilities and the way of managing the ports as shown in the tables 11 and 12

In this new, ever-changing, international and globalized environment, port Piraeus development role is becoming even more important and its contribution to local development more relevant than ever. The local level must be protected, the port's relationship with the urban fabric and the local community must not be disrupted. Thus it can contribute to the sustainable approach to development, mediating economic growth, contributing in various ways to the growth of business and employment, serving the needs of local society and reducing by taking appropriate measures, the environmental problems and the negative consequences it causes.

It becomes obvious that the Port of Piraeus is a dominant development factor, the utilization of which brings very important results not only at the National level, being the first Port of the country, but also at the Local level. It stimulates the Local Economy by contributing in various ways to the growth of Local business activity and Local employment, serves the needs of the Local community and is generally a pole of life and development. In the context of a modern, integrated and more complex concept for Local Development and through the cooperation of the competent bodies, there are possibilities and perspectives to connect the operation of the

Port, even more with the urban and the wider area, to reduce the environmental nuisances that arise.

In a recent newspaper article[37], the author Minas Tsamopoulos describes the port of Piraeus as a "*port hub in the global shipping networks*". The regular monthly approach of vessels with a capacity of more than 1 million containers, as shown in our figures 56, 57 and 58, justifies the optimistic characterization. He notes that the port for the year 2021 has lost the fifth place in the European competition from the port of Valencia, its big competitor, for only a few containers. The operator of the Container Terminal, COSCO has significantly improved many quality parameters of the port operation and especially the **connectivity** of the port. The University of Piraeus, through Porteconomics with the Professors Pallis and Vangelas, records and presents on an annual basis important parameters of connectivity of the port of Piraeus to the global maritime networks, through an analysis of data on ship-based approaches. 60% of the approaches concern feeder vessels, with a capacity of less than 3,000 TEUs. On the other hand, 15% of the approaches concern ships with a capacity of more than 12,500 TEUs (VLCS and ULCS) with ships over 18,000 TEUs constituting 4% of the total approaches. The port of Piraeus already serves the largest ships of the world fleet, a necessary condition for its further development. The largest port in Greece connects directly 73 different ports, in 31 different countries. COSCO is the main user of the port, as 24.5% of the approaches are made by ships managed by the Chinese company, which is also affiliated with the management company of the port. In second place is MSC with 15.5% of approaches, while the top five are closed by Evergreen in third place with 10.5%, Hapag-Lloyd with 10.5% and CMA-CGM with 4.5%. Deespite the effects of the pandemic (COVID-19) on international trade in the first quarter of 2022, COSCO record earnings of $ 4.4 billion. In conclusion the author prompts that the increase of connectivity in the land part of the transmission chains is an area in which PPA SA. and SEP SA should be focused, while the provision of value-added services to moving cargo remains in demand, which will significantly increase the port's economic impact on the local and national economy.

5 Future recommendation

We consider our study is a significant contribution to the meager existing container handling literature in the Mediterranean region by exploring concentration trends and competitiveness, correlating performance, assessments with market concentration. However, future research at national level, which concerns a specific Mediterranean country with its ports, may determine the interaction of market concentration, within the region, where the port belongs and the wider national market in which the other national ports are located. In this case we can talk for competition from an omnidirectional perception. An important element to be investigated

should affect the system that will suffer, if it faces emergency financial measures due to military operations, as faced by the countries of the European Union with the war in Ukraine. There may be a process that makes the maritime/hinterland trading system \independent through alternative routes taking into account the cost to keep this alternative system idle.

6 Conclusion

The settlement through our study “the Competitiveness and Financial Development of the Port of Piraeus in the Containerized Maritime Transportation Market” that the port yielded desired results and we see a continuous improvement in the services of the company, in competitive position of the port but also an increase in its profits. In fact, PPA SA is the second developing port in Mediterranean region and among the 10th in Europe which confirms the correctness of COSCO's operations. This further leads us to conclusion that, the course of the company can be characterized as successful with its achievement so far and their results. A prime achievement of Chinese company is even the competitive position of the port as it is and this is an important factor for the Greek economy. Afterwards PPA SA made one of the most profitable ports abroad due to its increased activity. From 2016 until now we notice a positive development of the port, which indicates that the privatization of the port of Piraeus from COSCO was the most necessary action in order to develop the Greek company and the Greek economy. Studying and watching the **effective competition** in the area we conclude that the COSCO is going to bring other positive results for PPA SA resulting in the port growing more and more. Hence, the course of the port after its privatization, according to our conclusions through our dissertation, can be characterized as beneficial and profitable both for the Greek and international economy and for the company itself. Ultimately the port of Piraeus fulfills all the requirements to be **the** leading transfer container center in the Mediterranean Sea.

BIBLIOGRAPHY

- K. Chlomoudis (2011), Trends and developments in the port industry, Ed. Papazisi
- Containerisation International Magazine (June 2013),'Bunker quarterly', *Full slow steaming ahead*, pg. 14
- Containerization International Magazine (December 2013), *'Top 100 container ports 2013'*, pg 16
- Containerisation International Magazine (December 2013), 'Looking forward/containerships of the future', *A matter of time,* pg. 28
- Dynamar (03/10/2014)'Dynaliners Weekly', *Ports*, pg. 3
- Dynamar (10/10/2014)'Dyaliners Weekly', *Ports*, pg. 4
- Dynamar (31/10/2014) 'Dynaliners Weekly' *Ports*, pg. 2
- Dynamar (2014), *The intra-Mediterranean container trades*, Marport Terminal Operators (exclusive report) Cap Icap Group (2014), Sectoral study ICAP GROUP - Transfer Services May 2014John Mangan and Chandra Lalwani Brian Fynes (2008), Port-centric logistics
- Ahmed Mehrem (2011), Master Thesis in *The future of Port Said East Port*
- Paul Mylonas,Chief Economist NBG Group (2013) *Container ports: An engine of growth*
- S. Papadimitriou - O. Schinas (2004), Introduction to Logistics, Ed. Stamoulis
- A. Pardali (2001), The port industry in the challenges of the globalized economy and integrated transport systems, Ed. Stamoulis
- Frans-Paul van der Putten (2014), *Chinese Investment in the port of Piraeus,Greece: The relevance for the EU and the Netherlands, Clingendael Report*
- Unctad (2013), *Review of maritime transport 2013*, United Nations publibation
- Vassilios K. Zagkas και Dimitrios V. Lyridis (2009), 'Piraeus Maritime Cluster', *An analysis of seaport cluster models for the competitiveness of maritime sectors: The* case of Piraeus
- Atkearny (2012), 'Balancing the imbalances in container shipping'

INTERNET SITES

- http://www.atkearney.com/paper/-/asset_publisher/dVxv4Hz2h8bS/content/balancing-the-imbalances-in-containershipping/10192
  (Access 24-12-2021)
- http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/
  (Access 23-12-2021)
- http://ec.europa.eu/transport/themes/infrastructure/index_en.htm
  (Access 23-12-2021)
- Hellenic Shipping News (2014) 'Mediterranean transshipment booms' http://www.hellenicshippingnews.com/1d5bc606-d9cd-46dd-a710ab9483fb5881/ , (Access 23-12-2021)
- Ing (2013) 'Ing international trade study: Turkey' http://www.ingcb.com/media/232663/turkey.pdf
  (Access 24-12-2021)
- Klaus Schwab, World Economic Forum(2014) 'Global competitiveness report 2014-1015' http://www3.weforum.org/docs/WEF_GlobalCompetitivenessReport_2014-15.pdf
  (Access 24-12-2021)
- http://www.olp.gr/en/
  (Access 24-12-2021)
- Pacific Tycoon(2014), 'Piraeus set to be Mediterranean's biggest port by 2016' http://pacifictycoon.com/blog/2014/02/12/piraeus-set-to-be-mediterraneansbiggest-port-by-2016/
  (Access 23-12-2021)
- http://www.scctportsaid.com/
  (Access 24-12-2021)
- http://www.pct.com.gr/pct_site/
  (Access 24-12-2021)

REFERENCES

(From various sources)

[1]Chlomoudis K. (2011) Trends and developments in the port industry, Athens: Ed. Papazisi.

[2] https://www.justice.gov/atr/herfindahl-hirschman-index

[3]https://www.xeneta.com/blog/new-mediterranean-region-port-structure (Access 10-02-2022)

[4] https://data.worldbank.org/indicator/IS.SHP.GOOD.TU (Access 21-12-2021)

[5] https://www.ceicdata.com/en/indicator/china/foreign-direct-investment (Access 10-02-2022)

[6] https://lloydslist.maritimeintelligence.informa.com/-/media/lloyds-list/images/top-100-ports-2021/top-100-ports-2021-digital-edition.pdf (Source: Lloyd's List One Hundred Ports 2021, Access 10-02-2022)

[7] Van de Voorde/Vaneslander — Discussion Paper 2009-2 — © OECD/ITF 2009, pg. 9

[8]Politi Paraskevi (2012) Liner Shipping: Strategic Alliances with Direction to Operations, pg. 14

[9]Statista Inc. (55 Broad Street; 30th floor New York, NY 10004 United States)

[10] In 2011 MAERSK ordered the construction of 20 Triple-E ships at DAEWOO shipyards, at a cost of $ 3.8 billion. Triple –E means Economies of scale, Energy efficient, Environmental friendly, elements that Maersk considers to be the most efficient ships.

[11] "ShipmentLink - Vessel Particulars [Enter EVER ACE]". www.shipmentlink.com. (Access 10-02-2022)

[12] "Shipbuilding projects worldwide search in New Ships Orderbook". www.new-ships.com. (Access 10-02-2022)

[13] Source: Container Usage Asset Management in the Global Container Logistics Chain by Paul Crinks, (Access 21-12-21)

[14] i.e. NVOCC: non vessel operating common carrier, which are companies that do not have their own ships but cooperate with shipping companies and have their own transport network (trucks, or possibly trains) offering complete solutions to customers.

[15] The Logistics Revolution and Transportation, 1997 by Bruce Allen, pg. 109 https://www.jstor.org/stable/1048727 (Access 10-02-2022)

[16] Map of the new Silk Road published on May 8, 2014. Source: xinhua.com (Access 10-02-2022)

[17] Source: Global Competiveness Report 2019 W. (Access 10-02-2022) https://www3.weforum.org/docs/WEF_TheGlobalCompetitivenessReport2019.pdf

[18] Trans-European transport network budget, see: http://ec.europa.eu/transport/themes/infrastructure/index_en.htm) (Access 21-12-2021)

[19] Vasilakis I. (2001) Investments in ports and their impact in inland: Methodological Approaches

[20] Chlomoudis K. (2011) Trends and developments in the Port Industry, Athens: Ed. Papazisi

[21]https://lloydslist.maritimeintelligence.informa.com/LL1135004/Top-10-box-port-operators-2020 and https://e.infogram.com/abfc8fc8-b9bd-4ebc-911e-87c786dcda6a?src=embed (Source: Drewry's Global Container Terminal Operators Annual Review and Forecast 2020/21, Access 10-02-2022)

[22]https://ajot.com/premium/ajot-mediterranean-sea-ports-in-the-middle (Source: American Journal of Transportation, Access 10-02-2022)

[23]https://lloydslist.maritimeintelligence.informa.com/-/media/lloyds-list/images/top-100-ports-2021/top-100-ports-2021-digital-edition.pdf (Source: Lloyd's List One Hundred Ports 2021, Access 10-02-2022)

[24]https://planbleu.org/wp-content/uploads/2021/12/MARITIME_TRANSPORT.pdf (Source: INERIS, 2019, Access 10-02-2022)

[25]https://planbleu.org/wp-content/uploads/2021/12/MARITIME_TRANSPORT.pdf (Source: INERIS, 2019, Access 10-02-2022)

[26]Sources in various times: BBC News, Bloomberg, BNN Bloomberg, CNBC, CNET, CNN, The Economist, Economist Intelligence Unit, Forbes, GeekWire, McKinsey & Co, Nasdaq, The New York Times, Reuters

[27]"Port Economics, Management and Policy" by Theo Notteboom, Athanasios Pallis, Jean-Paul Rodrigue 1st Edition, Copyright Year 2022

[28]Sources in various times: BBC News, Bloomberg, BNN Bloomberg, CNBC, CNET, CNN, The Economist, Economist Intelligence Unit, Forbes, GeekWire, McKinsey & Co, Nasdaq, The New York Times, Reuters

[29]http://www.beltandroadassociates.com/wp-content/uploads/2021/04/VAMVAKIDIS-PCT-BOR.pdf (Source: PCT SA, 2022, Access 20-04-2022)

[30]https://www.worldeconomics.com/ (Source: WORLD ECONOMICS/LONDON Access 07-04-2022)

[31]Source: own illustration on a map from the USA Central Intelligence Agency /1982

[32]Author illustration and calculations based on Lloyd's "List One Hundred Ports" 2015 & 2021

