

Congestion of Algerian seaports issue: A transition from the first-come, first-served (FCFS) system to the berthing window system (BWS) at a Marine Container Terminals

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Abstract :

Seaport congestion in Algeria is a growing concern for the Algerian authority. It has become a key factor restricting the international trade and economic development. Delays in exports and imports can influence trade balances and economic stability. In the end, significant congestion can reduce economic activity, affecting overall GDP growth. In this paper, facing the increasing pressure from intense congestion, we explore the viewpoint from the port management to alleviate the problem of congestion. Planning operation schedule need to be considered in port management. This article aims to provide an in-depth understanding of berthing window management system and its potential to transform port operations, highlighting the specific case of the seaport of Bejaia. Moreover, this study contributes to alleviating port congestion and to environmental sustainability by reducing ship emissions caused by waiting at port and inappropriate sailing speed.

Keywords: Berth scheduling, Time windows, Delayed vessel departure, Port congestion Management, Global supply chain, Algerian port authority, Marine container terminal operations, Shipping management.

JEL Classification: C61, L91, L95, R41, R40, R48

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1. Introduction

Maritime transportation has a major role in driving economic growth and globalization, as it accounts for four fifths of the world's total merchandise trade (Zavitsas et al, 2018). The innovation of containerization changed the course of the shipping industry and engendered significant changes to where and how goods are manufactured, the majority of goods are transported in containers (Fransoo & Lee, 2013, p.253). More than 80 percent of global merchandise trade (by volume) is transported via sea routes. A considerable and increasing proportion of this volume, accounting for about 35 percent of total volumes and over 60 percent of commercial value, is carried in containers (The World Bank Group, 2023). Considering the overwhelming reliance of global transport on the shipping industry, there is always a lot of focus on the reliability of shipping services. At the same time, marine container terminals are essential for freight movement and are a key element of maritime transport. A report from the United Nations Conference on Trade and Development (UNCTAD) emphasizes that marine container terminals play an essential role in global supply chains, with containerized trade anticipated to increase by 2.1% each year from 2023 to 2027 (UNCTAD, 2023);

Maritime transport, and consequently seaport services, are therefore vital for the economies of developing countries. Indeed, international trade is one of the main means of modernizing a country and the price of transport has become a determining factor in the competitiveness of the economies of nations (El Asli, 2018).

Ports and terminals, especially container terminals, can lead to delays in shipping, problems in the supply chain, extra costs, and lower competitiveness. (Dadashi, et al 2017) explain that marine container terminals are the « weakest link » of the supply chain (along with other intermodal terminals and their surrounding network) due to potential delays, cargo loss and damage. (Nze & Onyemechi 2018) explain that seaport congestion is a phenomenon associated with delays, queues, and extended travel and dwell times for ships and cargo at ports, often resulting in unpleasant consequences for logistics and the supply chain. These problems often result in additional costs, disruption to trade, reduces the competitiveness of the country and its hinterland, and hinders economic growth and poverty reduction. It has been well documented that any operational inefficiency in a marine container ports may cause a bottleneck in the global supply chain that damages to the efficiency and sustainability of international trade (Stahlbock, Vob, 2008), (Du, et al 2015).

As the marine container terminal business is capital intensive, terminal managers strive to improve utilization of the existing resources with operational changes rather than capital investment (Dulebenets, 2015).

Such resources include berths, container storage yard and cargo handling equipment (e.g. quay cranes, yard cranes, internal transport vehicles, etc.). Among these resources, the best use of the berth space is in the center position because it influences how the quay cranes are scheduled, how the yard storage is planned, the routes for the internal transport vehicles, and how quickly the vessel can complete its turnaround.

The latter is considered as one of the most important performance measures of a marine container terminal (Golias et al., 2009a; Du et al., 2011; Dulebenets, 2015). The berth scheduling concept known as berthing window system (BWS) aims to determine the assignment of vessels to berths, start service time for each vessel and the order of vessels at each berth.

In this article, we explore vessel berthing window management, an innovative approach to improving the efficiency of port operations. This concept helps reduce waiting times, optimize the use of port infrastructure, and improve operational planning and visibility. Our article focuses on analyzing berthing window management, highlighting the port implications when vessels are waiting, causing berthing delays and damaging the port's reputation. The main research question is : « what is the impact of berthing window implementation on container terminal performance and productivity? ».

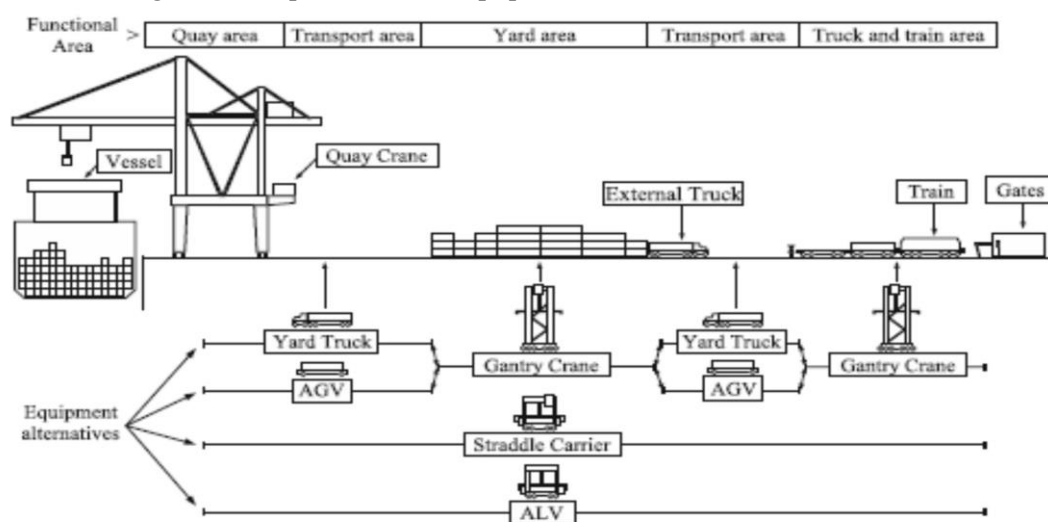
The structure of this paper is as follows: Section 2 provides the description of the port call process for understanding the complexities and challenges facing modern ports. Section 3 reviews and

