

An Empirical Analysis of Feeder Service Development and Container Traffic in Croatian Ports

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Abstract: Today, container ships represent a significant link in the global maritime transport of goods. The continued growth of the global economy is resulting in an increased demand for larger ships. While this demand has led to the development of very large container ships capable of carrying thousands of units on long-distance routes, it has simultaneously encouraged the expansion of smaller container ships designed to serve ports that cannot accommodate these giants. These ships form the backbone of feeder services, which distribute containers from major hub ports to smaller regional ports. As such, feeder transport is an essential component of the modern maritime container supply chain and a key factor in global economic development. The paper explains fundamental concepts in this transport system, including the roles of hub and spoke ports. After outlining the critical characteristics of feeder ships and services without which contemporary container shipping would not function, an analysis of container traffic in the Croatian ports of Rijeka and Ploče was conducted for the period 2019–2022. The results indicate that Croatian container ports are becoming increasingly competitive and gaining market recognition, particularly the Port of Rijeka, which has attracted substantial foreign investment. Continuous investment in port development has attracted leading global container shipping companies, significantly increasing annual cargo throughput.

Keywords: Feeder ship, Hub and spoke port, Maritime container transport.

1. Introduction

In the maritime transport of goods, container ships play an important role. The development of the world economy constantly imposes new requirements, resulting in ever-increasing dimensions and capacities of ships for transporting containers. Today, large container ships can transport over 24,000 twenty-foot equivalent units (TEU) [1]. The need for larger ships

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capable of transporting many containers over long distances has influenced the development of smaller-capacity container ships that can deliver containers to ports unsuitable for accommodating such large ships. This fleet represents a feeder service that transports container units from the main receiving ports to the surrounding smaller ports.

The establishment of the feeder service was crucial to the development of container traffic in Croatian ports. The Port of Rijeka operated without significant investments in its infrastructure from the 1970s until the end of the 1990s, when investments finally began [2]. This fact significantly weakened the competitiveness of the Port of Rijeka compared to other competing ports in the region, primarily Koper and Trieste. The turning point in the business of the Port of Rijeka was in 1999 when container shipping lines began revitalizing [2]. A comparison with other ports in the region that are technologically or organizationally more developed can provide answers on how to improve the effectiveness of the port itself. Certain studies analyze the maritime container traffic of the Republic of Croatia, whether it is an analysis of container traffic or a comparison with operations in this sector with competing ports in the northern Adriatic basin. Petrić and Pavletić (2019) in their work „Benchmarking Analysis of Factors Influencing Container Traffic in the Port of Rijeka” benchmark the factors affecting the container traffic of the ports of Rijeka and Koper [3]. Results show that the Port of Rijeka has excellent potential and, with proper development, will establish itself as the leading container port in the northern Adriatic basin. The harmony of traffic supply and demand directly affects the successful operation of every seaport. Jugović et al. (2011), in their paper „Traffic demand forecasting for port services”, researched traffic demand forecasting for Rijeka port [4]. They concluded that the market demand for services and container transshipment in Croatia's most significant port far exceeds the current capabilities of the existing terminal. Kolar et al. (2000) in their paper „Container-feeder service Rijeka (Ploče) – Gioia Tauro (Malta)” state that the introduction of feeder lines from world-renowned shipping companies significantly boosted the development of this port [5]. These lines established the connection of the Port of Rijeka with other world-leading container ports. Some recommendations are given, including the need to establish cooperation with potential users, the lack of an information system on the market situation, and the need to promote this navigation route with all its advantages [5]. Rathman et al. (2015) in „Analysis of the competitiveness of Port of Ploče at the container transport market and the possibilities for improvement” analyzed the competitiveness of the container market and the development possibilities of Croatia's second container port, Ploče [6]. The conclusion was that without a

significant investment in the port infrastructure and traffic routes towards the hinterland, Ploče could hardly compete with the more developed ports of the north. Kos et al. (2010) in their work “Structural analysis of Croatian container seaports” analyze relevant traffic parameters of the Croatian container seaports of Rijeka, Ploče and Split [7]. They conclude that infrastructural development plans, superstructural investment plans, as well as plans for essential investments in land connections to the hinterland, are projected for all Eastern Adriatic ports. Authors also state the future need for coordination between the dynamics of the mentioned plans and projects and their realization, traffic demands, and harmonization across all Eastern Adriatic ports.

The aim of this paper is to show the development of feeder service by analyzing container traffic in Croatian ports from 2019 to 2022 and what share of the total maritime traffic is represented by container transport. The port's development planning will be analyzed, focusing on modernization, the importance of hinterland connections, and the increase in traffic as primary goals. In addition, this paper's additional goal is to highlight the importance of the feeder service, without which today's maritime container transport would be impossible.

This research is based on quantitative and qualitative analyses of container traffic at the Croatian ports of Rijeka and Ploče for the period 2019-2022. The data were obtained through a review of data from port authorities, pilot services, and shipping agencies. A comparative analysis was used to assess the difference in the level of development and competitiveness between the analyzed ports. A SWOT analysis was used to identify the main internal and external factors influencing their future development.

The main scientific contribution of the paper lies in the systematic identification of feeder services as a necessary condition for the sustainable growth of container traffic, although not sufficient on its own. Empirical findings show that feeder connectivity alone does not automatically lead to a structural transformation of a port's competitive position. Instead, its impact depends on complementary factors such as terminal depth, infrastructure capacity, long-term concession agreements, and hinterland integration. In this way, the study shows that connectivity must be embedded in broader structural and institutional frameworks in order to generate cumulative growth effects.

The comparative approach applied in this research enables a differentiated interpretation of development directions within the same national port system. The divergence between Rijeka and Ploče confirms that similar institutional conditions do not necessarily produce similar

performance outcomes, thereby highlighting the importance of strategic investment decisions in shaping port competitiveness.