[33]Author calculations based on Lloyd's "List One Hundred Ports" 2015 & 2021

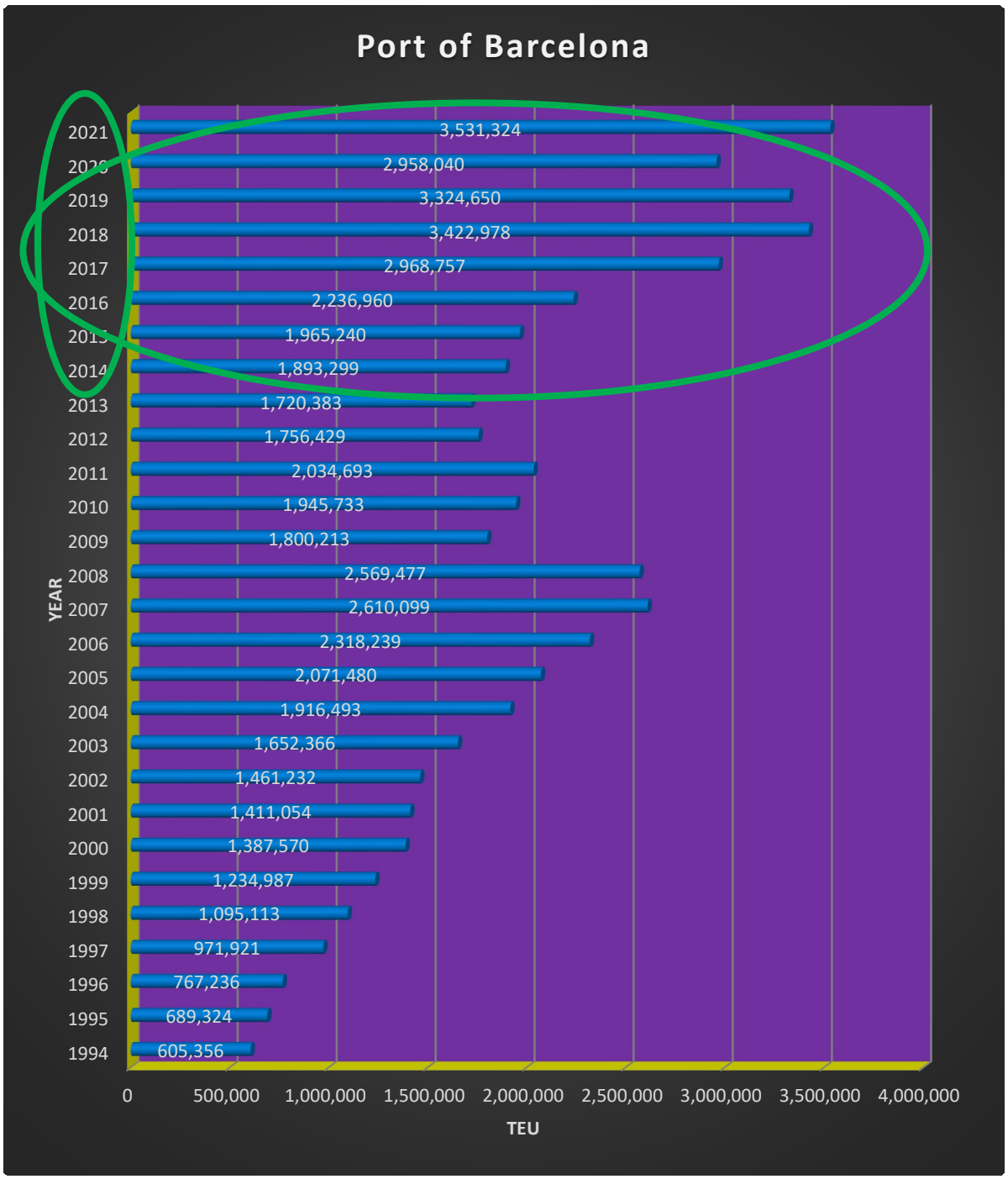
[34]Gwin 2001 Access 20-04-2022

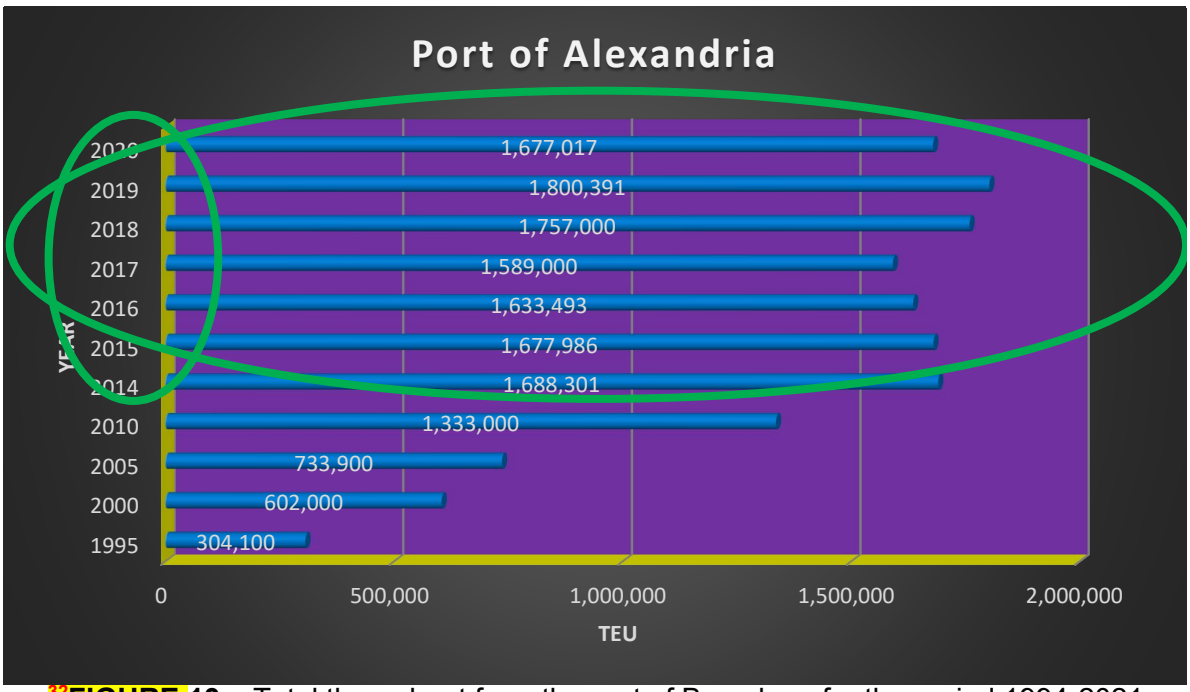
[35]Source: author, as the referenced sites in the table 12

[36]https://www.newmoney.gr/roh/palmos-oikonomias/nautilia/pireas-limani-komvos-sta-pagkosmia-naftiliaka-diktia-pinakes/ (Newspaper Proto Thema 24-04-2022, author Minas Tsamopoulos e-mail mtsamopoulos@gmail.com)

ANNEX 1

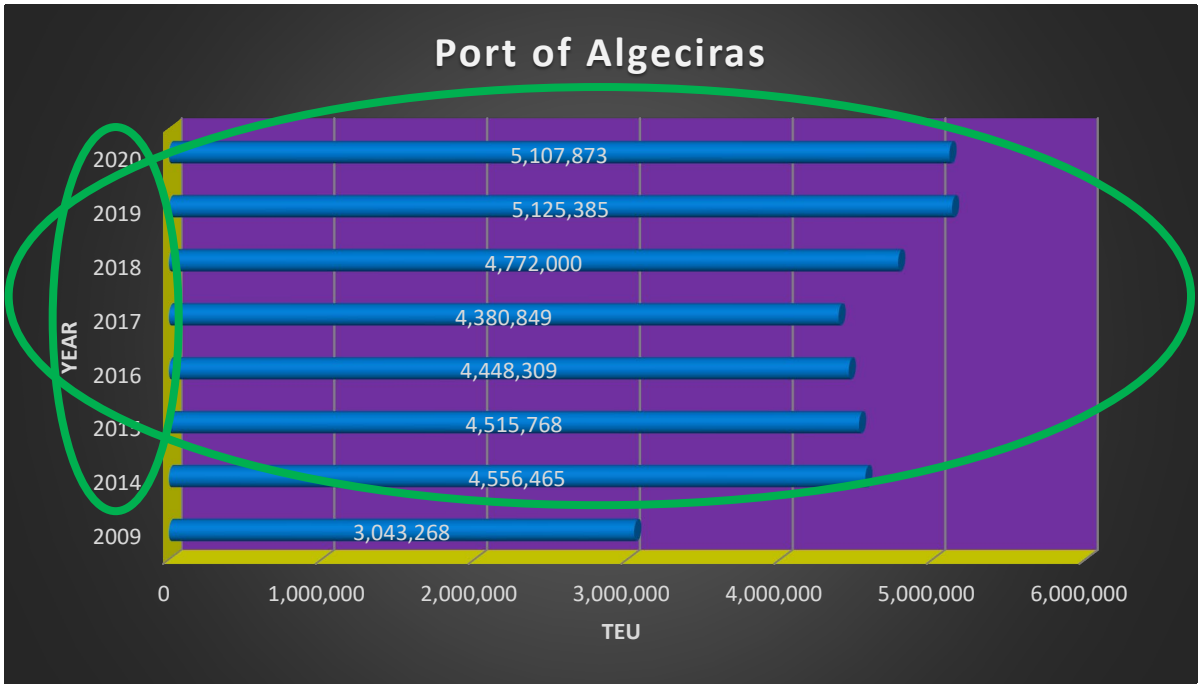
Total throughput from 13 major Mediterranean ports for specific period & TEU market share



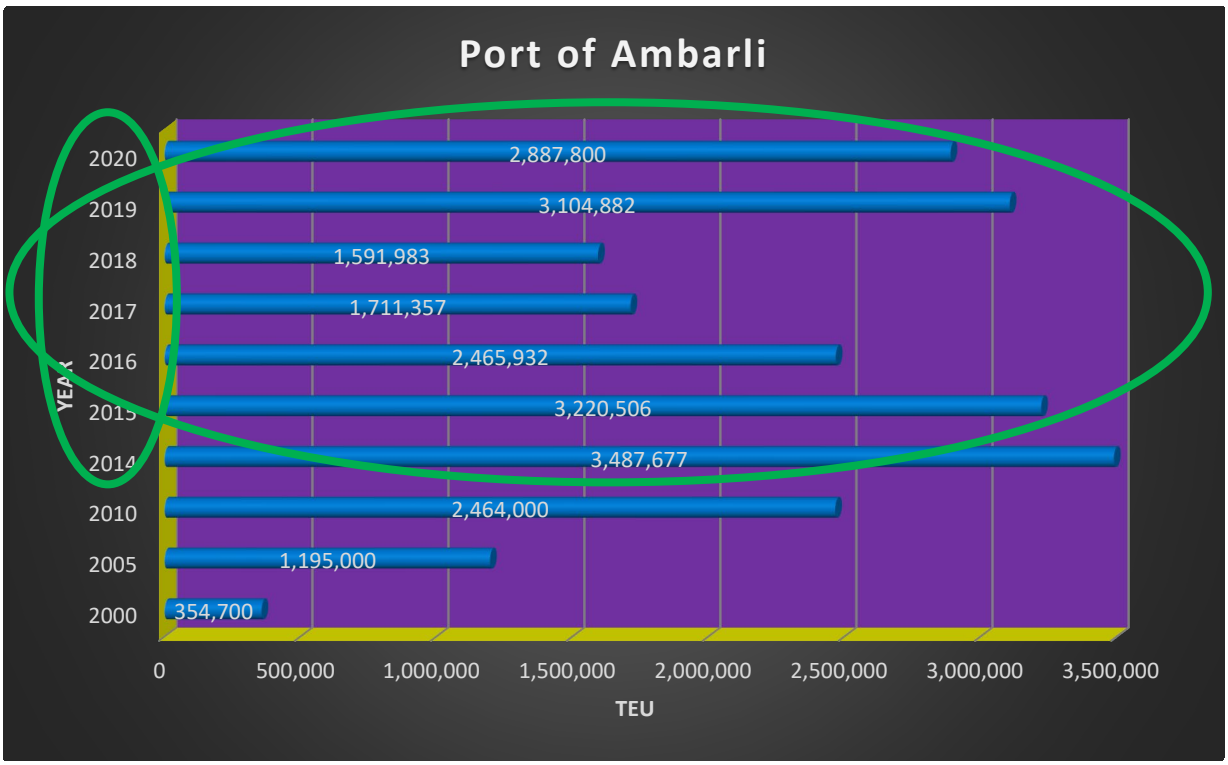


[32]**FIGURE 13** – Total throughput from the port of Barcelona for the period 1994-2021

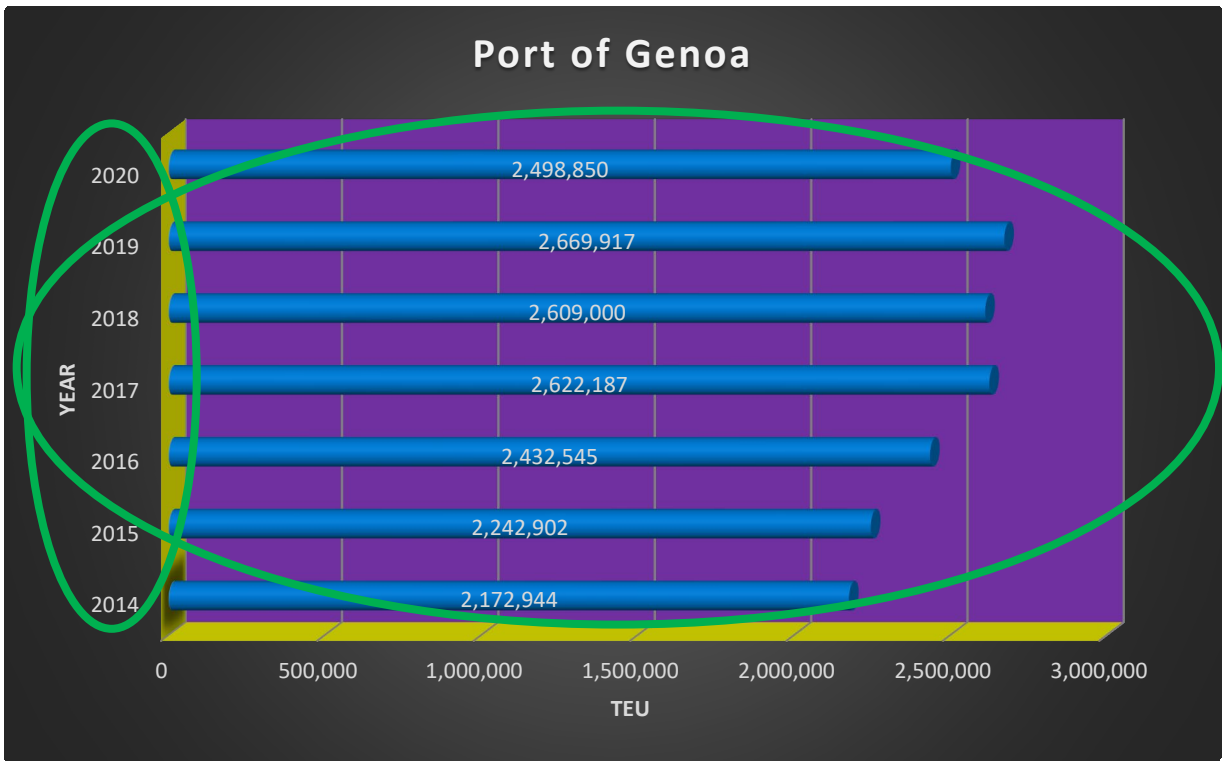
[32]**FIGURE 14** - Total throughput from the port of Alexandria for the period 1995-2020



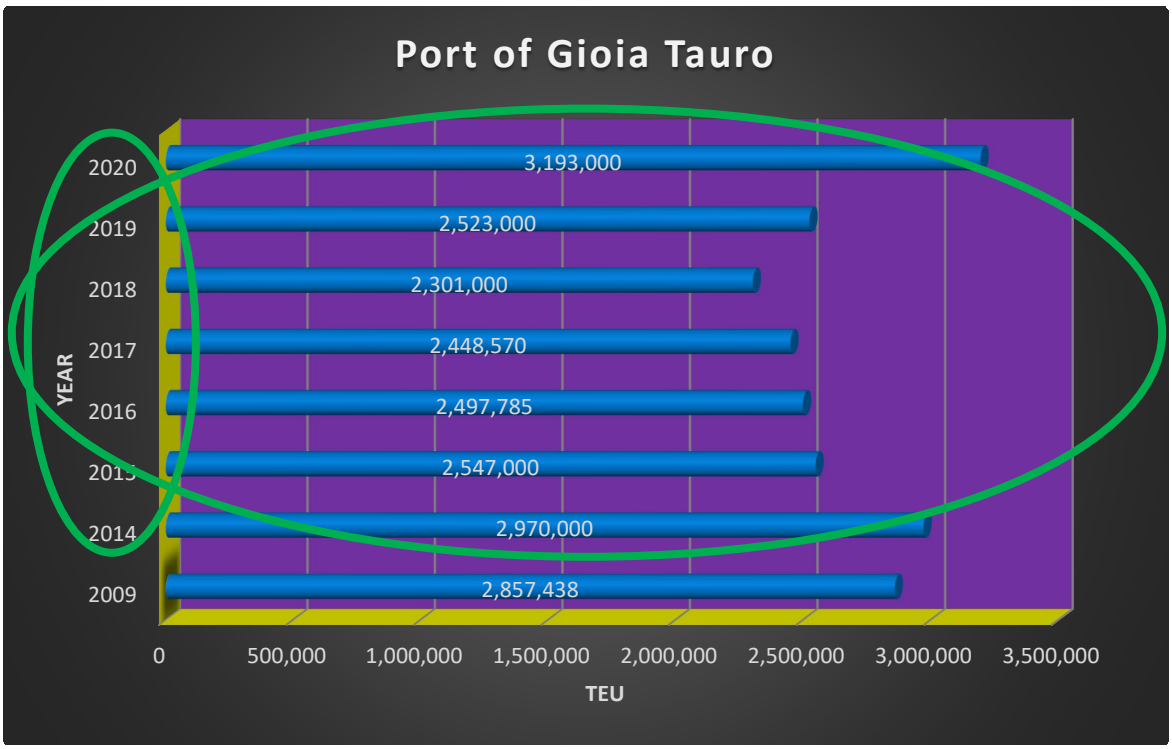
[32]**FIGURE 15** - Total throughput from the port of Algeciras for the period 2009-2020



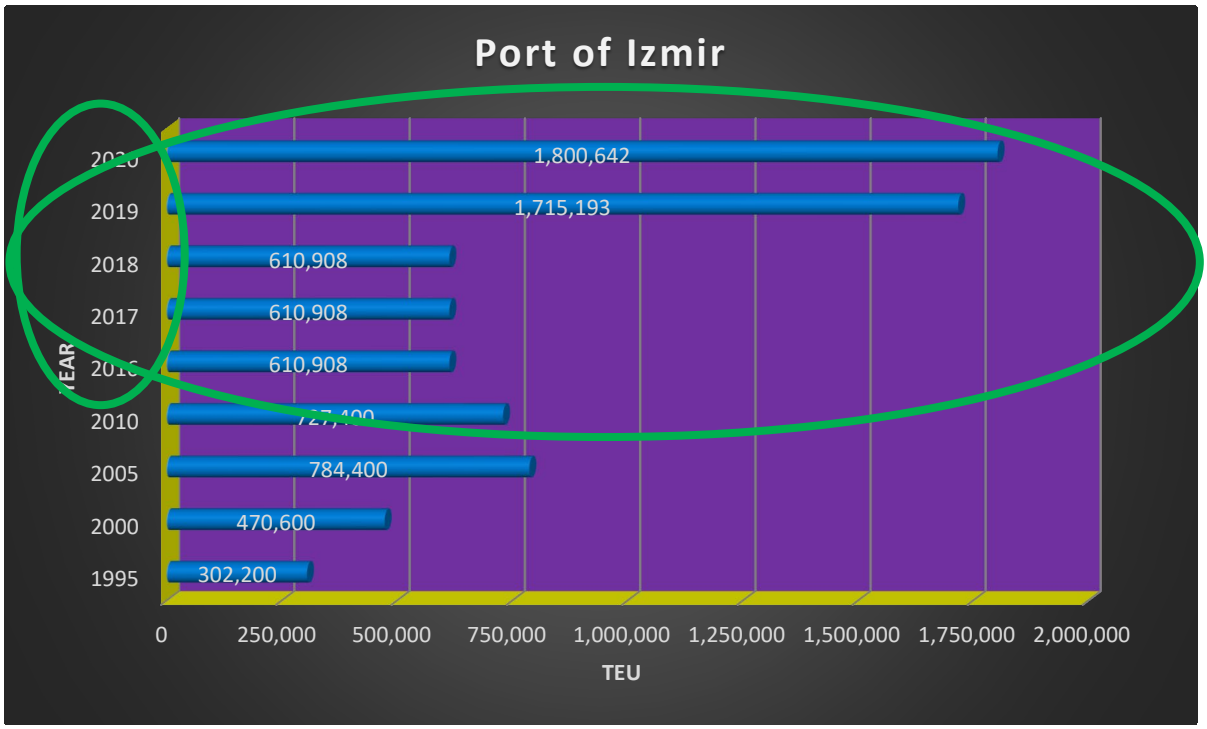
[32]**FIGURE 16** - Total throughput from the port of Ambarli for the period 2000-2020