summarizes the relevant berthing window management (BWM) literature. In sections 4, we analyze the adoption of this system at the Port of Bejaia and its impact on the port's overall performance. We evaluate the advantages, obstacles, and enhancements resulting from the use of berthing windows, offering useful perspectives for other ports thinking about implementing comparable systems. Ultimately, section 5 recaps the key contributions and discoveries of this research. This article seeks to offer a comprehensive insight into berthing window management and its capacity to enhance port operations, focusing on the particular example of the Port of Bejaia.

2. Logistics in a container terminal

The general processes in a marine container terminal can be described as a sequence of events from the arrival of a ship loaded with import containers to the departure of the containers to the customers, or the reverse chain, i.e., from the arrival of the containers intended for export to their departure on board the ship. When a ship arrives at the port, it must first find a berth. The containers on board must be unloaded by quay cranes. These cranes pick up the containers from the ship and place them on the platform, where they are then transported to the stacks in the storage areas. This area is served by gantry cranes or straddle carriers. After a certain period of time, the containers are removed from the stacks and transported by vehicles to other means of transport (trains, trucks, other vessels). Figure n°1 summarizes these different operations and also presents the alternatives using the various terminal handling equipment.

Figure n°1: Operations and equipment in a marine container terminal

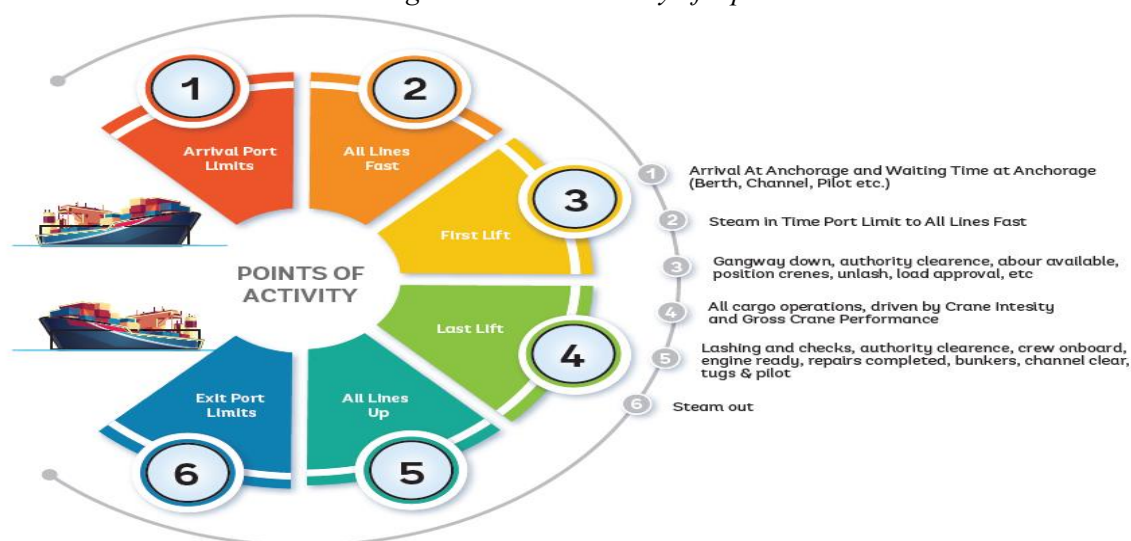


Source: Meisel, F. (2009). Seaside operations planning in container terminals. Contributions to management science. Physica-Verlag. A Springer company

2.1 Description of the port call process

The port call process is an important part of managing ship movements and involves the last part of the journey before reaching the port, the services and activities that happen when ships arrive or leave, and the handling of cargo during these times. In figure n°2, an illustration of these processes, and the different actors involved, is presented. In most ports, FCFS is used to coordinate port calls in liner shipping, which means that the allocation of berths is determined by the sequence of the arrival of vessels to the port (Cho et al., 2022).

Figure n°2: the Anatomy of a port call



Source: The World Bank, (2023), *Transport global practice. The container port performance index 2022*, S&P Global market intelligence. Washington,

2.2 Berth planning at marine container ports

The practice earlier amongst ports was to handle vessels on a First Come First Served (FCFS) basis, which meant that the port would handle vessels in the order in which they arrived at the port. While this might seem logical, it neglected the profit-maximisation aspect and did not give any options for carriers who might be willing to pay a premium for the rights to be berthed upon arrival (at a pre-defined time). For container carriers to maintain schedule reliability and follow published vessel timetables, it is crucial that they are assured of receiving a berth upon arrival at a time previously agreed upon with the port. In the absence of such an agreement, it might well happen that when the container vessel arrives at the port, there might be a higher-than-usual number of other vessels at the port, which, under the First Come First Served method, will be given priority, which will necessitate longer waiting times for the container vessel and cause delays in its subsequent journey.