The ports of Rijeka and Ploče were selected as case studies because they represent the two main container ports in the Republic of Croatia. Rijeka is the leading Croatian container port in the northern Adriatic, while Ploče is the only active container port in the southern part of the country with significant differences in annual cargo traffic, infrastructure development, and hinterland structure compared to the Port of Rijeka. These differences enable a comparative analysis of the role of feeder services under different operational and development conditions, as well as an understanding of the dynamics of container transport in the Republic of Croatia. The choice of the 2019–2022 period primarily reflects the availability of data for that period. In addition, this period coincides with significant infrastructure investments, the introduction of new services at the Port of Rijeka, and the reactivation of feeder links in the Port of Ploče, making it particularly suitable for analyzing their impact on container traffic trends.

2. Term and Emergence of Container Ship Feeder Service

A container ship feeder service is a short- and medium-distance liner shipping service that connects regional ports with major hubs within a hub-and-spoke container transport system. Its role is to transport containers from major regional ports to smaller ports and to consolidate export cargo in the opposite direction. This container transport enables the integration of these ports into global maritime transport flows [8].

In modern container transport, a feeder ship is small to medium-sized (Table 1). The essential characteristic of these ships is that they sail according to a predetermined schedule. As for the classification of these ships, although today, some shipowners use much larger ships, they are most commonly classified into three main types according to their size and capacity [8]:

- Feeder containership (up to 1,000 TEU) – these ships are the smallest and ideal for operating in small ports with low cargo volumes.
- Feedermax containership (1,000–2,000 TEU) – these ships are typically used to transport cargo to medium-sized or high-volume small ports.
- Panamax containership (2,000–5,000 TEU) – these ships are the largest feeder ships. They transport cargo from the largest hub ports to smaller ones and are also used in transoceanic routes with moderate cargo volume.

Since feeder ships call at smaller ports where the infrastructure may be less developed, they are regularly equipped with cranes for handling containers.

Table 1 – *Technical characteristics of feeder ships up to 5,100 TEU*
(source: authors according to [9])

TEU	400	1,000	2,000	2,500	3,000	4,000	5,100
Draft (m)	6.9	8.6	10.5	11	11.5	12.5	13.5
LOA (m)	108	145	185	198	215	260	295
LPP (m)	105	140	175	190	205	245	280
Breadth (m)	17.8	23	28	32.2	32.2	32.2	32.2
Sea margin	15	15	15	15	15	15	15
Engine margin	10	10	10	10	10	10	10
Deadweight (t)	5,700	13,500	26,500	33,000	39,000	51,000	63,500
Speed (kt)	17.1	18	19.6	20.2	20.8	21.1	21.9
SMCR power	4,350	7,350	13,100	16,250	19,300	22,800	28,500

The draft of these ships ranges from 6.9 to 13.5 m, with length overall from 108 to 295 m, and the width from 17.8 to 32.2 m. These ships reach speeds between 17 and 22 knots (Table 1).

In liner shipping, and therefore in the feeder transport service, there is a trend towards rationalising the number of port calls to reduce costs [10]. A significant advantage of this type of transport is the predetermined schedule and movement of container units. In this way, shippers' costs and inventory at all levels were significantly reduced, which is an essential factor for efficient manufacturers. The feeder service is the main reason container transport by sea has become more efficient and profitable [10]. All these benefits associated with the feeder service relate positively to the total cost of the end user of the transport. According to Dynamar Maritime Reports, 124 shipping companies offer feeder services worldwide, which can be divided into two major groups [11]:

- Dedicated operators – shipping companies engaged in maritime transport using their own container units.
- Common operators – smaller shipping companies that do not use their own container units.

Table 2 – World's top fifteen container operators
(source: authors according to [12])

Carrier	Total			Owned		Chartered	
	TEU	Share	Ships	TEU	Ships	TEU	Ships
MSC	5979659	19.8	837	2998500	539	2981100	298
Apm-Mears	4330262	14.4	712	2514600	332	1815600	380
CMA CGM	3752827	12.4	644	1919800	266	1832900	378
COSCO	3228681	10.7	502	1894200	192	1334400	310
Hapag-Lloyd	2159023	7.2	286	1294300	127	864600	159
ONE	1916909	6.4	244	783600	92	1133200	152
Evergreen	1688810	5.6	222	1029200	137	659500	85
HMM	852169	2.8	76	672500	48	179600	28
Zim	721712	2.4	128	38700	9	682900	119
Yang Ming	695304	2.3	93	300300	57	394900	36
Wan Hai	508063	1.7	121	491300	113	16600	8
PIL	328524	1.1	91	198800	70	129600	21
SITC	171930	0.6	110	161300	100	10600	10
KMCT	161723	0.5	66	89,000	31	72700	35
X-press	158496	0.5	85	100600	43	57800	42

Table 2 shows an overview of the fifteen world's largest container shipping companies according to market share, number of own ships, and chartered ships. It is important to point out that five of the top fifteen leading global carriers (MSC, Maersk, CMA CGM, COSCO, and Hapag-Lloyd) operate regular services to the Port of Rijeka. The presence of world's leading container shipping companies is a key factor contributing to the growth of container traffic [12].

Analysing the breakdown of operated capacity by TEU for the 15 largest container shipping companies, it is evident that a few of them are exclusively feeder carriers, led by the X-Press shipping company, which took the leading position ahead of the Unifeeder shipping company regarding feeder service (Table 3).

The fleet structure presented in Table 3 is directly related to the operational characteristics of the Croatian ports. The dominance of ships below 5,000 TEU in the fleets of several major carriers corresponds to the size of ships currently calling at Rijeka and Ploče through feeder services. At the same time, the growing share of large-capacity ships highlights the importance of ongoing infrastructure investments in Rijeka, which will enable the berthing of deep-sea ships and reduce its dependence on transshipment via hub ports. For the Port of Ploče, whose infrastructure currently limits the arrival of larger ships, the feeder segment remains the primary mode of integration into global container flows.