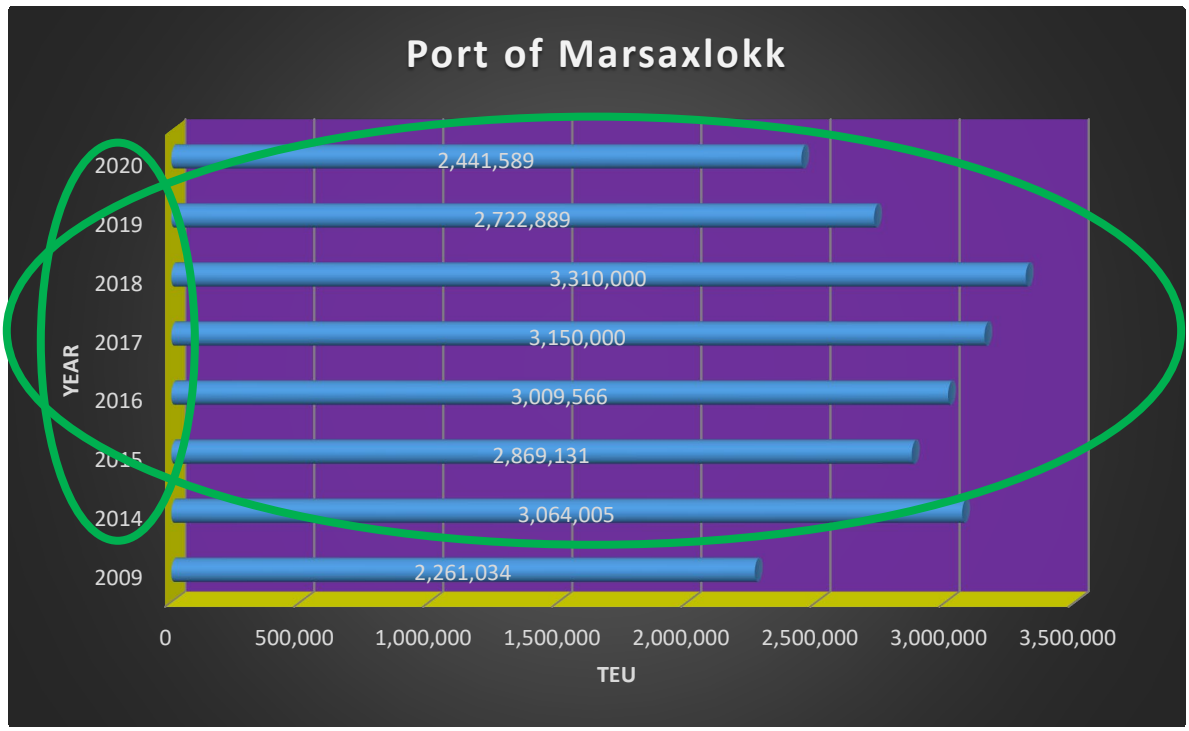
[32]**FIGURE 17**- Total throughput from the port of Genoa for the period 2014-2020



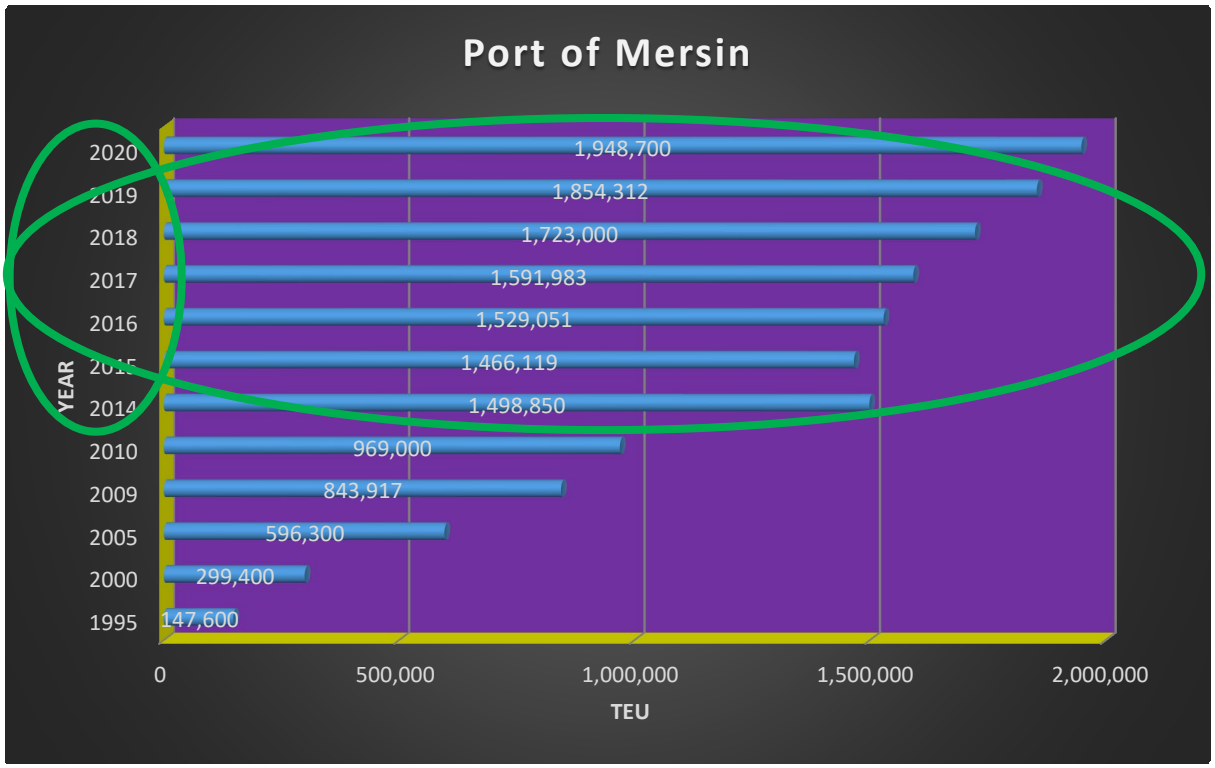
[32]**FIGURE 18** - Total throughput from the port of Gioia Tauro for the period 2009-2020



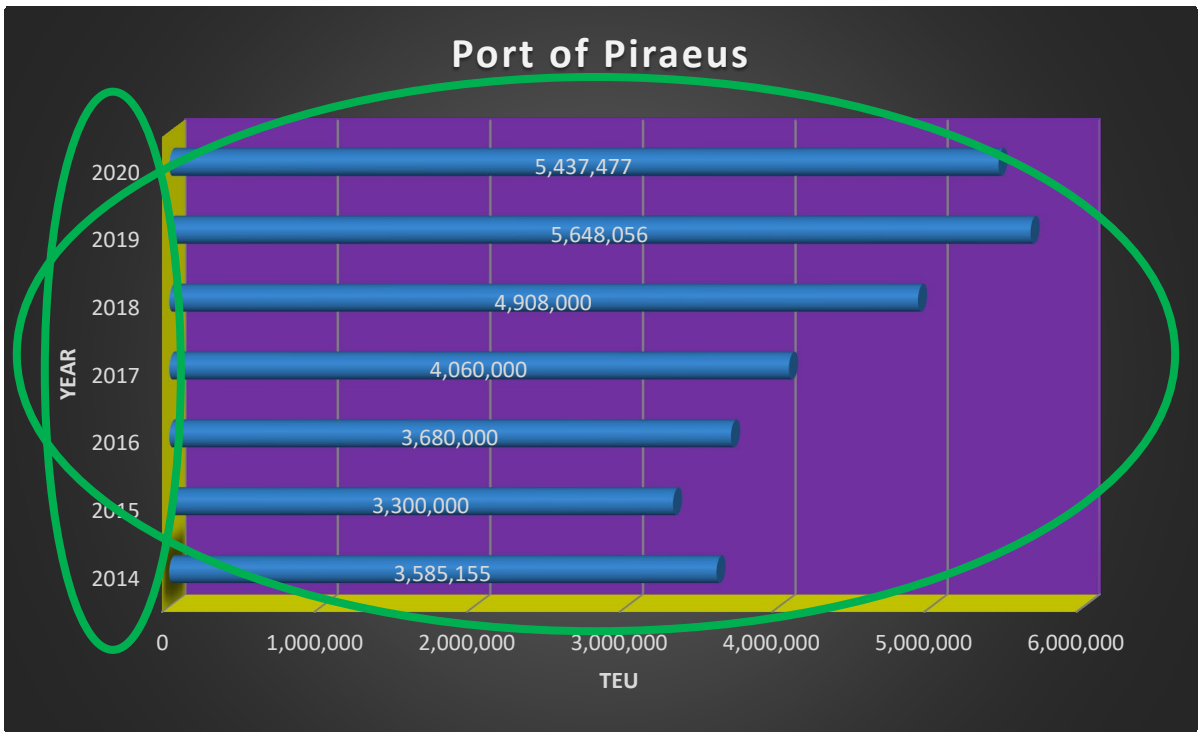
[32]**FIGURE 19** - Total throughput from the port of Izmir for the period 1995-2020



[32]**FIGURE 20** - Total throughput from the port of Marsaxlokk for the period 2009-2020



[32]**FIGURE 21** - Total throughput from the port of Mersin for the period 1995-2020



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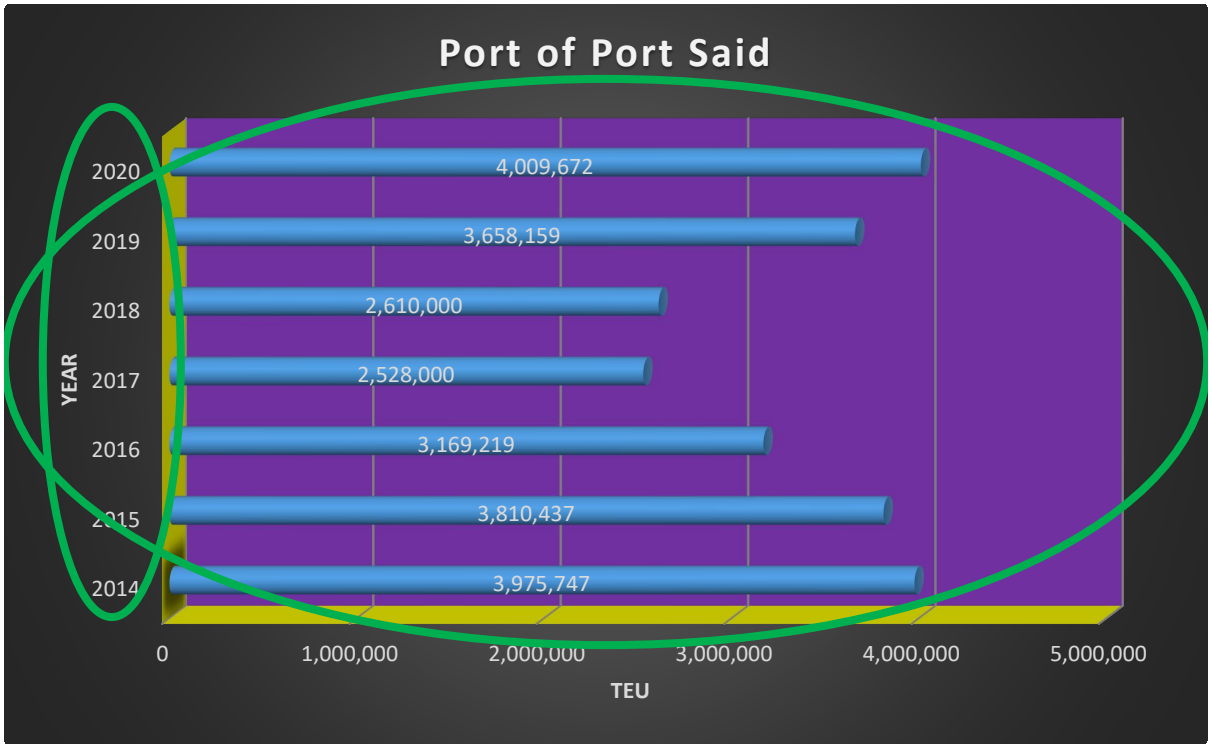
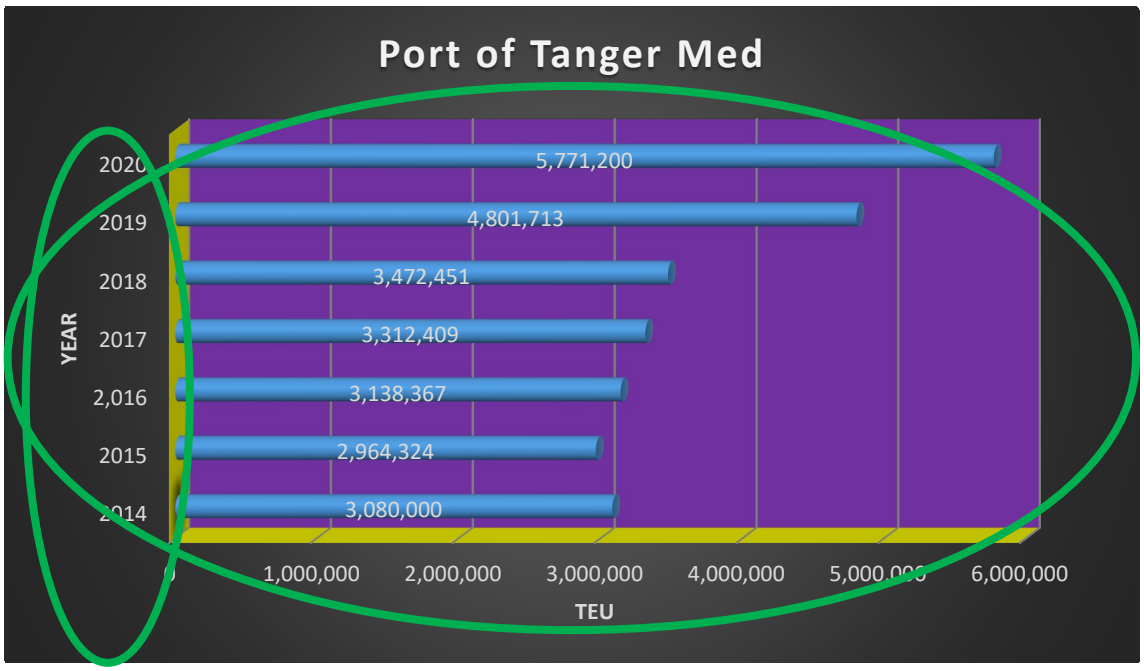
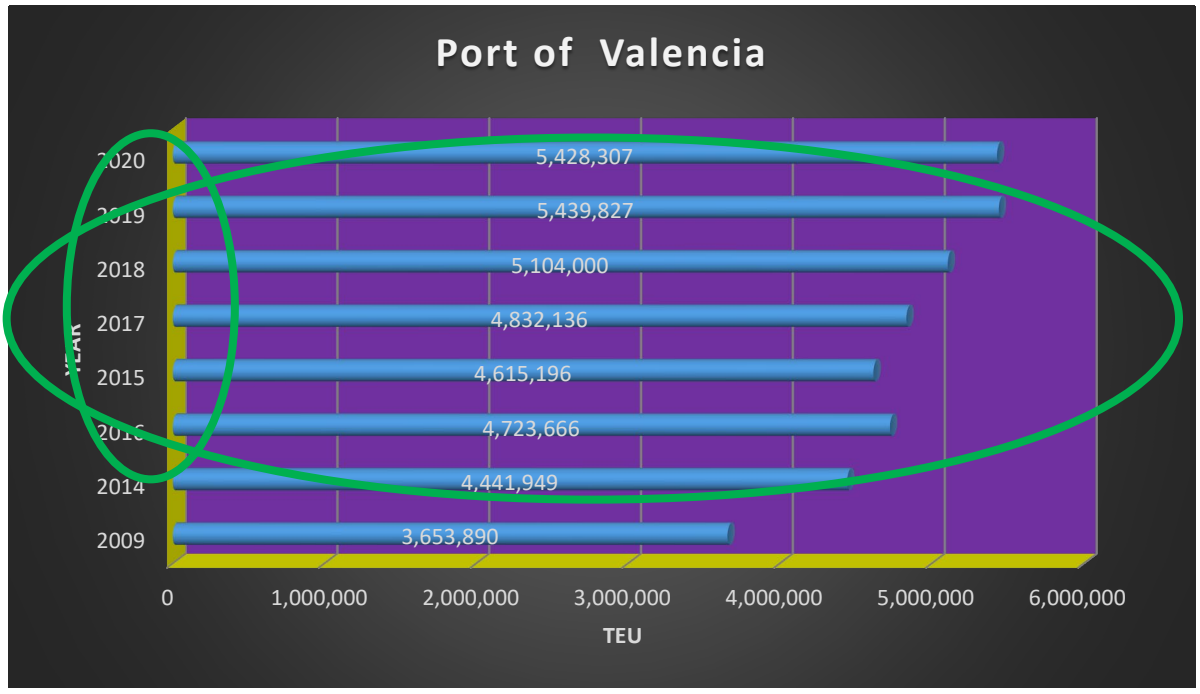
[32]**FIGURE 22** - Total throughput from the port of Piraeus for the period 1995-2020