Studies have explored potential benefits associated with the transition from FCFS to alternative arrival policies. Transitioning from FCFS to berth windows management (BWM) positively affects berth utilization in the Port of Amsterdam (Eisen et al., 2021). Similarly, simulations of a coordinated arrival policy based on pilotage and towage capacity have shown to reduce delays in the Port of Rotterdam (Nikghadam et al., 2023). In addition, a proposed policy aimed at minimizing maximum delays at a port owned by Abu Dhabi ports shows potential for reducing total delays and improving resource utilization compared to FCFS (Abou Kasm et al., 2021).

3. Overview of the relevant literature

In this section, we first briefly review the traditional First-come, first-served (FCFS) studies, and then we review Berth window management system (BWMS) objectives and benefits.

3.1 First-come, first-served (FCFS) method literature

To make container terminals more competitive, terminal managers work hard to improve how well the terminal runs by better using the equipment and facilities there. In this context, numerous academic studies and scientific articles have supported the positive impact of berthing windows system on port performance. The coordination mechanism used to allocate arriving vessels to berths during port calls is the FCFS (first-come, first-served) method (Cho et al., 2022; Li et al., 2022; Imai et al., 2001). Berth allocation under the FCFS method is determined by the order of vessel arrival at the port (Cho et al., 2022; Alvarez et al., 2010). Although the FCFS method is perceived as fair by stakeholders (Roseaeg, 2010), the literature highlights several inefficiencies associated with this port

call process. These inefficiencies include delays (and the resulting economic impact on vessel efficiency), poor resource utilization, and increased emissions (Cankaya et al., 2019; Strandenes, 2004; Adland and Jia, 2018). It is also argued that the FCFS method promotes speed competition among shipping lines and the « rush-to-wait » phenomenon, which is inefficient in terms of fuel consumption and emissions (Kontovas and Psaraftis, 2011; Adland and Jia, 2018). In the FCFS method, information sharing among port call stakeholders is also limited and sometimes discouraged (Cho et al., 2022; Nikghadam et al., 2023). According to Cho et al. (2022, p. 104): «Under the current FCFS rule, the broker does not share information with other brokers and only seeks to secure a favourable slot for the tanker under his/her charge.» Previous studies on alternative berth allocation policies for coordinating port calls have compared the first-come, first-served (FCFS) method with other berth allocation policies, analyzing their potential advantages and disadvantages. To improve port efficiency, Imai et al. (1997) concluded that it is necessary to find and operate optimal berth allocation policies, rather than relying on the FCFS method. Several studies on berth allocation policies are presented and evaluated in the literature. These studies are outlined below.

Imai et al. (1997) were the first to introduce the idea that, for high port efficiency, the optimal allocation of ships to berths should not be based on « the First Come, First Served (FCFS) rule ». Eisen et al. (2021) used a simulation-optimization approach to examine the potential of berth allocation policies by testing four alternative priority rules for oil tankers in the Port of Amsterdam. These priority rules are: 1) FCFS with fixed arrival times, 2) Without FCFS with fixed arrival times, 3) Pre-booking policy with a 48-hour advance booking restriction, and 4) Pre-booking policy without restriction, i.e., berth reservations can be made at any time. Compared to a baseline scenario based on the FCFS method, their results show that scenarios where berths can be pre-booked without restriction offer the greatest improvement in terms of berth utilization.

Yildirim et al. (2020) use a simulation-optimization approach to evaluate the first-come, first-served (FCFS) policy in comparison with other hybrid berth allocation policies, considering different operational characteristics such as ship size in the Port of Izmir, Turkey. The results of their proposed policies reduce the average vessel waiting time and increase berth utilization compared to the FCFS policy. Alvarez et al. (2010) also adopt a simulation-optimization approach to compare the FCFS policy with two alternative berth policies: Standardized Estimated Times of Arrival (SETA) and Global Optimization of Speed, Berths, and Equipment (GOSBEA). Their results, based on market conditions in 2008 and 2009, indicate that the GOSBEA policy achieves a 6% reduction in total fuel consumption compared to the other two policies. In addition, the average waiting time in ports is reduced by more than one hour and half an hour compared to the FCFS policy and SETA, respectively. Abou Kasm et al. (2021) distinguish between a policy aimed at minimizing the total delay and another aimed at minimizing the maximum delay. They argue that the latter is fairer, as it reduces the gaps between waiting times. They use a mixed-integer linear programming approach to evaluate the berth policy minimizing the maximum delay while considering several constraints. Their proposed berth policy is simulated for Abu Dhabi Port, showing an improvement over the existing FCFS policy used in this port. The maximum delay is reduced from 6 hours to 4.5 hours, the total delay from 42 hours to 18 hours, and the utilization rates of tugs, pilots, and pilot boats increased from 75.56%, 21.9%, 24.4% to 82.93%, 24.1%, 26.8%. They also found that the results of their proposed policy improve as the port congestion rate increases. Zhang et al. (2016) propose a mathematical model of canal-berth coordination in a Chinese port. They then compared their model with the FCFS policy and a simple genetic algorithm approach. Their proposed model results in a reduction in the total waiting time, total scheduled time, and maximum waiting time for visiting vessels. Nikghadam et al. (2023) propose a coordination policy based on information sharing and vessel differentiation in the Port of Rotterdam. Vessel service providers (tug and pilot organizations) share information about arriving vessels with each other, and pilots can prioritize vessels requiring less towing. Simulation of their policy shows that a 30% reduction in waiting times can be achieved, while service providers improve their performance. Their coordination policy and prioritization of

vessels requiring less towing were motivated by the fact that the Port of Rotterdam suffers from limited towing capacity, thus constituting a bottleneck in the call process.