Table 3 – Breakdown of units operated by TEU size range of 15 leading shipping companies (source: authors according to [12])

Rank	Carrier	Breakdown of units operated by TEU size range						
		18,000-24,000	12,500-17,999	10,000-12,499	7,500-9,999	5,100-7,499	3,000-5,099	< 2,999
1	MSC	52	111	24	144	79	148	269
2	Mearsk	31	49	35	88	93	180	236
3	CMA CGM	12	69	48	57	76	105	277
4	COSCO	39	51	16	53	41	156	177
5	Hapag-Lloyd	12	49	17	48	28	67	65
6	ONE	12	39	19	37	36	47	54
7	Evergreen	22	20	20	30	27	28	97
8	HMM	12	22	8	4	8	13	9
9	Zim			7	21	17	32	41
10	Yang Ming		25	8	8	15	7	30
11	Wan Hai		13			11	46	51
12	PIL		2	4	2	8	32	43
13	SITC							110
14	KMCT					6	7	52
15	X-Press					4	8	73

3. Analysis of Container Traffic in the Croatian Ports

The largest and busiest Croatian container port, Rijeka, is located in the Kvarner Gulf. Its geographical position offers excellent possibilities for connections with the interior of the country, primarily Zagreb and other parts of Europe [13]. Its location gives it great potential to take a leading role in the North Adriatic area as the region's most important port for trade directed towards the Middle East and Asia. In addition to Rijeka as the most important Croatian container port, it is also essential to mention the Port of Ploče, which has established itself as the main cargo port of the southern part of Croatia. In recent years, Ploče has attracted some large shipping companies whose ships regularly call at the Port of Ploče. In addition to the two mentioned ports, there was a container terminal in the Port of Split which has closed in February 2022 [14].

The analysis of container traffic in the Croatian ports of Rijeka and Ploče for the period 2019–2022 shows that the observed changes are not only the result of short-term market fluctuations but also reflect deeper structural differences in their development models, level of integration into global liner shipping networks and overall competitive positioning.

3.1. Development of the Container Terminal of the Port of Rijeka

The Port of Rijeka is where almost all types of cargo are handled so that certain parts of the port are designed for a specific type of cargo. As for the container part and the handling of containers, the Jadranska Vrata container terminal located in the Sušački basin operates within the Port of Rijeka, which began operations back in 1977. The first container crane was installed in the Port of Rijeka in that initial construction phase. After that, in 1987, a 300-meter-long southern shore with a depth of 11.2 meters was built. In 2003, the Government of the Republic of Croatia launched the Rijeka Gateway Project in cooperation with the International Bank for Reconstruction and Development. Rijeka Gateway is the most extensive project since the founding of the Republic of Croatia, which initiated the comprehensive revitalisation of part of Rijeka's coastal area. In 2013, after implementing the Rijeka Gateway project, the second phase of the terminal's construction was completed at the container terminal, with the extension of the pier for another berth and increased storage areas. The depth of the terminal has been increased to 14.2 meters, and it is possible to accept ships up to 370 meters, which have achieved a maximum capacity of 600,000 TEU. The Jadranska Vrata concessionaire installed a new coastal crane and storage equipment for handling containers. In 2018, a project to improve the infrastructure of the Port of Rijeka was approved, and its implementation will increase the capacity and accommodation of larger ships [16]. Figure 1 presents essential historical events that influenced the development of the Port of Rijeka.

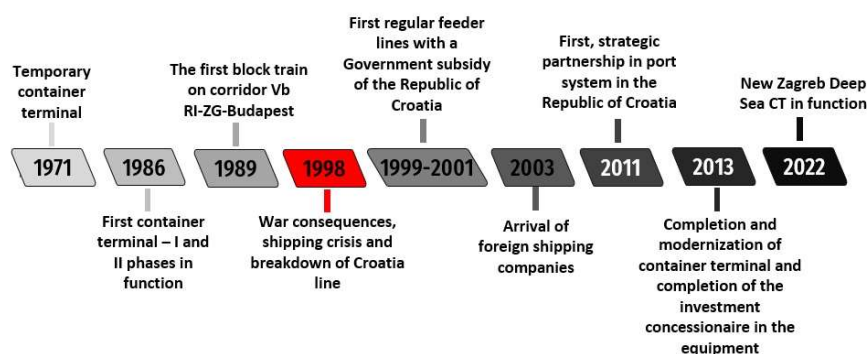


Fig. 1 – Timeline of significant events that influenced the development of the Port of Rijeka (source: authors according to [17])

As far as container traffic is concerned, the most significant achievement was the completion of the first phase of works on the construction of the Zagreb Deep Sea container terminal in 2019, which also marked the

completion of the comprehensive project of reconstruction of the Rijeka traffic route, known as the Rijeka Gateway project. The container terminal will be connected to road network via the new state road D-403 that connects the Port of Rijeka, more precisely, the Zagreb Deep Sea container terminal to the Škurinje junction, which is under construction. In this way, the Zagreb Deep Sea container terminal will be connected to the network of Croatian highways. With the completion of the construction of the D403 road, which will relieve local city traffic and reduce traffic congestion, the quality of life in Rijeka will improve significantly, primarily due to the reduction of air pollution [17]. Another significant investment concerned the container terminal in Rijeka as part of the project "Improving the infrastructure in the Port of Rijeka – container terminal "Zagrebačko pristanište". This project includes the construction of a new intermodal terminal for cargo transshipment at the new Zagreb Deep Sea container terminal. The works on this project were completed entirely at the end of 2022.