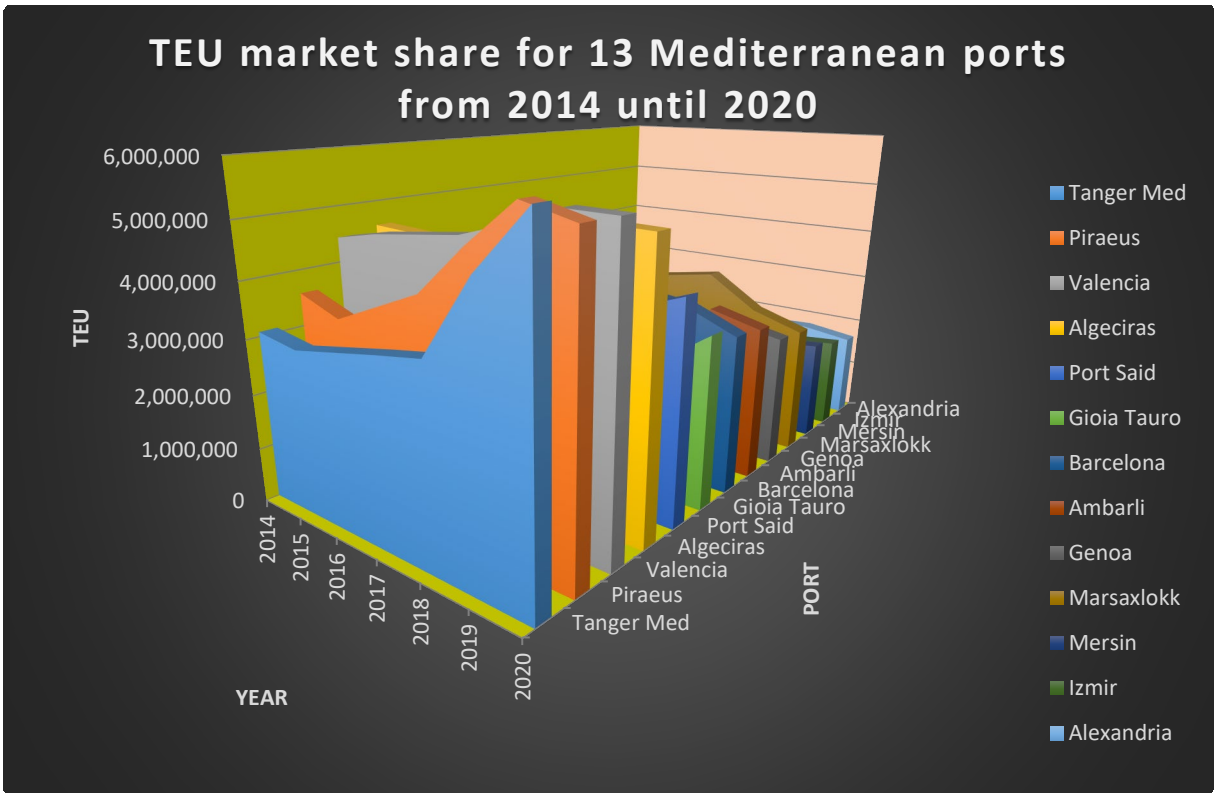
[32]**FIGURE 23**- Total throughput from the port of Port Said for the period 2014-2020



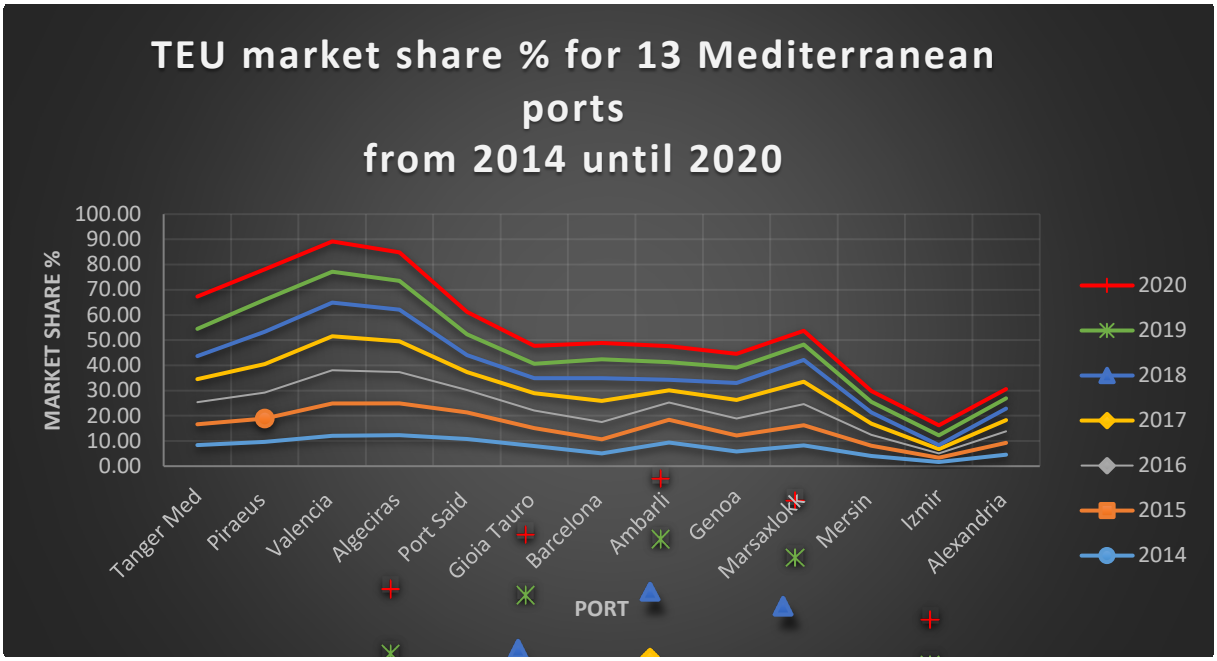
[32]**FIGURE 24** - Total throughput from the port of Tanger Med for the period 2014-2020



[32]**FIGURE 25** - Total throughput from the port of Valencia for the period 2009-2020



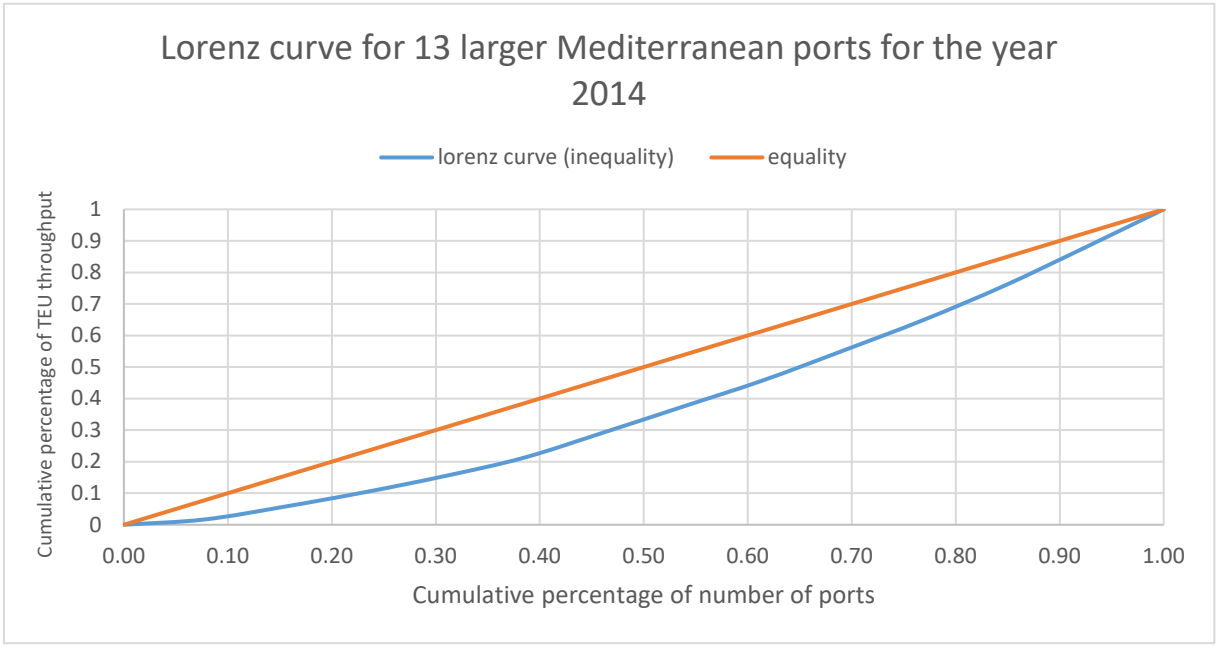
[32]**FIGURE 26** – TEU market share for 13 Mediterranean Ports (2014-2020)



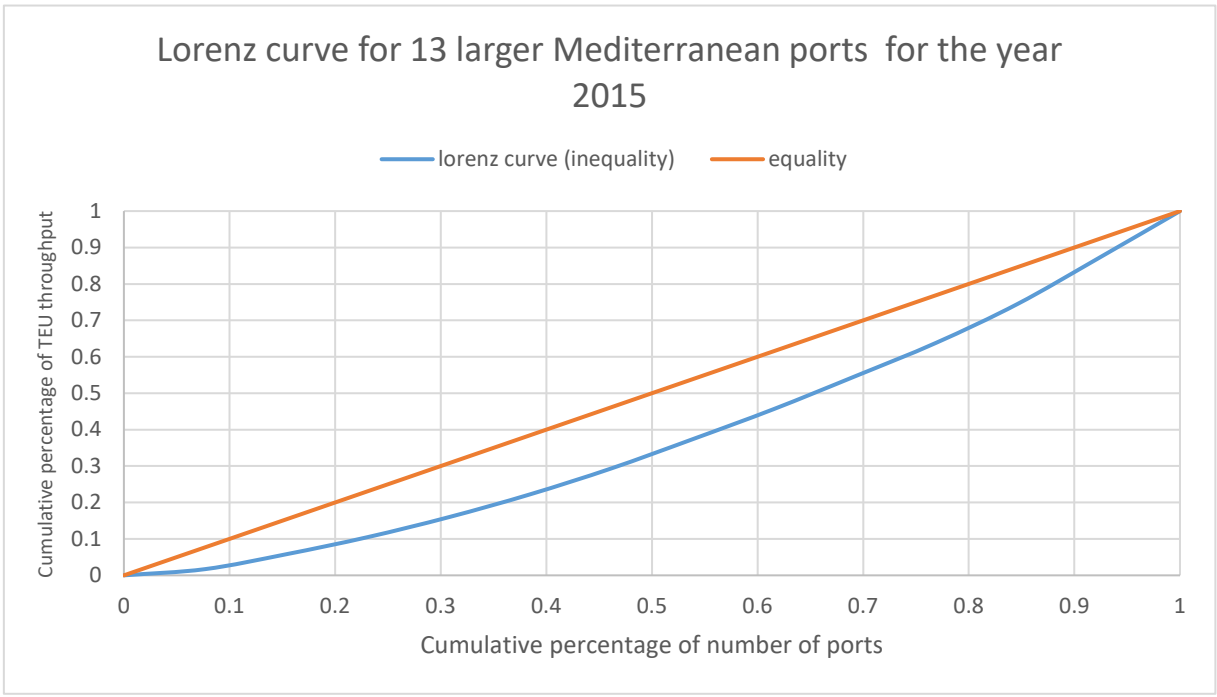
[32]**FIGURE 27** – TEU market share % for 13 Mediterranean Ports (2014-2020)

ANNEX 2

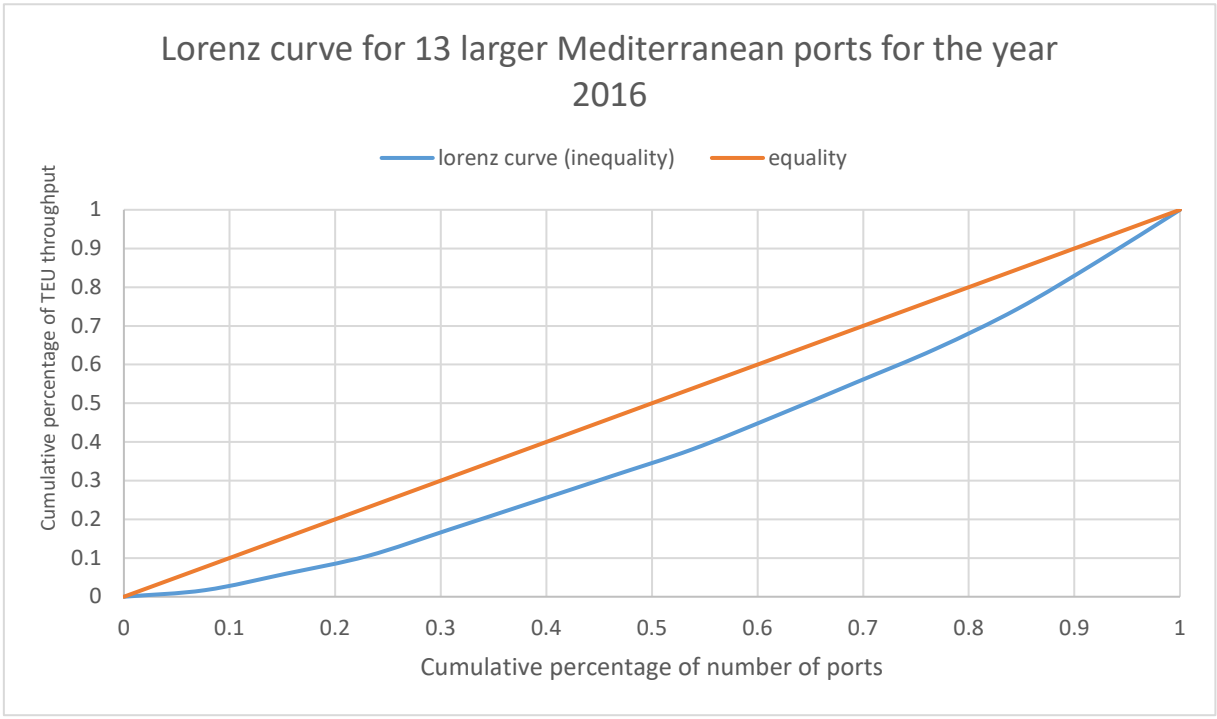
Lorenz curves and share analysis for 13 major Mediterranean ports from 2014 until 2020