3.2 Berth window management system (BWMS)

The Berth Window Management System (BWMS) is a crucial IT tool for port operations. It facilitates the management of vessel berth activities by assigning, via a web platform, a pre-established berth schedule to a ship-owner operating at the port. This schedule is based on each vessel's estimated time of arrival (ETA) and departure (ETD) (Wang & Sun 2015).

3.2.1 Berth window system objectives

UNCTAD. (2020), explain that a berth window system aims to:

1) Enhancing waiting times and expenses

a) Shortening vessel wait periods at the port: By efficiently planning when vessels arrive and leave, the system decreases expensive idle time at the port and improves sea traffic flow.

b) Boosted efficiency of port activities: The improved organization of loading and unloading tasks through the system makes the best use of port resources (like cranes, docks, and staff) and raises the speed of container handling.

c) Lowered demurrage fees: By reducing wait times and making operations more efficient, the system lessens the fees ship-owners incur for delays, providing substantial savings.

2) Better predictability and preparation

a) Enhanced predictability for ship operators: With advance knowledge of their docking times, ship-owners can plan their work more effectively, manage their costs better, and handle their fleets with greater efficiency.

b) Availability of flexible schedules: The system enables ship-owners to select docking dates and times that suit their specific requirements, thus fostering increased flexibility and improved adjustment to operational challenges.

3) Greater visibility and oversight for the port

a) All-inclusive display interface: The system equips the port with a display interface that allows real-time monitoring of vessel statuses (docked, waiting, and positioned), their estimated arrival times, departure times, estimated time of placement, and other important details.

b) Local scheduling administration: The system empowers the port to manage docking schedules on its own, considering local restrictions and adjusting plans if unexpected situations arise.

3.2.2 Benefits of the berth window management system

The system's benefits include:

1) Collaborative planning optimized allocation: The BWMS provides maritime planners and berth window planners with a user-friendly interface that provides a comprehensive view of the terminal's organization. This includes real-time vessel information, berth availability, and data on berth infrastructure such as bollards and cleats. This transparency promotes collaborative planning between terminals and inbound carriers, ensuring optimal berth window allocation based on vessel size, cargo type, and turnaround requirements. Delays and inefficiency due to improper berth allocation are now a thing of the past.

2) Empower users through self-service: The BWMS goes beyond traditional communication methods by offering extensive self-service features. Carriers, agents, and port authorities benefit from direct access to essential berth information through an easy-to-use web interface. This eliminates the need for phone calls or emails, simplifying access to information and accelerating decision-making processes. Stakeholders can access real-time berth availability, track vessel schedules, and even request specific berths based on their needs, all through the BWMS platform.

3) Flexible integration and scalability: The system boasts remarkable flexibility, offering seamless integration with existing port management software. BWMS can be delivered as part of a comprehensive vessel planning suite, providing a comprehensive view of port operations. It can also operate as a standalone application for ports that do not require a full suite of features. This scalability

ensures compatibility with existing infrastructure, minimizes disruptions, and maximizes return on investment.

4. Application of berthing windows at the port of Bejaia

4.1 Company adoption of the system

To improve productivity and service quality for the terminal container, the Bejaia Port Company, in collaboration with its subsidiary SPA BMT (Bejaia Mediterranean Terminal), decided to implement the Bejaia Port Berthing System. This berthing window system is a modern management system designed for handling container ships and managing port calls for liner ships. Additional improvement opportunities include extending the berthing window system to all types of ships docking at the Port of Bejaia.

4.2 Objectives of the implemented system

The Bejaia Port Berthing System is a modern online management system designed to optimize container ship processing. Its objectives are to:

- ✓ Eliminate long waits in harbor and the resulting demurrage charges.
- ✓ Ensure smoother vessel rotations.
- ✓ Improve productivity and quality of service for container ships.
- ✓ Provide ship-owners with schedules allowing them to select dates and time slots for ship arrivals.
- ✓ Provide the port with a display interface (ships at berth, expected ships, in harbor, ETA, ETB, ETD, etc.).

4.3 The berth window management system (BWMS) stakeholders at the port of Bejaia

Within the Berthing Window System (BWS) at the Port of Bejaia, several stakeholders are involved in information dissemination, using channels such as data and electronic messages. These stakeholders include:

- ✓ The Bejaia Port Authority, which plays a central role in coordinating and managing port operations.
- ✓ Shipping companies such as MSC, MEARSK, CMA CGM, etc., which are responsible for planning and organizing their vessel movements.
- ✓ Customs and control services, responsible for regulating and monitoring import-export activities.
- ✓ The Algerian Coast Guard and the Border Police, which ensure maritime border security and control.
- ✓ Terminal operators (BMT - Bejaia Mediterranean Terminal), who manage the loading and unloading of goods at the docks.
- ✓ Importers and freight forwarders, who are involved in logistics and managing the flow of goods through the seaport,

These various stakeholders collaborate and exchange essential information via electronic systems, helping to ensure the efficient flow of port operations and the smooth running of commercial activities.