Undoubtedly, the Rijeka Gateway project is the most significant investment in the history of the Port of Rijeka. Namely, the future container terminal on the Zagreb coast is expected to start operations in 2025. The terminal will be one of the most modern remotely controlled container terminals in this part of Europe. Once completed, the terminal will have a 680 m long berth and an annual throughput of 1,055,000 TEU and will be able to serve ships up to 24,000 TEU [18]. This project also considers sustainability, implementing modern technologies to reduce environmental harm [17]. With the realisation of this significant investment, the Port of Rijeka will gain new momentum, and all the preconditions will be created for it to assume a leading position in this part of Europe.

3.2 Container Traffic at the Port of Rijeka

The container terminal at Brajdica (AGCT) is managed by the company Jadranska vrata, whose majority owner since 2011 has been the Philippine ICTSI with a 51% stake, while the rest of the ownership of 49% belongs to the Port of Rijeka d.d. In addition to two direct services, it also hosts five feeder services. With them, smaller container ships arrive in Rijeka, which connects other ports of a particular service with the hub port, where containers from different parts of the world arrive. Weekly feeder services at the AGCT container terminal in Rijeka are as follows [19]:

1. **Piraeus Rijeka Express (PRS)** – COSCO, OOCL

(weekly feeder service from Greece)

Ports: Rijeka → Piraeus → Rijeka

2. **Adriatic Express Service** – Hapag-Lloyd

(weekly feeder service)

Ports: Piraeus → Damietta → Koper → Ancona → Rijeka → Venice → Piraeus

3. **Line H** – MSC

(weekly feeder service to Rijeka via Gioia Tauro)

Ports: Gioia Tauro → Bar → Rijeka → Ploče → Gioia Tauro

4. **Maersk ADX-XCL** – Maersk

(weekly feeder service to Rijeka via Piraeus)

Ports: Piraeus → Damietta → Koper → Ancona → Rijeka → Venice → Piraeus

5. **ADRIANAF** – CMA CGM

(weekly feeder INTRA MED service to Algeria and Malta)

Ports: Bejaia → Malta → Rijeka → Venice → Koper → Ancona → Bar → Taranto → Malta → Bejaia

In addition to these five feeder services, two direct services from the Far East have been established every week [19]:

1. 2M Alliance – Maersk, MSC Hamburg SUD direct weekly services from the Far East to Rijeka and vice versa, ships with up to 15,000 TEU capacity. Name of service: Phoenix (MSC) and AE12 (Maersk)

Ports: Tianjinxingang → Dalian → Busan → Ningbo → Shanghai → Shekou → Singapore → Suez → Port Said East → Haifa → Koper → Trieste → Rijeka → Trieste → Port Said East → Suez → King Abdullah Port → Salalah → Singapore → Tianjinxingang

2. Ocean Alliance – CMA CGM, COSCO, EVERGREEN and OOCL direct weekly services from the Far East to Rijeka, ships with up to 10,000 TEU capacity. Name of service Phoenician Express (CMA CGM), AEM6 (COSCO), BEX2 (Evergreen), AAS (OOCL)

Ports: Shanghai → Ningbo → Busan → Shekou → Singapore → Alexandria → Koper → Trieste → Rijeka → Port Said West → Jeddah → Port Kelang → Shekou → Shanghai

The mentioned shipping lines indicate the exceptional connectivity of the Port of Rijeka, which is contributed mainly by the established feeder services operated by leading container shipping companies. The presence of the world's leading container shipping companies, MSC and Maersk, points to the importance of the Port of Rijeka in global container shipping.

The operation of the Port of Rijeka is based on eight receiving terminals, each for a different type of cargo. Additionally, the Omišalj terminal for liquid cargo is located on the northern side of the island of Krk near the Port of

Rijeka. To get a clear picture of the importance of container traffic for the Port of Rijeka and the Republic of Croatia, Figure 2 shows the total number of arrivals of different types of ships in the Port of Rijeka (including the liquid cargo terminal in Omišalj) from 2019 to 2022.

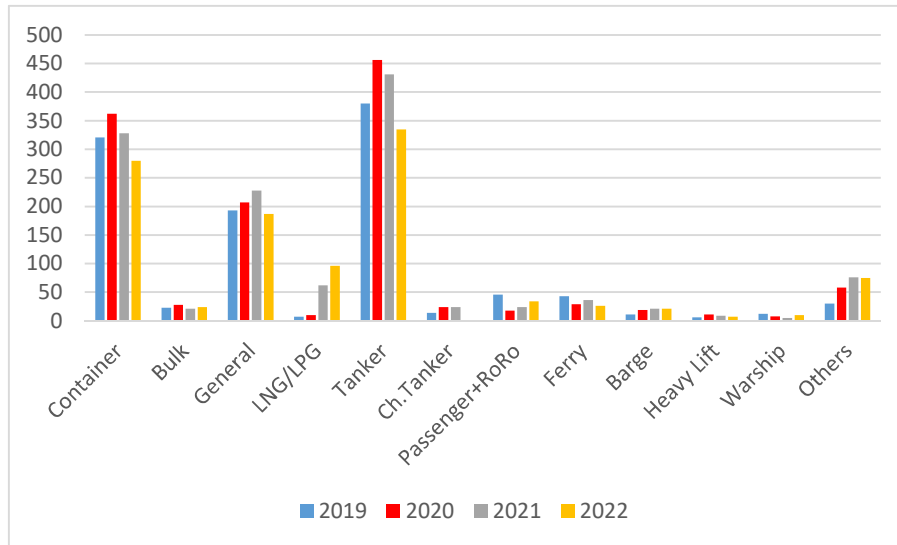


Fig. 2 - Types of ships calling at the Port of Rijeka from 2019 to 2022
(source: authors according to [19])

Figure 2 shows that the number of container ship arrivals has been, by far, the most represented type of ship traffic in the Port of Rijeka over the last four years. This is followed by liquid cargo ships arriving at the Omišalj terminal, which is located nearby and is not an integral part of the port.