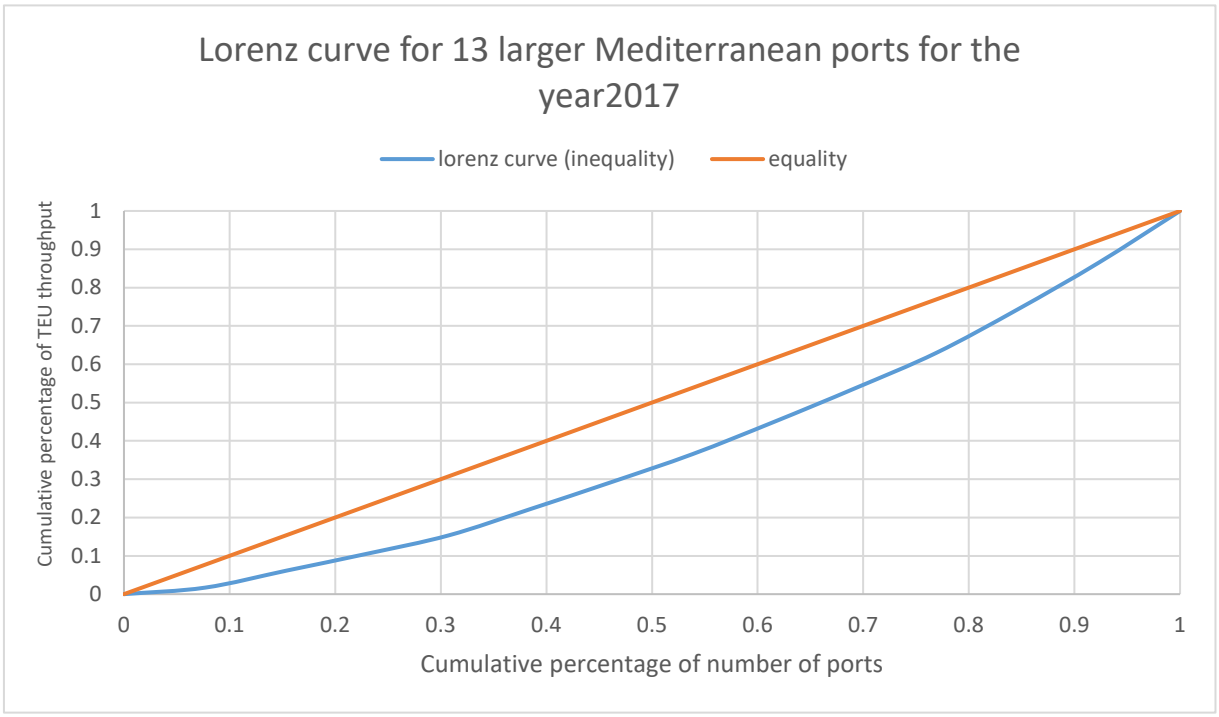
[32]**FIGURE 30** – Lorenz curve for 13 larger Mediterranean ports for the year 2014



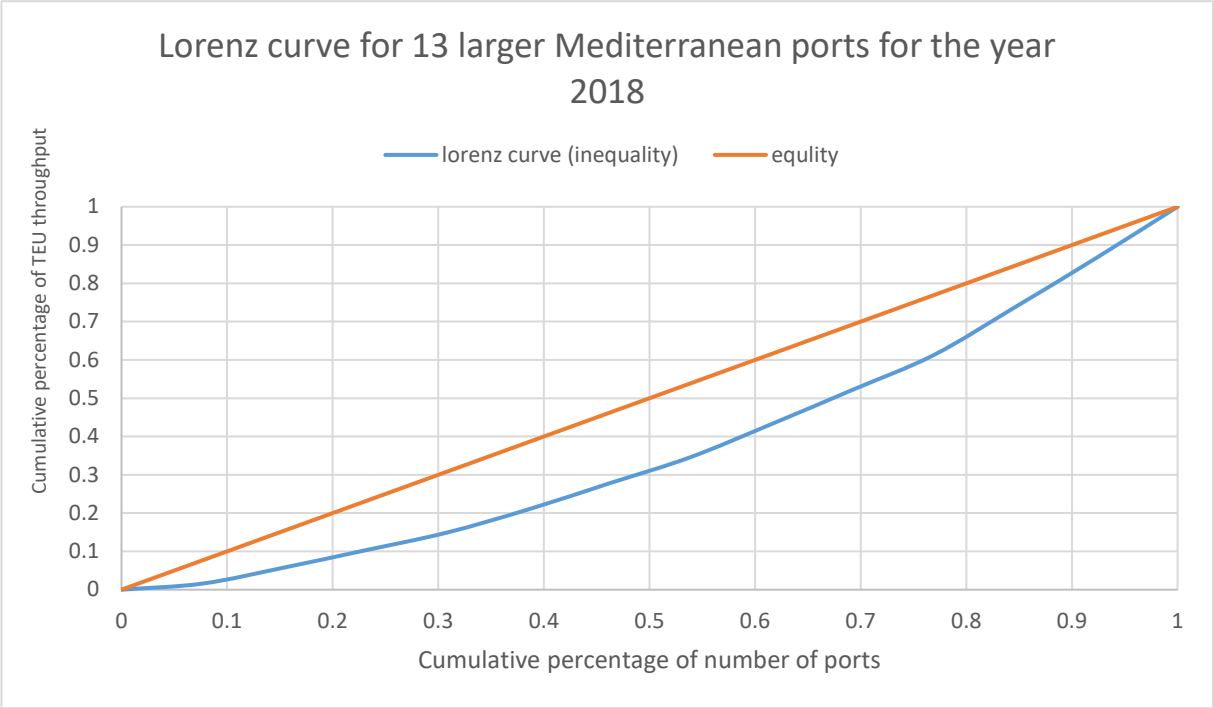
[32]**FIGURE 31** – Lorenz curve for 13 larger Mediterranean ports for the year 2015



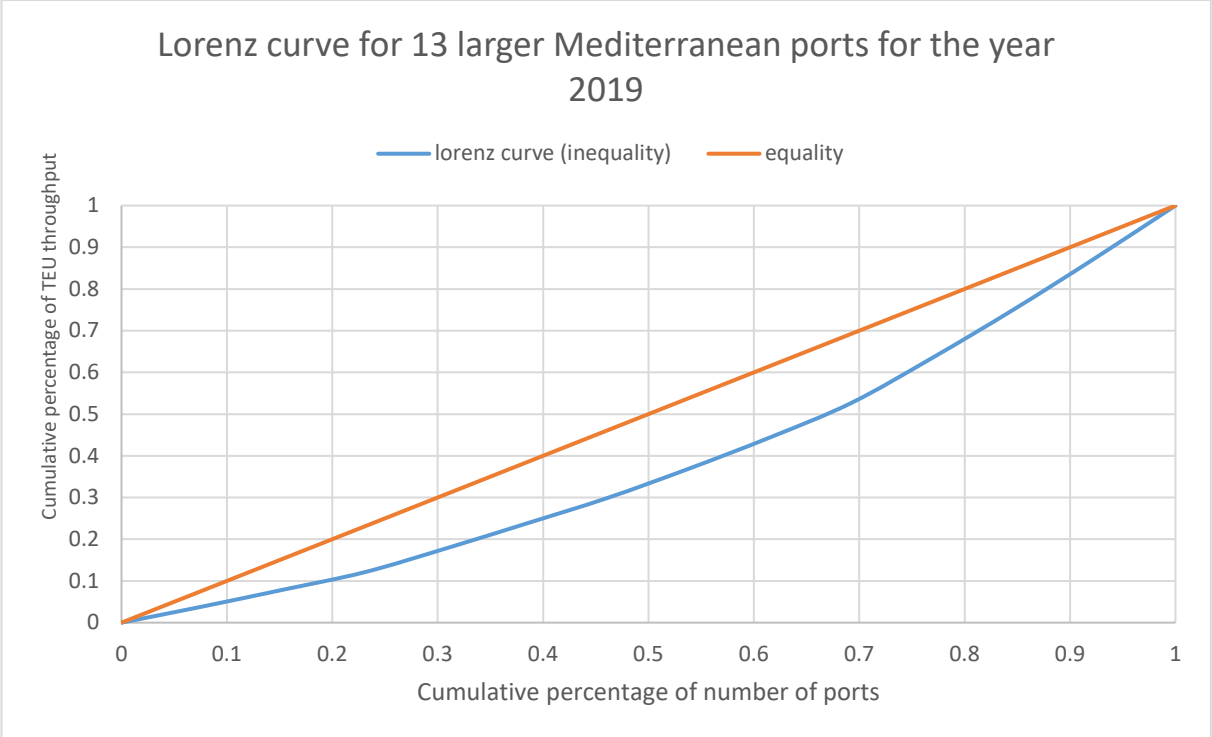
[32]**FIGURE 32** – Lorenz curve for 13 larger Mediterranean ports for the year 2016



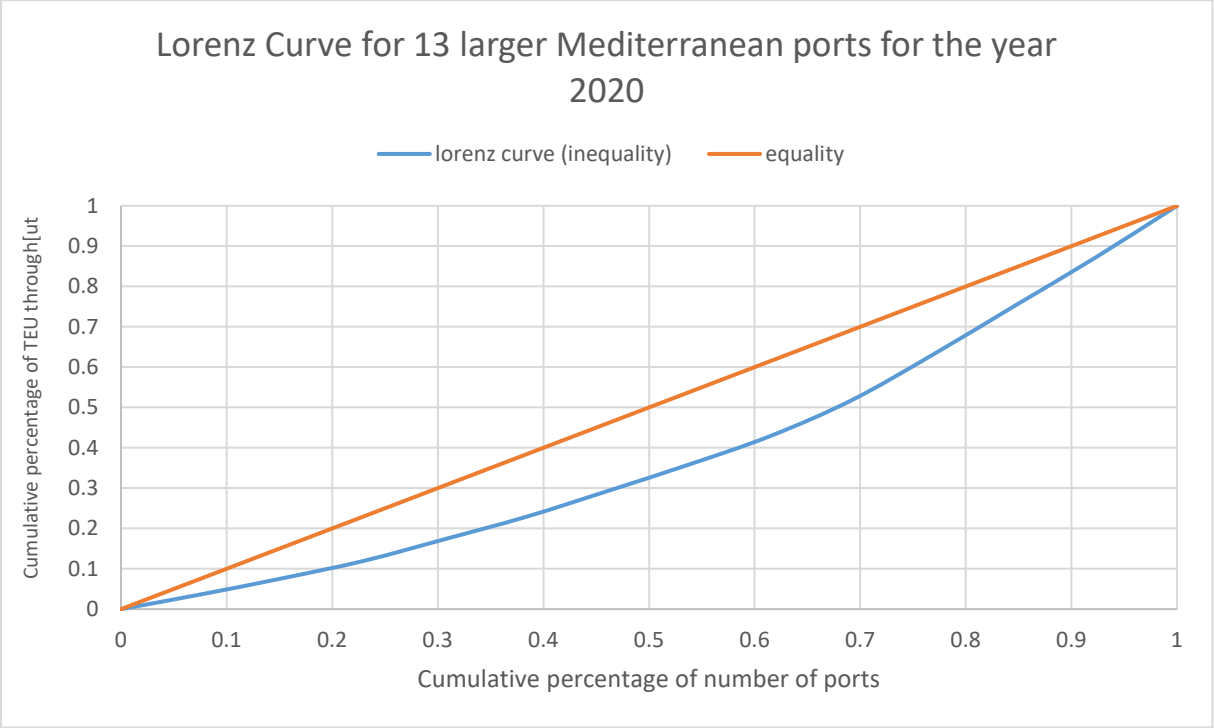
[32]**FIGURE 33** – Lorenz curve for 13 larger Mediterranean ports for the year 2017



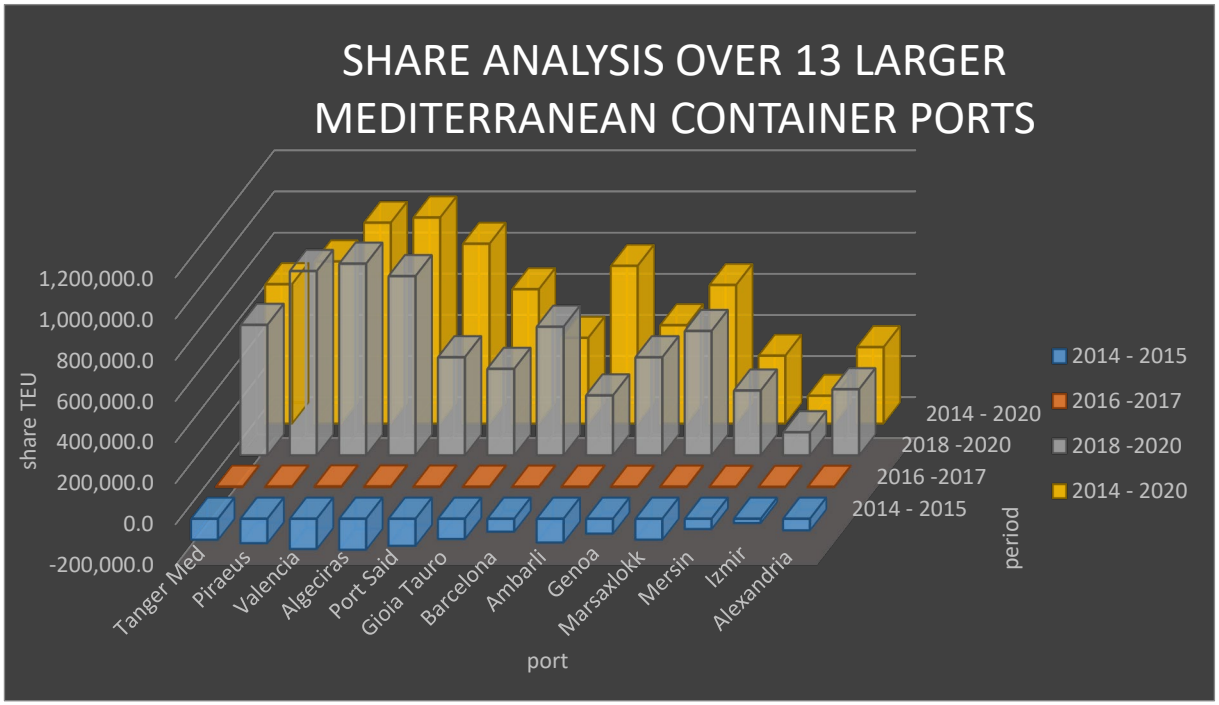
[32]**FIGURE 34** – Lorenz curve for 13 larger Mediterranean ports for the year 2018



[32]**FIGURE 35** – Lorenz curve for 13 larger Mediterranean ports for the year 2019



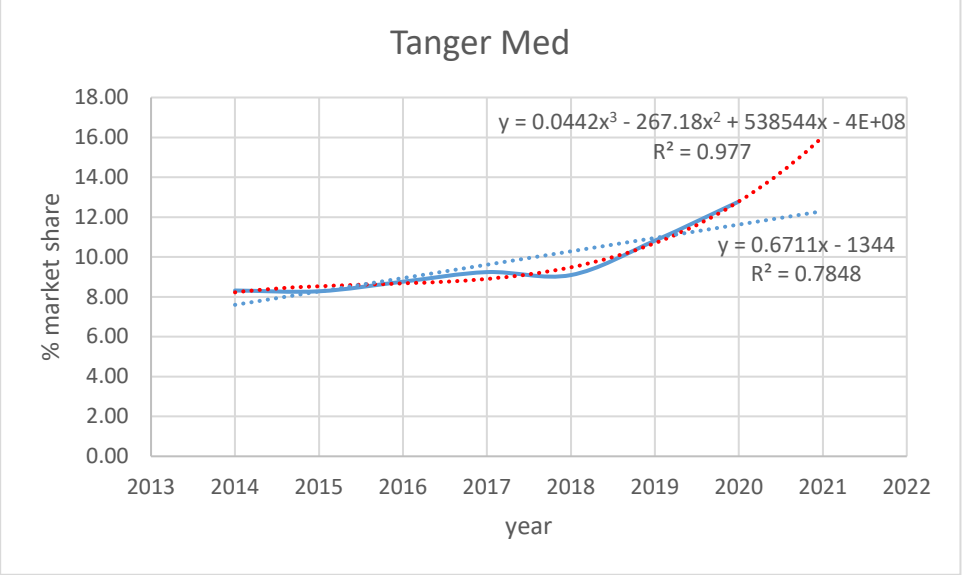
[32]**FIGURE 36** – Lorenz curve for 13 larger Mediterranean ports for the year 2020