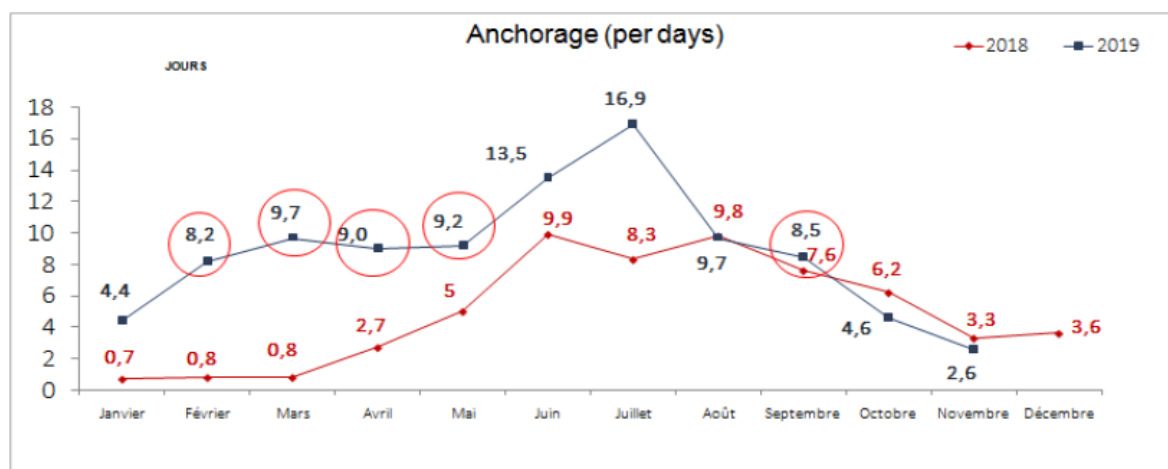
4.4 The impact of the berthing window system on waiting times in the harbor

4.4.1 The issue of vessel waiting times in the harbor

Let's explore together the issue of vessel waiting times in the harbor, focusing specifically on the average waiting time for the port of Bejaia as of November 30, 2019, which stood at 8.7 days, compared to 5 days during the same period in 2018.

As the statistics below show (figure n°3), vessel waiting times from January to July 2019 are much longer than those of 2018. While the estimated wait times for both years in August are at the same time, beyond this month, there is a slight divergence between the two years, as well as a decrease in waiting times. The average for the harbor as of 11/30/2019 is 8.7 days compared to 5 days in 2018 at the same period.

Figure n° 03: Problem of waiting times for ships in harbor



Source : Ouali F, Messaoudi S, (2023), *Système d'information et performance logistique : Cas des fenêtres d'accostage de l'entreprise portuaire du Bejaia (EPB)*, mémoire Master en SCFSE, Université de Bejaia, A Mira

a) Detailed data interpretation

This graph (figure n°3) highlights a very sharp increase in vessel waiting times in 2019 compared to 2018 at the Port of Bejaia. In 2018, waiting times remained at reasonable levels, with occasional peaks of 9.9 days in June and 9.8 days in August, but without any major excesses. However, from the beginning of 2019, waiting times began to climb significantly. From June onwards, the situation deteriorated significantly, with records being broken month after month, reaching 13.5 days in June and then 16.9 days in July 2019, levels much higher than the previous year.

This severe congestion in mid-2019 indicates that the Port of Bejaia encountered significant capacity and flow issues during this period. The average waiting time as of November 30, 2019, was 8.7 days, compared to 5 days during the same period in 2018. Such a massive and sudden deterioration in performance cannot be considered normal and is attributed to the COVID-19 crisis, which has disrupted many aspects of port operations.

b) Optimization of port operations: reduction of waiting times in harbor, processing and container stay

The table n°1 below presents the data collected. This data includes the average vessel waiting time in berth, the average time spent at the berth, and the average container dwell time at the terminal. All these measurements are expressed in days.

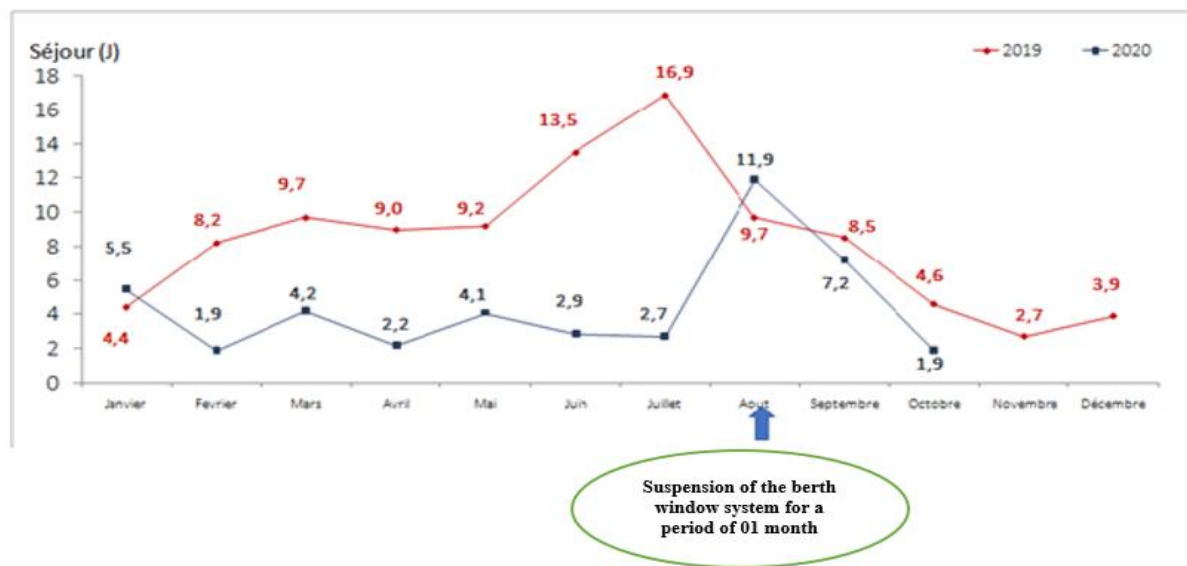
Table n°1: Average evolution of the waiting time in the harbor, at the quay and stay of a container at the terminal in days before and after installation of the berthing window system.