Regarding the size of the ships calling at the Port of Rijeka, ships between 100 and 200 m in length are the most represented. Figure 3 shows ship arrivals in the Port of Rijeka from 2019 to 2022 according to the size of the ship.

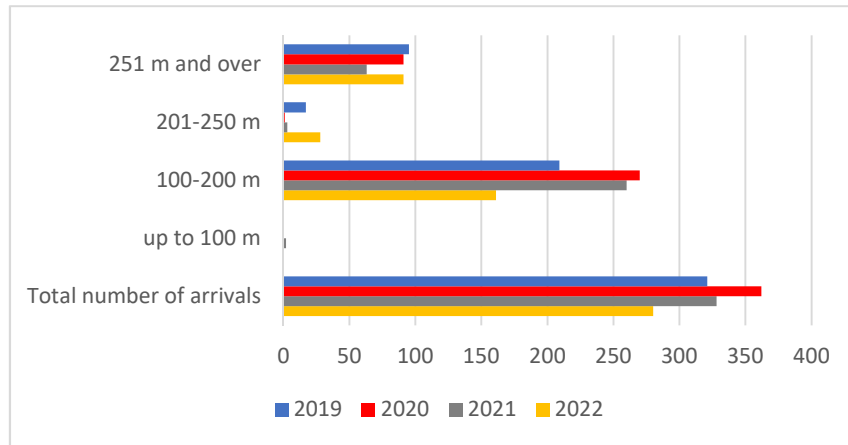


Fig. 3 - The size of the ships calling at the Port of Rijeka from 2019 to 2022
(source: authors according to [19])

One of the indicators of the successful operation of a port is the annual cargo turnover. With the establishment of feeder lines and the arrival of large shipping companies, the annual container traffic of the Port of Rijeka is increasing almost continuously. It has grown significantly in recent years due to the realisation of significant investments. Figure 4 gives an insight into the annual container traffic of the Port of Rijeka from 2003 to 2022.

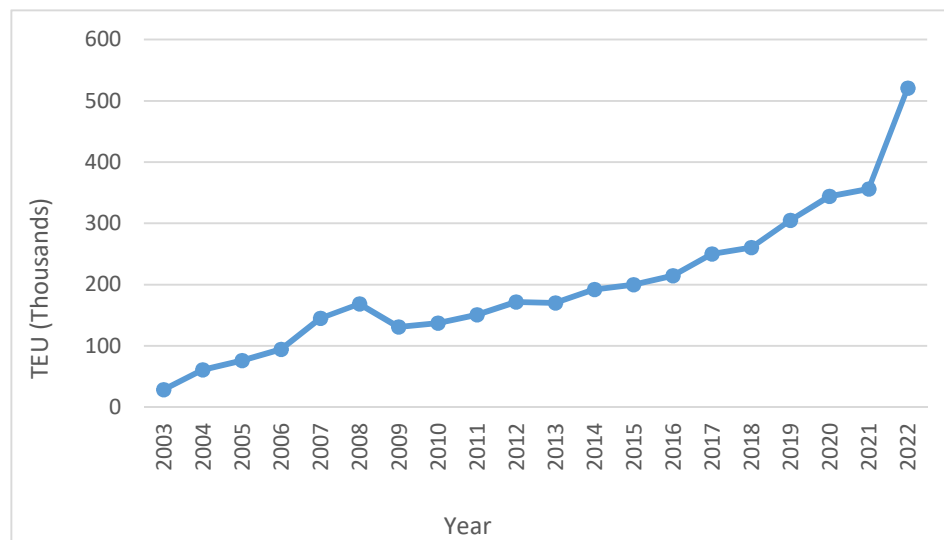


Fig. 4 - Overview of the annual container traffic in the Port of Rijeka
(source: authors according to [15])

It is essential to point out the signed concession agreement in November 2021, with the Dutch company APM Terminals (51%) in a consortium with the Croatian energy conglomerate ENNA Logic (49%) for a period of 50 years. It represents the most significant agreement in terms of importance and value for the Port of Rijeka [18]. Considering the ongoing investments and modernisation of the future container terminal, Rijeka is the region's leading port. The depth of the terminal will be 20 m, enabling the accommodation of the largest container ships. At the same time, the main competitor, the Port of Koper, has a draft limit of 15 m, which is another indicator that the Port of Rijeka has the potential to take over the position of the leading container port in the region.

A systematised overview of all advantages, disadvantages, opportunities, and threats for a specific port is best presented by the SWOT analysis (Figure 5). It can be defined as a diagnostic and prognostic instrument that enables and facilitates planning measures to strengthen advantages and dismantle weak points, the first step in determining the existing and desirable position [20].

S	STRENGTHS	W	WEAKNESSES
	+ Geographical position: strategic location and good hinterland + The presence of the world's leading container shipping companies + Long-term concession agreement for the container terminal + Support from the Government of the Republic of Croatia		– Insufficient development of multimodal transport – Limited capacity of the port and difficulties in the port-city connection – Administrative burden of the maritime sector – Increased cargo traffic and industrial activities can lead to environmental concerns
O	OPPORTUNITIES	T	THREATS
	+ EU membership and opportunities from European funds + Expansion projects (ongoing and planned), including a new container terminal and the development of rail connections + Investments in eco-friendly practices and technology + Ability to accommodate the largest container ships		– Proximity of competitive ports – The political instability of neighbouring countries, especially in the east – The risk of increasing maritime accidents with a negative impact on the environment – A global or regional economic downturn can reduce cargo volumes and negatively affect port revenue

Fig. 5 – SWOT analysis for the Port of Rijeka (source: authors)

The SWOT analysis shown in Figure 5 aims to give a better insight into the current state of the Port of Rijeka, including its advantages and disadvantages as well as opportunities and threats that could affect the further operations of this port.