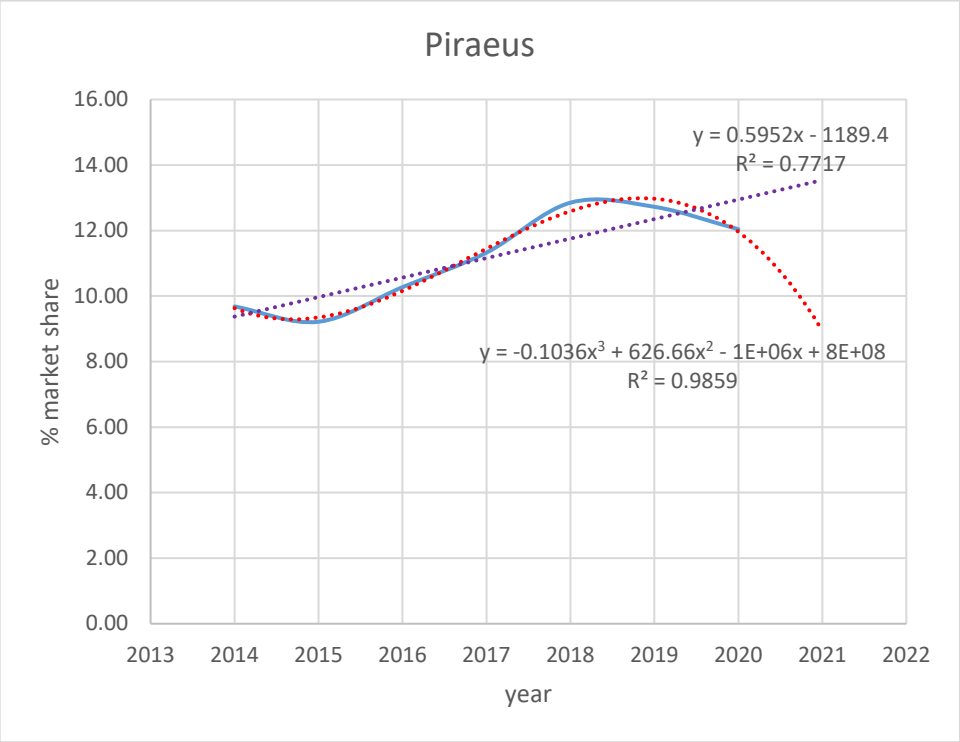
[32]**FIGURE 38** – Share analysis over 13 larger Mediterranean ports from 2014 until 2020

ANNEX 3

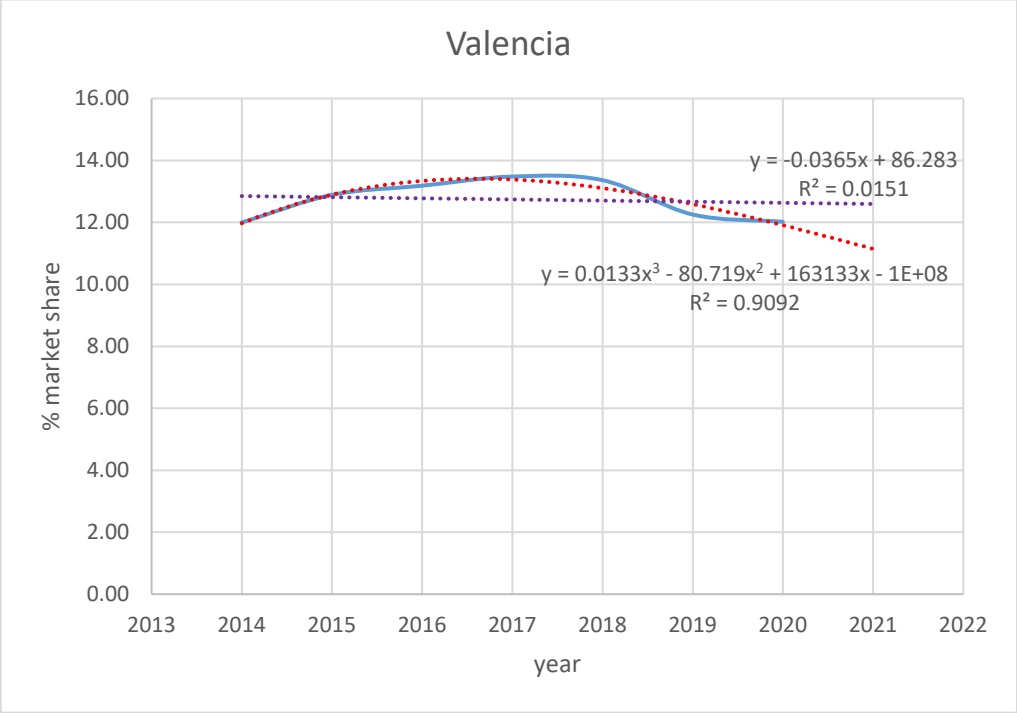
Percentage throughput for 13 major Mediterranean ports from 2014 until 2020



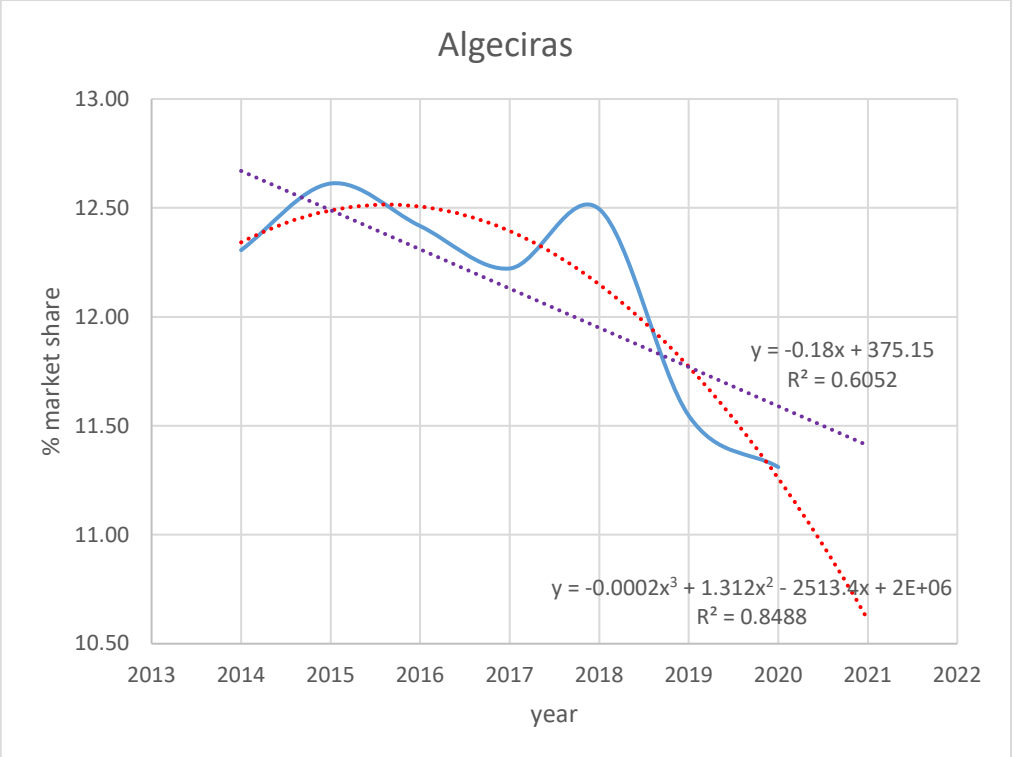
[32]**FIGURE 43** - Percentage throughput from the port of Tanger Med 2014-2020



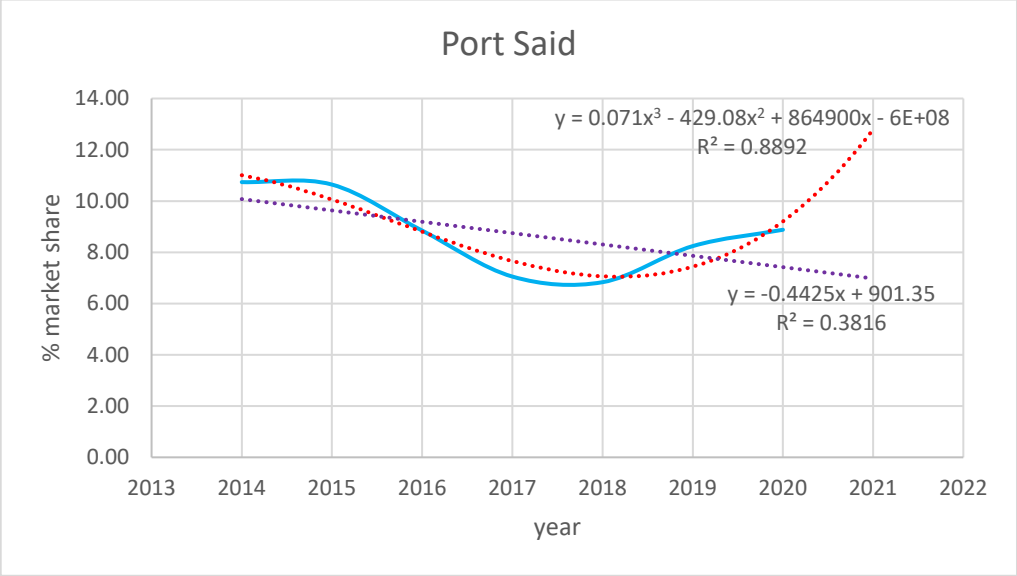
[32]**FIGURE 44** - Percentage throughput from the port of Piraeus 2014-2020



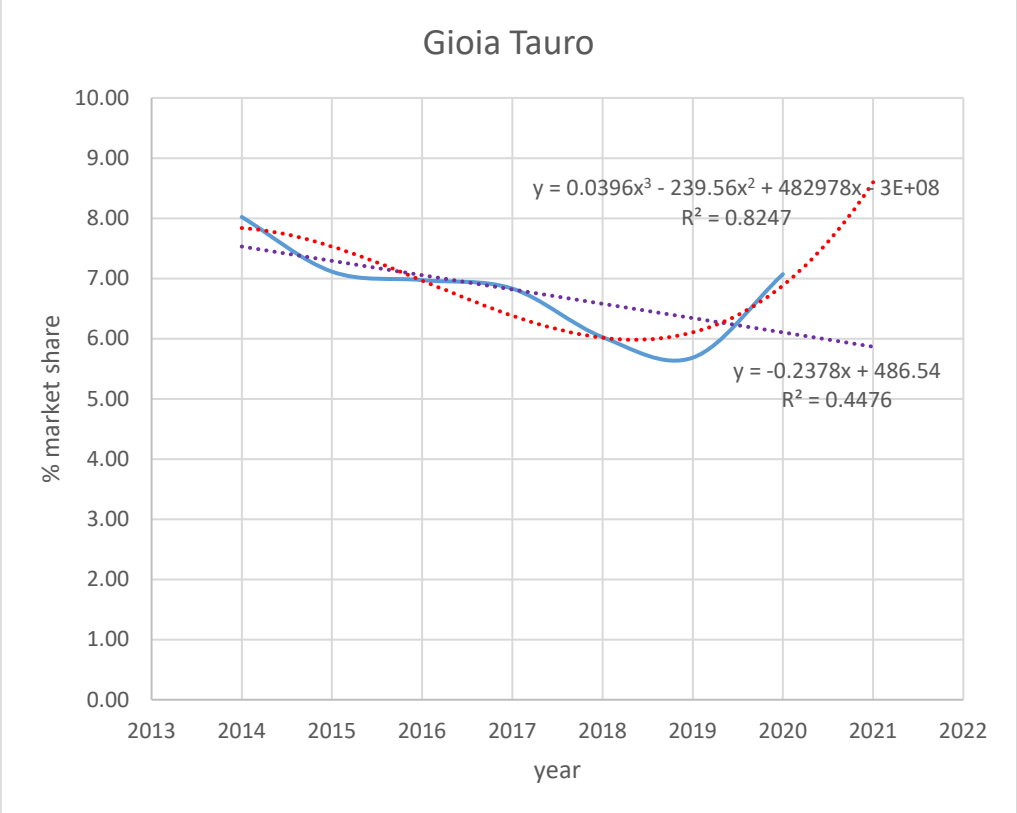
[32]**FIGURE 45** - Percentage throughput from the port of Valencia 2014-2020



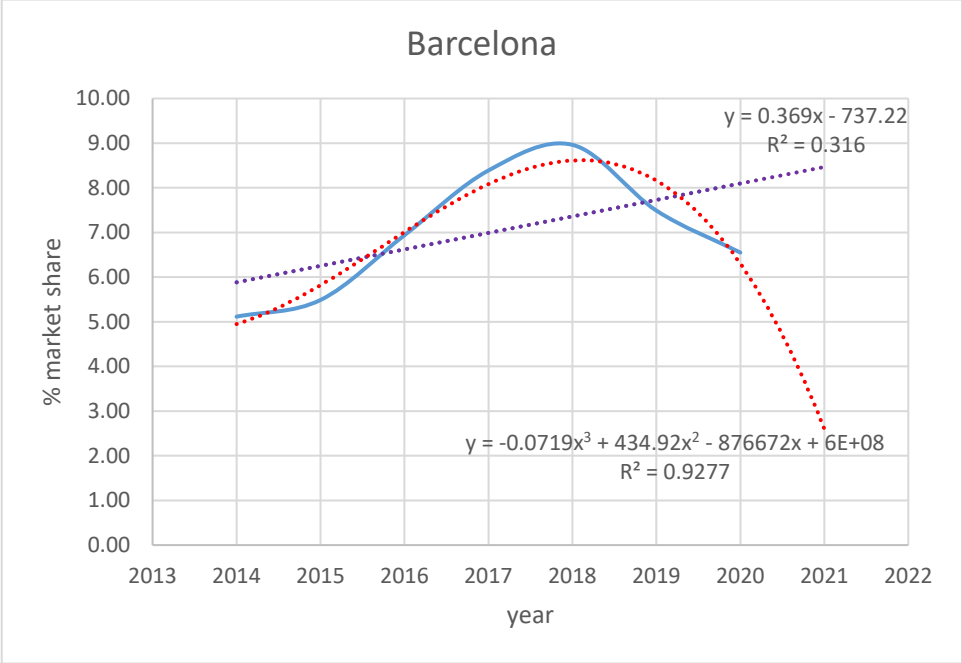
[32]**FIGURE 46** - Percentage throughput from the port of Algeciras 2014-2020



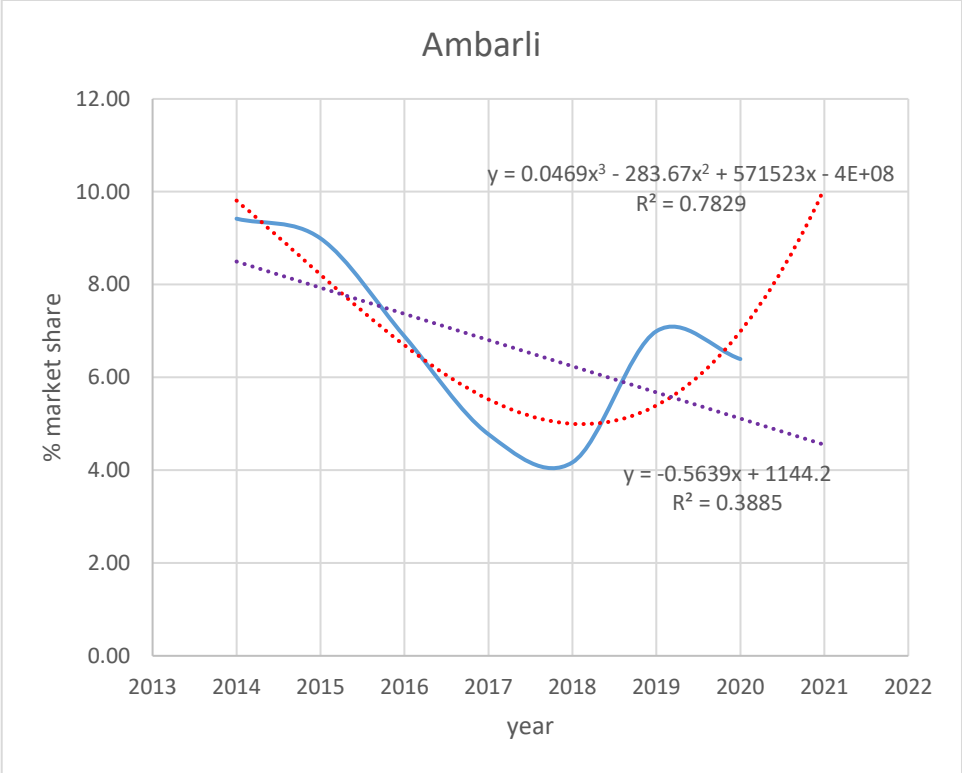
[32]**FIGURE 47** - Percentage throughput from the port of Port Said 2014-2020