Section	Before installing the berth window system	2020	2021	2022
Average stay in the harbor (in days)	5.42	02	0.6	0.5
Average stay at the quay (in days)	3.12	03	1.8	1.5
Average stay of a container at the terminal (in days)	26	18	14	12

Source : Besbas, Z. Sayad M. A, (2024), *Gestion des fenêtres d'accostage : cas du port de Bejaia*, master, Sciences de la navigation, Ecole Nationale Supérieure Maritime

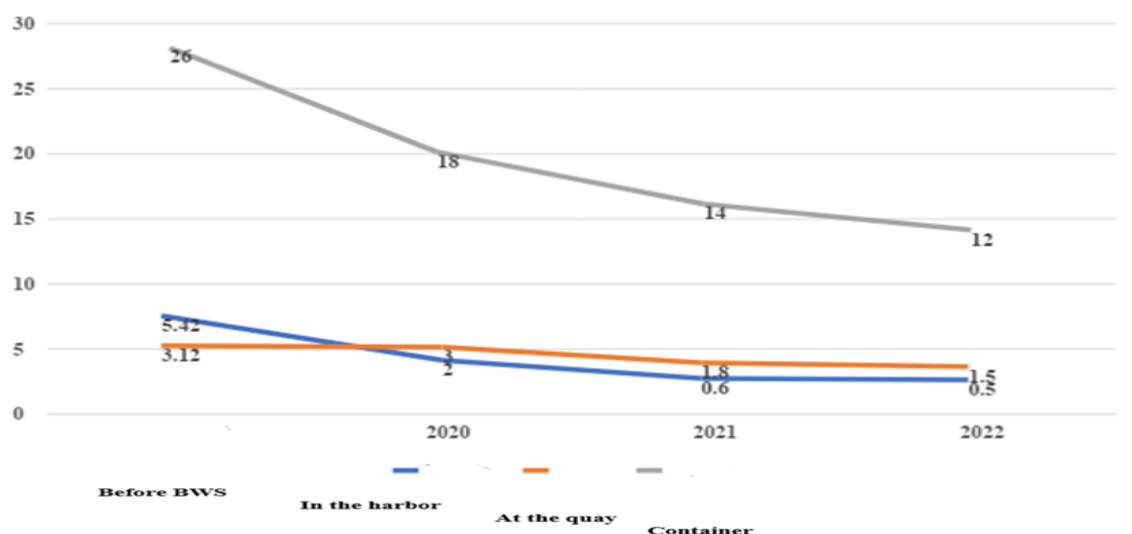
As we can see in the graph below (figure n°4), before the application of the berthing window system during the year 2019, there was a fairly high overload of ships waiting in the harbor compared to the year 2020 which was much less so and this after using the berthing window system. Nevertheless, an increase in the number of days spent in the harbor was identified from July to August 2020, due to the suspension of the system for a period, but which very quickly ended up decreasing after this period of time. Therefore, it is necessary to say that the application of this system makes it possible to minimize long days of waiting and puts an end to the resulting demurrage.

Figure n°4: The impact of the docking window system on waiting times in the harbor (2019/2020)



Source : Ouali F, Messaoudi S, (2023), *Système d'information et performance logistique : Cas des fenêtres d'accostage de l'entreprise portuaire du Bejaïa (EPB), mémoire Master en SCFSE, Université de Bejaia, A Mira*

Figure n°5: Curve of the average evolution of the waiting time in the harbor, at the quay and stay of a container at the terminal in days before and after adoption of the berth window system.



Source : Besbas, Z. Sayad M. A, (2024), *Gestion des fenêtres d'accostage : cas du port de Bejaia, master, Sciences de la navigation, Ecole Nationale Supérieure Maritime*

1) Detailed interpretation of data by year

a) In the harbor: The average waiting time for ships in the harbor decreased significantly from 2019 to 2022, dropping from 5.42 days to 0.5 days. This positive trend is explained by better management of ship arrivals, particularly thanks to the implementation of the berthing window system. Indeed, as early as 2020, a significant reduction in waiting time to 2 days was observed, followed by a continuous decline to reach 0.6 days in 2021. This trend was confirmed in 2022, with waiting time stabilizing at 0.5 days. This significant optimization of waiting times in the harbor reduces potential delays in the supply chain and improves the overall efficiency of the port terminal.