3.3 Development of the Container Terminal of the Port of Ploče

Besides Rijeka, the Port of Ploče is the second and currently the only other Croatian container port following the closure of the container terminal at the Port of Split in 2022. Located in the south of Croatia, it has gained increasing importance in maritime container transport, particularly in recent years. Like Rijeka, the Port of Ploče has established feeder lines since 1999, enabling connections with Mediterranean hub ports and initiating the development of container traffic in that port. Thanks to the established feeder lines, the Port of Ploče is becoming increasingly recognised by the world's leading container shipping companies, thus becoming part of the world's container flows. An essential advantage of the Port of Ploče is its location. It is connected by road in three directions, including the shortest north-south route and the most convenient transport connection between the Baltic and the Adriatic Sea. In the north-south direction, the completion of the Vc corridor is of strategic importance for the Port of Ploče. Predictions indicate that work on the corridor will be completed in 2028. That corridor will connect the Port of Ploče with Budapest and pass through Bosnia & Herzegovina and eastern Croatia to Hungary.

Although not to the same extent as the Port of Rijeka, investments in Ploče also led to the opening of a new container terminal. The first phase of construction was completed in 2011. The length of the container terminal is 280 meters, and the total storage area is 38,000 m² with a capacity of 60,000 TEU. The depth at the terminal is 13.80 meters. It is equipped with two mobile cranes and an STS crane. Compared to the Port of Rijeka, whose container terminal has already undergone several development phases and is preparing to accommodate ships of up to 24,000 TEU, the Port of Ploče is still in an earlier stage of infrastructure development. Its current depth and terminal capacity limit the arrival of larger ships, which explains its exclusive reliance on feeder services.

The empirical data indicate that feeder connectivity alone has not been sufficient to generate sustained growth. Unlike Rijeka, Ploče does not have direct deep-sea services and remains fully dependent on feeder connections through Mediterranean hubs. This structural dependence limits its bargaining power within liner networks and increases its sensitivity to strategic decisions made by major hub ports and global carriers.

In recent years, the Ploče Port Authority has based its activities on three fundamental components: infrastructure development, ecology, and digitalisation. In this sense, in addition to the container and bulk terminals, a port information system and numerous infrastructure facilities, including parts of the railway, road, water supply, and electrical and digital networks, have been developed for the Port of Ploče to meet the increasingly complex market demands. With the increase in container traffic, the conditions are created to realise the remaining phases of the planned development [21].

While investments in Rijeka are primarily aimed at positioning the port as a leading regional port, the development of the Port of Ploče focuses on gradually expanding its feeder-based traffic and strengthening its role as a regional port for the Bosnian and Herzegovinian hinterland.

The comparison with the Port of Rijeka indicates that the two Croatian container ports currently operate at different levels of development and perform different functions within the national and regional port system. Rijeka is evolving into a main gateway port with direct intercontinental connections and large-scale infrastructure projects, while Ploče functions as a feeder-oriented regional port with a strong dependence on its close hinterland. However, the completion of Corridor Vc and the planned expansion of terminal capacities could significantly reduce this gap and strengthen the competitive position of the Port of Ploče in the medium term.

3.4 Container Traffic of the Port of Ploče

Not to the same extent as the Port of Rijeka, container traffic in Ploče has increased over the last two years after a significant dropping during the pandemic. As a relatively small port, the Port of Ploče managed to impose itself and attract the world's leading container shipping companies.

According to data from the Ploče pilot service, ships arriving in Ploče are operated by the world's leading shipping companies in container traffic, MSC and X-Press. Container ships belonging to the MSC company are 170 to 200 meters long and have more cargo, on average 250 unloadings and 150 loadings. Almost all ships have bow thrusters to reduce tug costs. The ships operated by the shipping company X-Press are slightly smaller in size, 125 to 150 meters, with an average handling of about 150 unloadings and about 80 loadings. These ships used to call at the Port of Split regularly, but for some time now, they have removed Split from their schedule, increasing the Port of Ploče traffic.

Unlike Rijeka, which, besides the feeder service, also has direct lines, the Port of Ploče only has established feeder lines. Mainly, two large shipping companies maintain feeder shipping lines in the Port of Ploče, X-Press and Maersk as follows:

Adriatic X-PRESS-a (ADX a) - X-Press feeder service [22]

Ports: Piraeus → Durres → Piraeus → Bari → Ploče → Bar → Piraeus

Line H - MSC weekly feeder service to Rijeka via Gioia Tauro [18]

Ports: Gioia Tauro → Bar → Rijeka → Ploče → Gioia Tauro

At the end of 2022, after a five-year suspension, Maersk Line, one of the largest shipping companies in the world, reintroduced services through the Port of Ploče as part of the feeder line 49T Adriatic [23]. This significant event substantially improved container traffic in the Port of Ploče.

49T Adriatic – Maersk feeder service:

Ports: Piraeus → Bar → Ploče → Piraeus → Durres → Rijeka → Durres

The Port of Ploče has seven terminals that provide professional services in maritime transport, port operations, cargo storage, and freight forwarding. It is categorised as a port of universal purpose and serves for the transshipment of almost all types of cargo that appear in international maritime traffic. In the cargo structure in the Port of Ploče, bulk cargo predominates, primarily coal. Figure 6 shows the total share of the main types of cargo in the traffic of the Port of Ploče in the period from 2019–2022.