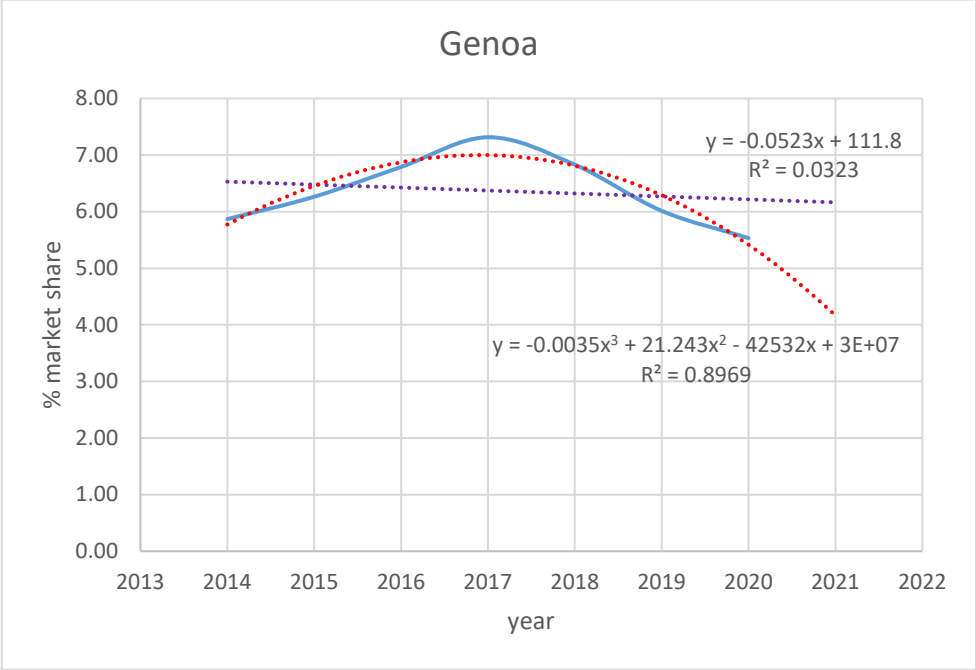
[32]**FIGURE 48** - Percentage throughput from the port of Gioia Tauro 2014-2020



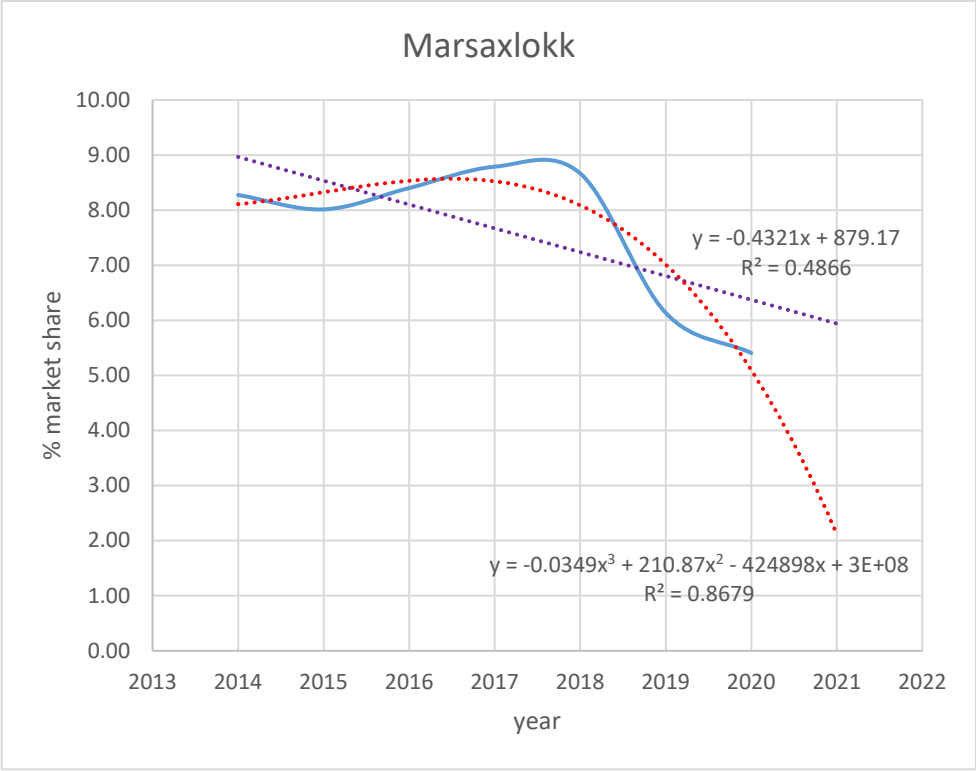
[32]**FIGURE 49** - Percentage throughput from the port of Barcelona 2014-2020



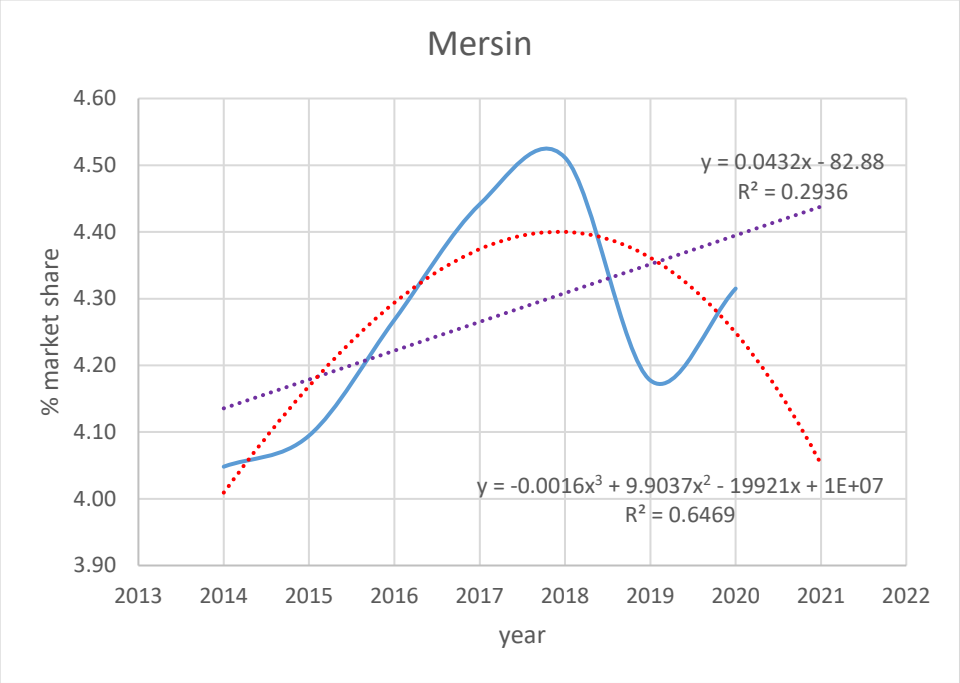
[32]**FIGURE 50** - Percentage throughput from the port of Ambarli 2014-2020



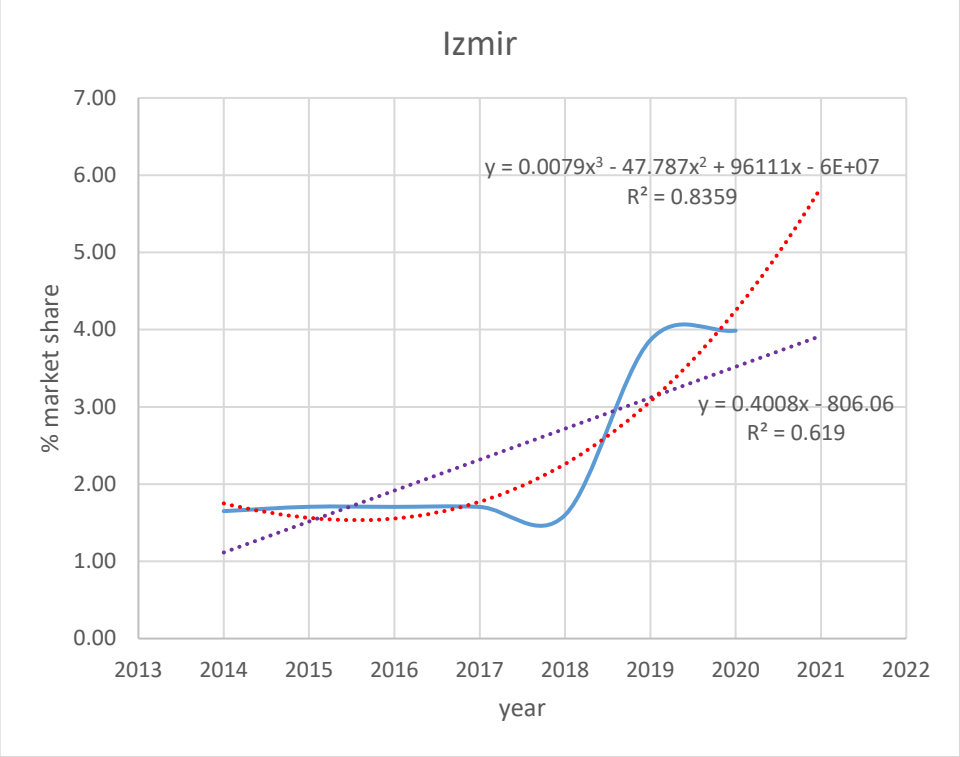
[32]**FIGURE 51** - Percentage throughput from the port of Genoa 2014-2020



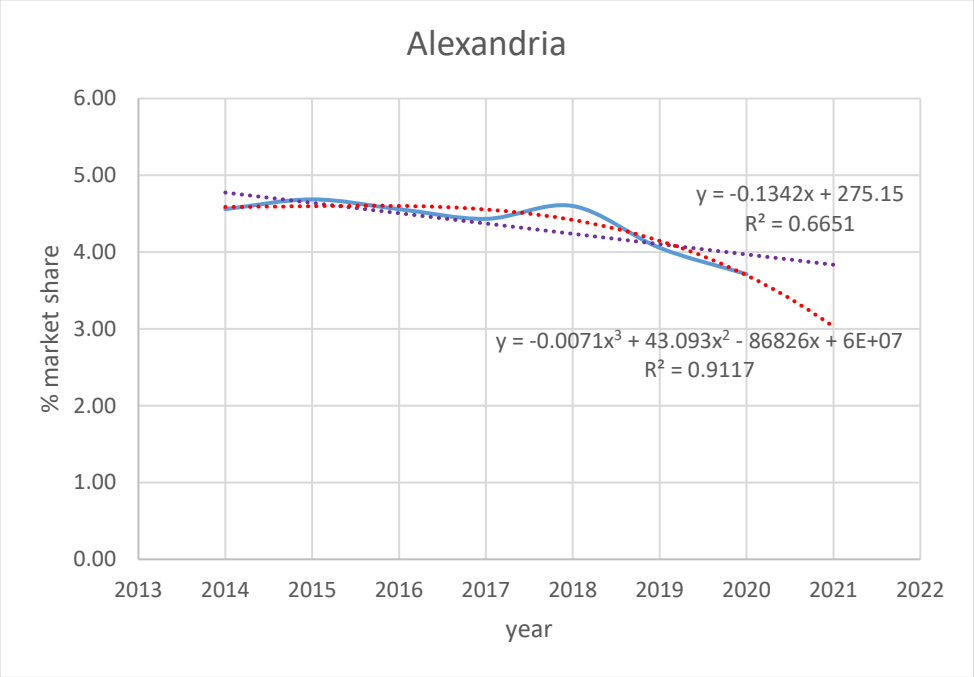
[32]**FIGURE 52** - Percentage throughput from the port of Marsaxlokk 2014-2020



[32]**FIGURE 53** - Percentage throughput from the port of Mersin 2014-2020



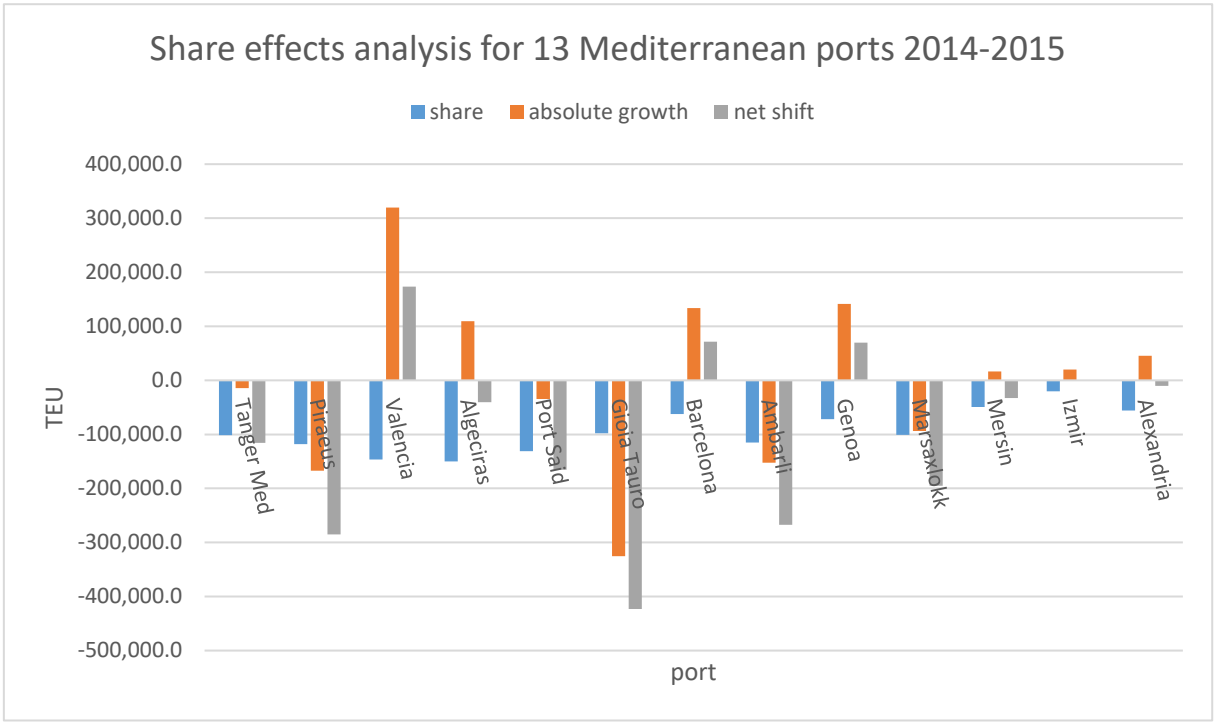
[32]**FIGURE 54** - Percentage throughput from the port of Izmir 2014-2020