b) At Berth: The average vessel stay at berth decreased significantly from 2019 to 2022, from 3.12 days to 1.5 days. This positive trend is explained by the optimization of vessel handling processes at berth, particularly through port operations optimization measures. In fact, a slight improvement was observed in 2020, with an average of 3 days, followed by a continued decline to 1.8 days in 2021. This trend was confirmed in 2022 with a further improvement and an average of 1.5 days. This significant optimization of vessel handling time at berth reduces waiting times and improves the overall efficiency of the port terminal, thus contributing to a better flow of maritime traffic.

c) Container at the terminal: The average container dwell time at the terminal decreased significantly from 2019 to 2022, dropping from 26 days to 12 days. This positive trend is due to the optimization of container handling processes, notably through infrastructure investments and improved management procedures. In fact, a notable reduction to 18 days was observed in 2020, followed by a continued decline to 14 days in 2021. This trend continued in 2022 with further optimization and an average of 12 days. This significant reduction in container dwell time at the terminal improves the fluidity of port operations, reduces storage costs, and allows for a more efficient response to customer needs.

In short, the figures demonstrate a significant improvement in the management of port operations, with a notable reduction in the time spent in the harbor, at the quay, and at the terminal. Behind every ship that berths faster, every container that leaves the terminal sooner, there are teams able to work in better conditions, goods that arrive at their destination faster, and more satisfied customers. These improvements have an impact far beyond the port itself. They contribute to a more fluid supply chain, a more dynamic economy, and a society where time and efficiency are at the service of humanity. It is therefore with optimism and confidence that we can view the evolution of these figures, as they are a sign of a port that is modernizing, adapting, and, above all, placing people at the heart of its concerns.

2) Optimizing container and container ship traffic

A summary table of container activity for the period 2019 to 2022 is presented below in table n°2. This table provides a concrete illustration of the observed trends and highlights the progress made in port efficiency.

Table n°2: Container activities between 2019 and 2022

Container activity	2019	2020	2021	2022
Total containers	243 508	249 556	204 666	232 973
Number of container ships	229	258	265	264

Source : Besbas, Z. Sayad M. A, (2024), Gestion des fenêtres d'accostage : cas du port de Bejaia, master, Sciences de la navigation, Ecole Nationale Supérieure Maritime

Analyzing the table, several observations can be made:

a) Total containers: The total number of containers handled varied over the four-year period analyzed. In 2019, 243,508 containers were handled, followed by a slight increase in 2020 to reach 249,556 containers. However, a notable decline was observed in 2021, with 204,666 containers handled. In 2022, a slight recovery was observed, with a total of 232,973 containers handled. These fluctuations can be explained by various factors, such as changing economic conditions, international trade trends, and disruptions caused by the COVID-19 pandemic.

b) Number of container ships: The number of container ships calling at the port has fluctuated in recent years. In 2019, 229 vessels were registered, followed by an increase in 2020 to 258 units. 2021 saw a further increase to 265 vessels, before a slight decline to 264 vessels in 2022. This variation is explained by a combination of factors, including market demand, capacity utilization, and port operations planning.

Port data analysis, while essential, must be complemented by other factors such as port capacity, infrastructure, resources, and current policies and regulations. Furthermore, for a more in-depth analysis, it is necessary to compare this data with other key indicators such as vessel productivity, container utilization rate, and customer satisfaction. By cross-referencing and analyzing all of this information, it is possible to gain a comprehensive view of the port's performance, identify areas for improvement, and make informed strategic decisions to optimize its efficiency and competitiveness. Given the significant impact of the COVID-19 pandemic on 2020, it is crucial to examine data over a longer period to gain a more comprehensive view of the performance and evolution of container traffic at the Bejaia Port Company. This in-depth analysis will provide a better understanding of long-term trends and identify factors influencing the port's container activity.

Data analysis reveals an overall positive trend, marked by decreased waiting times in the harbor, at the quay, and at the terminal. This trend suggests optimizations in port operations, resulting in reduced lead times, better planning, and optimization measures. These improvements are expected to have a positive impact on the port's efficiency and productivity, as well as on the satisfaction of customers and stakeholders involved in port activities, including ship-owners. The berthing window system implemented at the Port of Bejaia has proven to be a real success, bringing considerable improvements to the performance of the port's supply chain. Indeed, waiting times have been significantly reduced, thus contributing to optimizing the port's overall efficiency and productivity. This success is explained by enhanced planning of port operations and the implementation of judicious optimization measures, making it possible to minimize delays and make the best use of available resources. Ship-owners, the main players in this supply chain, have not failed to express their satisfaction with the system, welcoming the significant improvements observed in their activities and the increased reliability of port services.

5. Conclusion

Our results clearly highlight the observable advantages of the Port of Bejaia's Berthing Window administration System (BWMS), emphasizing improved port operations and administration. However, it is crucial to reconsider some BWMS components in order to enhance port performance and the berthing procedure even further. By closely analyzing the system's current functioning and issues, we may think about making changes to shorten harbor wait times and save needless expenses and interruptions to operations.

Port infrastructure could be used more effectively if policies like reservation periods or a first-come, first-served policy were implemented. In conclusion, even if the port of Bejaia has already seen notable benefits thanks to the BWMS, a proactive evaluation of its application could improve its effectiveness and serve as a template for other ports looking to streamline their logistics management.