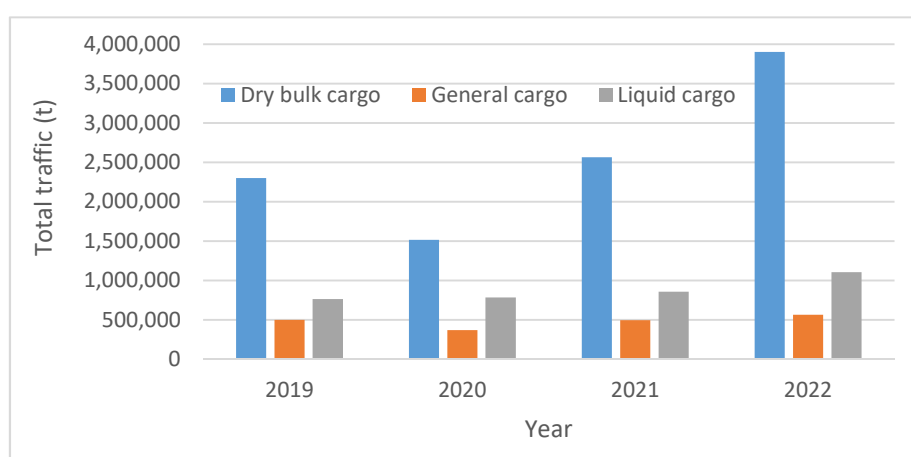


Fig. 6 - Share of main types of cargo in the Port of Ploče 2019-2022
(source: authors according to [21])

Excluding the shipping company Maersk, which revived the feeder line including the Port of Ploče at the end of 2022, two large shipping companies maintain feeder services at this port. The number of arrivals of their ships in the Port of Ploče is shown in Figure 7.

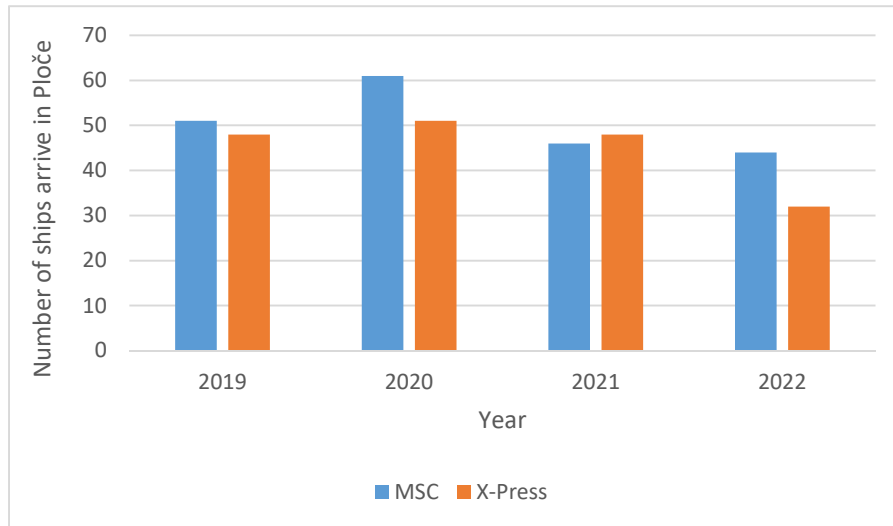


Fig. 7 - Number of container ships arriving at the Port of Ploče 2019-2022
(source: authors according to [24])

In the Port of Ploče, container traffic is less dominant than in the Port of Rijeka. However, the Port of Ploče has a very high potential for increasing container traffic, since the average current traffic volumes amount to only about 40% of the total capacity. An overview of container traffic in Ploče is shown in Figure 8.

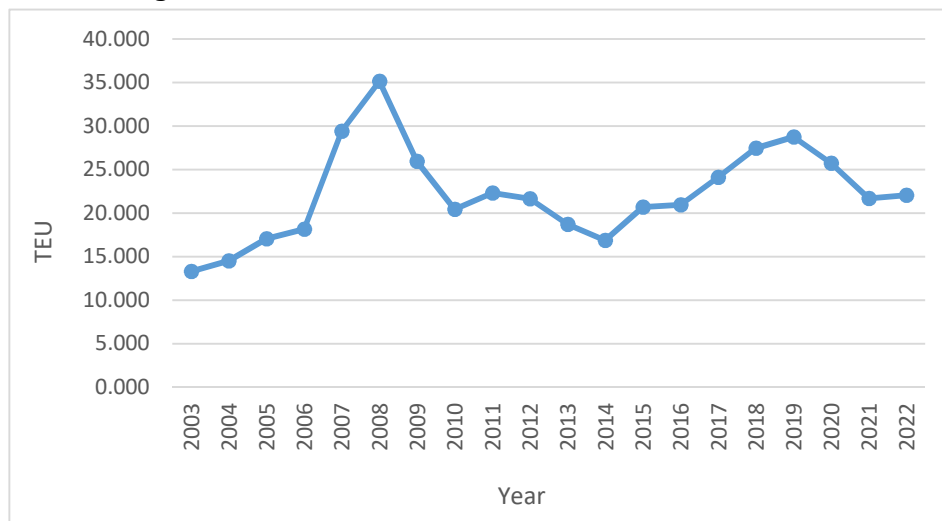


Fig. 8 - Overview of the annual container traffic at the Port of Ploče
(source: authors according to [21])

It can be seen that the container traffic of the Port of Ploče has experienced many fluctuations and that the traffic decreased significantly during the pandemic years. In contrast, this was not the case at the Port of Rijeka, which recorded an increase in container traffic during the same period. The record number of transhipped containers, 35,124 TEU, was achieved in 2008, after which traffic has not exceeded 30,000 TEU to date [21]. The SWOT analysis shows all internal and external factors that can affect the operation of the port. Internal factors refer to strengths and weaknesses, while opportunities and threats represent external factors that can affect the efficiency of the Port of Ploče (Figure 9).