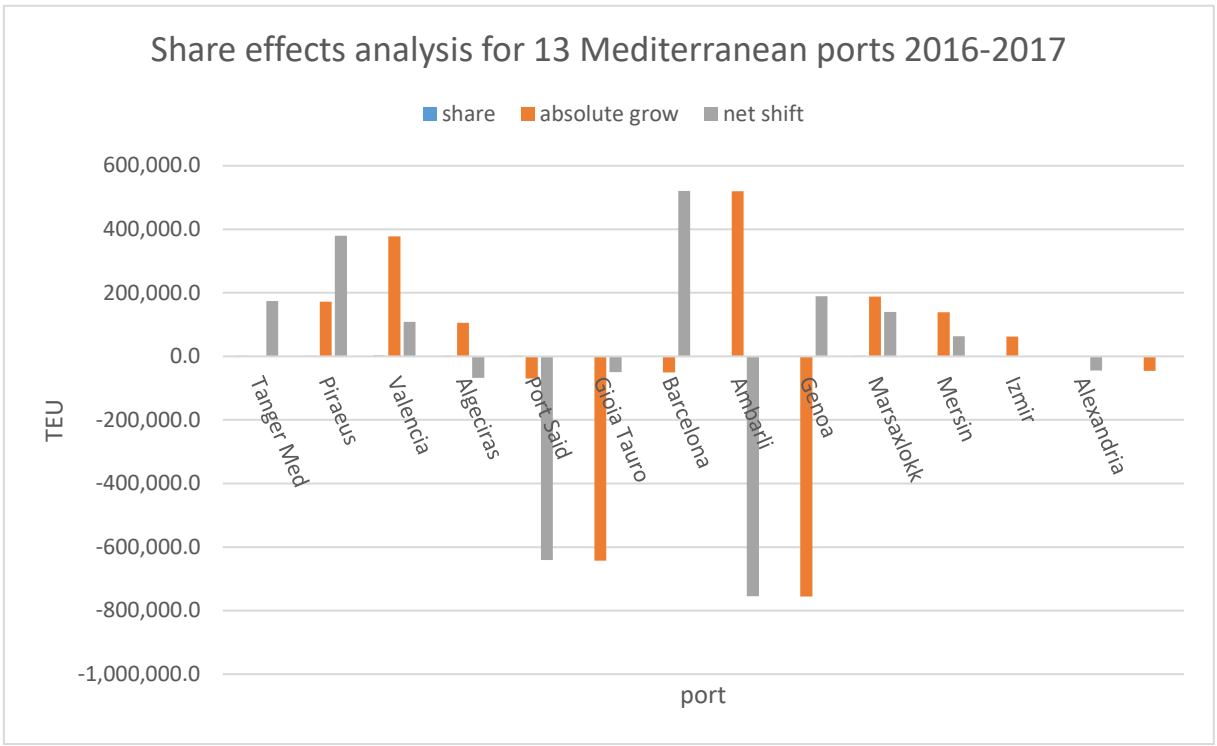
[32]**FIGURE 55** - Percentage throughput from the port of Alexandria 2014-2020

ANNEX 4

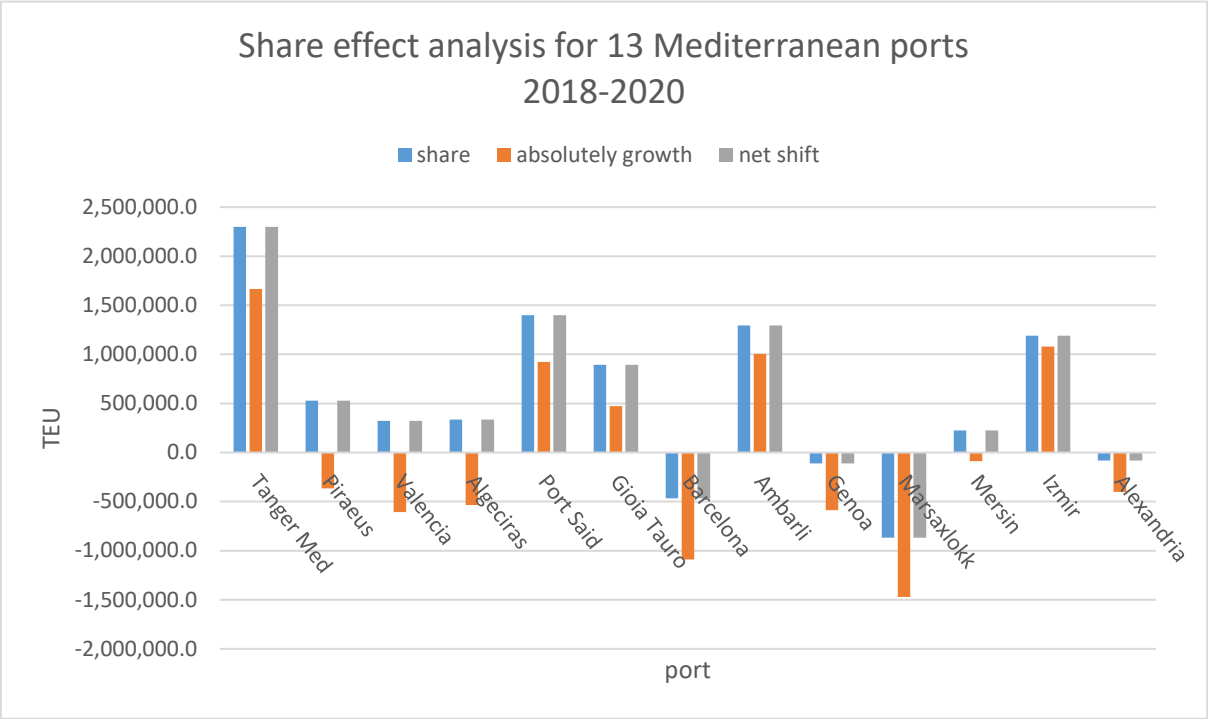
Share effect analysis for 13 major Mediterranean ports from 2014 until 2020



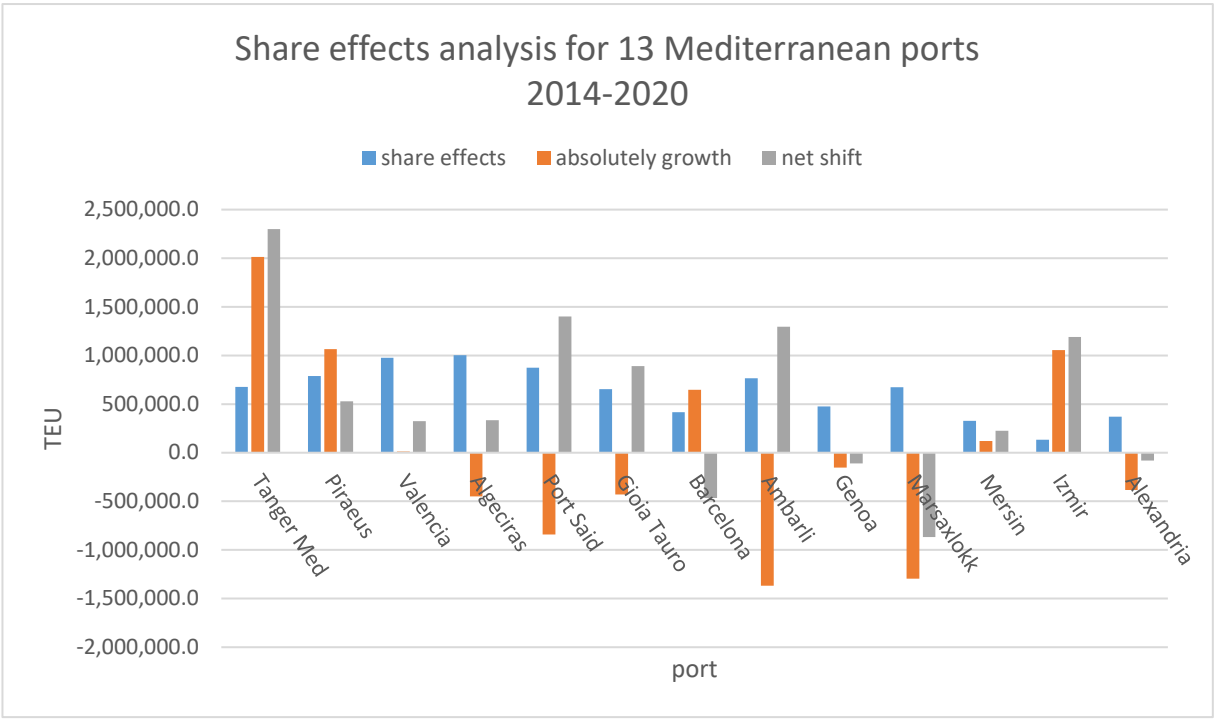
[32]**FIGURE 39** – Share analysis over 13 larger Mediterranean ports from 2014 until 2015



[32]**FIGURE 40** – Share analysis over 13 larger Mediterranean ports from 2016 until 2017



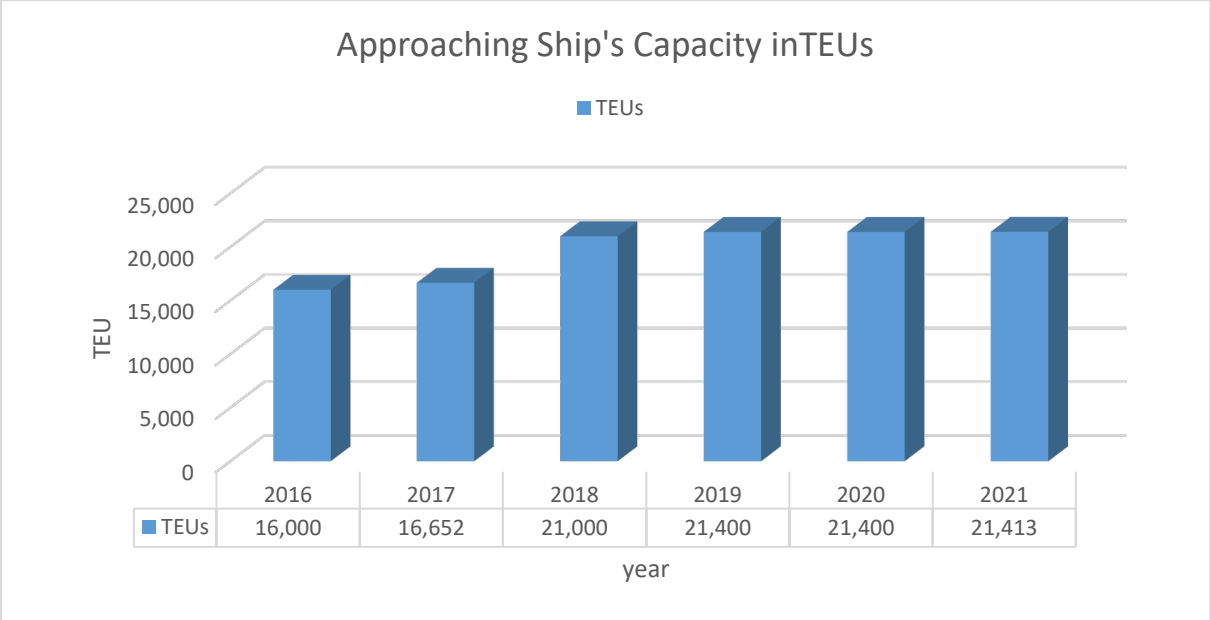
[32]FIGURE 41 – Share analysis over 13 larger Mediterranean ports from 2018 until 2020



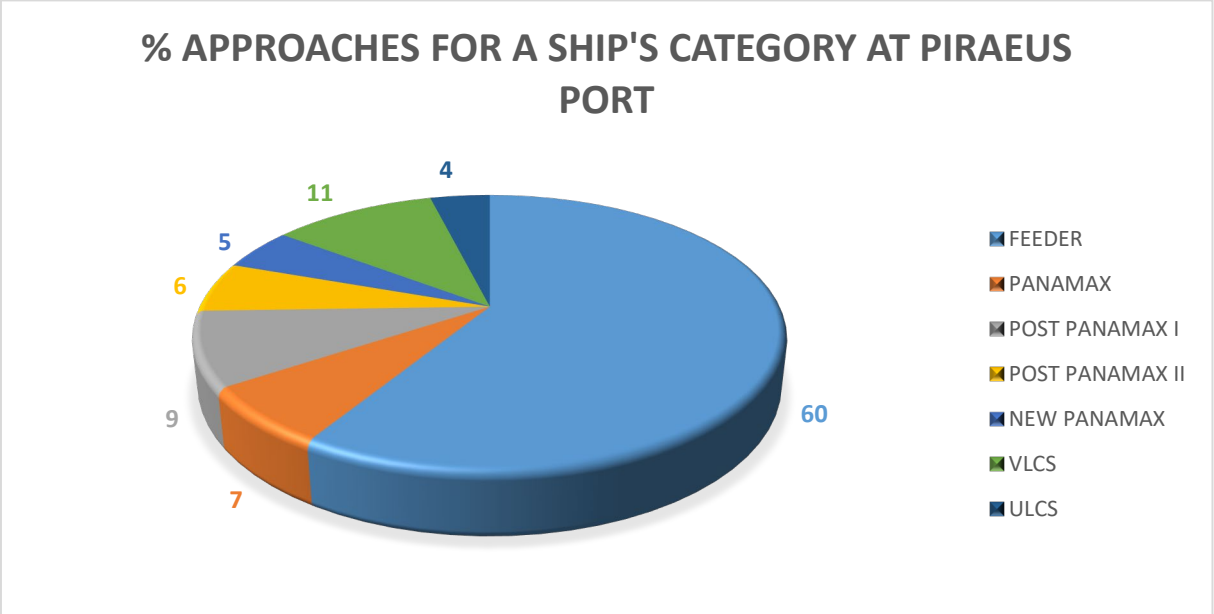
[32]FIGURE 42 – Share analysis over 13 larger Mediterranean ports from 2014 until 2020

ANNEX 5

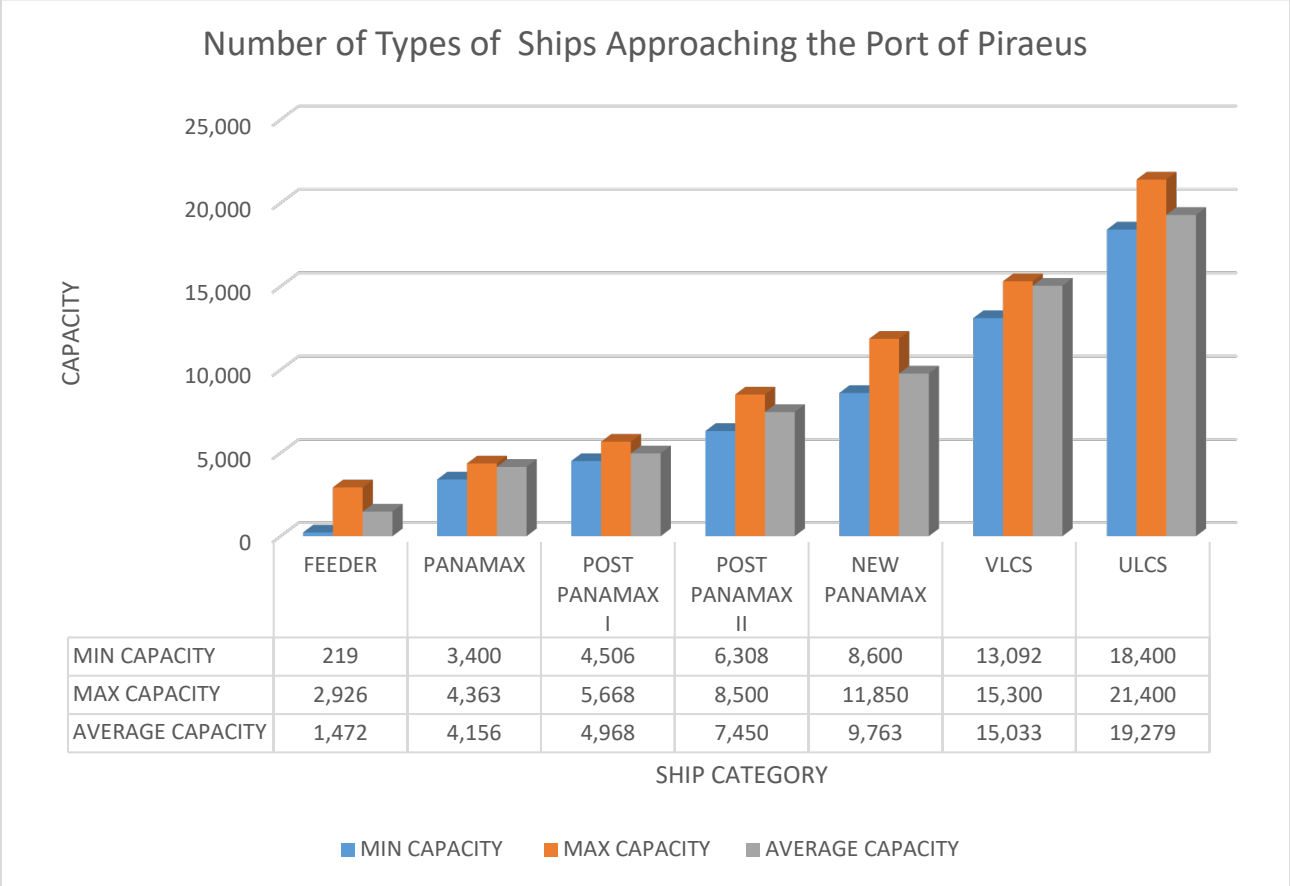
Approaching ships at the Piraeus port



[32]**FIGURE 56** – Approaching Ship's Capacity in TEUs for 2021



[32]**FIGURE 57** – Presentence of ship's category approaching the Piraeus port for 2021



[32]**FIGURE 58** – Number of types of ships for each category approaching the Piraeus port for 2021