S	STRENGTHS	W	WEAKNESSES
+	Favourable geographical and geopolitical position	–	Lack of long-term strategic plans
+	Strategic partnerships with the world's leading shipping companies	–	Environmental regulations and concerns may pose challenges to the port's operations and expansion plans
+	Proximity to markets of neighbouring countries	–	Slow implementation of development plans
+	Free zone of the Port of Ploče	–	Port technology lagging behind that of competing ports
O	OPPORTUNITIES	T	THREATS
+	EU membership and funding opportunities	–	The political instability of neighbouring countries, especially in the east
+	Increased importance following the completion of Corridor Vc	–	Opposition from the local population due to the proximity of the port
+	Further modernisation of port technology	–	A global or regional economic downturn can reduce cargo volumes and negatively affect port revenue
+	Embracing eco-friendly and sustainable practices can enhance the port's reputation and attract environmentally-conscious customers	–	Investments and development of other nearby ports

Fig. 9 – SWOT analysis for the Port of Ploče (source: authors)

The SWOT analysis in Figure 9 identifies strengths and weaknesses, as well as opportunities and possible threats, related to the further development of the Port of Ploče.

With the continuation of investments and the realisation of development plans, which include the extension of the quay to 330 m, increasing storage capacity to 25 hectares, and returning large shipping companies, the Port of Ploče can certainly ensure its place on the market. With the closure of the container terminal in Split in February 2022 [25], the

Port of Ploče remains the only Croatian container port in the southern part of the Adriatic.

Overall, container traffic in the Port of Ploče is characterised by lower volumes, greater variability, and complete dependence on feeder services, which clearly differentiates from the development model of the Port of Rijeka. This confirms that the level of integration into global liner shipping networks and the scale of infrastructure investments are the key determinants of container traffic growth in Croatian ports.

4. Conclusion

This paper sets out to analyse the role of feeder services in the development of container traffic in Croatian ports and to examine the recent traffic trends and development potential of the Ports of Rijeka and Ploče during 2019–2022. The results confirm that container feeder services connectivity represents a crucial factor in integrating Croatian ports into global container flows and in strengthening their market competitiveness.

The two Croatian container ports analysed in this paper are crucial for their region and the country. As the main Croatian port, Rijeka has achieved continuous growth in container throughput, which is directly associated with the arrival of leading global shipping companies, the establishment of regular feeder and direct services, and significant infrastructure investments. These findings support the research objective that port modernisation and improved hinterland connections are key prerequisites for increasing annual container traffic. With a terminal depth of even 20 meters, the world's largest container ships will be able to call at Rijeka. It is also important to mention the recently signed concession agreement for the development and economic use of the Zagreb Deep Sea container terminal. The Port Authority of Rijeka signed a concession agreement with the recognised international operator of container terminals, the Dutch APM Terminals, in a consortium with the Croatian ENNA Logic for 50 years. The concessionaire will develop and manage a modern container and Ro-Ro terminal located in the western part of the Port of Rijeka area. The Concessionary undertook to build the necessary infrastructure and fully equip the Zagreb Deep Sea container terminal in phases 1 and 2. The concessionaire also guarantees one million TEU container traffic in the first two years of the terminal's operation. All this additionally ensures a favourable development prospects for the Port of Rijeka.

The Port of Ploče lags significantly behind Rijeka regarding container traffic, but it plays a significant role in the country's economy. Although it is a Croatian port, it is essential for the economy of neighbouring Bosnia and

Herzegovina, and with the completion of Corridor Vc, the Port of Ploče will further expand its operations to other countries of Western and Central Europe. As for container traffic, although there are a lot of fluctuations, the completion of the Vc corridor and the expansion of the existing terminal will create conditions for the arrival of large shipping companies that will recognise the potential of this port. The modern container terminal has strengthened the position of the Port of Ploče in the intermodal network, and the increase in container traffic creates the conditions for the realisation of the second and third phases of construction and, thus, the expansion of available capacities. Namely, due to the proximity of Ploče, Split lost cargo, and additionally, traffic fell due to the enormous increase in freight rates. In 2021, traffic at the terminal amounted to 3,000 TEU, only 10% of the terminal's total capacity. An increase in freight rates seems to be the main reason for closing this terminal, which confirms the statement of the company Luka, whose jurisdiction is the container terminal. Despite state incentives and equipping the terminal with the giant crane at the time, this terminal could not overcome the adverse effects. The terminal was closed according to the decision of the company Luka, and it is not known when or if it will be reopened. Consequently, only Rijeka and Ploče remain of the maritime container terminals in Croatia.

Some limitations should be taken into account when interpreting the results. The analysis covers a relatively short time period. It is based exclusively on secondary data, which limits the ability to apply more complex modelling and to capture the long-term effects of ongoing infrastructure investments. Furthermore, the research focuses on two case studies within a specific regional port system, so the findings cannot be directly generalised to all port systems. Nevertheless, the selected ports are representative of small and medium-sized ports integrated into hub-and-spoke networks, and the identified relationships between feeder connectivity, infrastructure development and traffic performance provide relevant insights for other ports with similar structural characteristics.

By comparing the two ports, the study shows that the level of infrastructure development, the quality of connectivity with the hinterland and the degree of integration into global liner networks determine the intensity of container traffic growth.

In conclusion, Croatian container terminals have moved from a peripheral position towards a stronger participation in international maritime traffic, with Rijeka emerging as the primary national gateway and Ploče as a port with significant growth potential. The findings contribute to a clearer understanding of the relationship between the development of feeder services and container traffic and provide a basis for future strategic

planning to increase the competitiveness of Croatian container ports in the northern Adriatic and in the European transport system.

Although this paper provides an empirical analysis of feeder service development and container traffic in the Croatian ports of Rijeka and Ploče, several areas remain open for further research.

The present study covers the period 2019–2022, which includes years marked by global supply chain disruptions. A longer observation period would enable a more comprehensive assessment of whether the projected capacity expansion and guaranteed traffic volumes result in sustained structural growth or only short-term traffic increases. Detailed examination of hinterland transport corridors represents an important research direction. The completion of Corridor Vc is expected to influence the development potential of the Port of Ploče significantly. Future studies could explore the environmental dimension of shipping services and container port development. With increasing regulatory pressure related to decarbonization and sustainable transport, it would be worthwhile to examine how the introduction of greener technologies affects operational efficiency and environmental performance.

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