Referrals and references:

1. Abou Kasm, O., Diabat, A., & Bierlaire, M. (2021). Vessel scheduling with pilotage and tugging considerations. *Transportation Research Part E: Logistics and Transportation Review*, 148, 102231.
2. Adland, R. O., & Jia, H. (2018). Contractual barriers and energy efficiency in the crude oil supply chain. In 2018 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM) (pp. 1-5). IEEE.
3. Alvarez, J. F., Longva, T., & Engebretsen, E. S. (2010). A methodology to assess vessel berthing and speed optimization policies. *Maritime economics & logistics*, 12, 327-346.
4. Besbas, Z. & Sayad M. A, (2024), Gestion des fenêtres d'accostage : cas du port de Bejaia, master, Sciences de la navigation, Ecole Nationale Supérieure Maritime

5. Cankaya, B., Wari, E., & Eren Tokgoz, B. (2019). Practical approaches to chemical tanker scheduling in ports: A case study on the port of houston. *Maritime Economics & Logistics*, 21, 559-575.
6. Cho, J., Craig, B., Hur, M., & Lim, G. J. (2022). A novel port call optimization framework: A case study of chemical tanker operations. *Applied Mathematical Modelling*, 102, 101-114.
7. Dadashi, A., Dulebenets, M. A., Golias, M. M., Sheikholeslami, A., (2017), A novel continuous berth scheduling model at multiple marine container terminals with tidal considerations, *Maritime Business Review*, Vol. 2 No. 2, 2017, pp. 142-157
8. Dulebenets, M.A. (2015), "Models and solution algorithms for improving operations in marine transportation", Dissertation, The University of Memphis.
9. Du, Y., Chen, Q., Quan, X., Long, L. and Fung, R.Y. (2011), "Berth allocation considering fuel consumption and vessel emissions", *Transportation Research Part E*, Vol. 47 No. 6, pp. 1021-1037
10. Du, Y.; Chen, Q.; Lam, J.S.L.; Xu, Y.; Cao, J.X. (2015), Modeling the impacts of tides and the virtual arrival policy in berth allocation. *Transport. Sci.* 2015, 49, 939–956.
11. Eisen, H. E., Van der Lei, J. E., Zuidema, J., Koch, T., & Dugundji, E. R. (2021). An Evaluation of First-Come, First-Served Scheduling in a Geometrically Constrained Wet Bulk Terminal. *Frontiers in Future Transportation*, 2, 709822.
12. El Asli, N. (2018). Problème intégré d'allocation des zones d'accostage et de grues de manutention dans un terminal à conteneurs : Application au terminal tunisien de Radès. Thèse par articles présentée à l'école de technologie supérieure comme exigence partielle à l'obtention de doctorat en génie. École de technologie supérieure université du Québec.
13. Fransoo, J. C., & Lee, C. Y. (2013). The critical role of ocean container transport in global supply chain performance. *Production and Operations Management*, 22(2), 253–268. <https://doi.org/10.1111/j.1937-5956.2011.01310.x>
14. Golias, M.M., Boilé, M. and Theofanis, S. (2009a), "Berth scheduling by customer service differentiation: a multi-objective approach", *Transportation Research Part E*, Vol. 45 No. 6, pp. 878-889.
15. Imai, A., Nagaiwa, K. I., & Tat, C. W. (1997). Efficient planning of berth allocation for container terminals in Asia. *Journal of Advanced transportation*, 31(1), 75-94.
16. Imai A., E. Nishimura, and S. Papadimitriou. (2001), The Dynamic Berth Allocation for a Container Terminal. *Transportation Research Part B*, Vol. 35, 2001, pp. 401-417.
17. Kontovas, C., & Psaraftis, H. N. (2011). Reduction of emissions along the maritime intermodal container chain: operational models and policies. *Maritime Policy & Management*, 38(4), 451-469.
18. Li, R., Zhang, X., Jiang, L., Yang, Z., & Guo, W. (2022). An adaptive heuristic algorithm based on reinforcement learning for ship scheduling optimization problem. *Ocean & Coastal Management*, 230, 106375.
19. Nikghadam, S., Vanga, R., Rezaei, J. & Tavasszy, L. (2023). Cooperation between vessel service providers in ports: An impact analysis using simulation for the Port of Rotterdam. *Maritime Transport Research*, 4, p.100083.
20. Nze, I. C., & Onyemechi, C. (2018). Port congestion determinants and impacts on logistics and supply chain network of five African ports. *Journal of Sustainable Development of Transport and Logistics*, 3(1), 70-82. doi:10.14254/jsdtl.2018.3-1.7.
21. Ouali F, & Messaoudi S, (2023), Système d'information et performance logistique : Cas des fenêtres d'accostage de l'entreprise portuaire du Bejaïa (EPB), mémoire Master en SCFSE, Université de Bejaïa, A Mira
22. Rosaeg. E. (2010). A System for Queuing in Ports. Working paper. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1697404
23. Stahlbock, R., Vob, S. (2008), Operations research at container terminals: A literature update. *OR Spectrum* 2008, 30, 1–52.

24. Strandenes, S. P. (2004). Port pricing structures and ship efficiency. *Review of Network Economics*, 3(2).
25. The World Bank Group (2023), A Comparable Assessment of Performance based on Vessel Time in Port, The Container Port Performance Index 2022, Transport Global Practice
26. UNCTAD. (2020), Review of Maritime Transport 2020. United Nations Conference on Trade and Development, 2020.
27. Wang, H., and X. Sun. (2015), "Optimal Berth Allocation in Ports : Models and Methods." *Journal of Maritime Research* 12.3, pp : 67-82.
28. Yıldırım, M. S., Aydın, M. M., & Gokkus, U. (2020). Simulation optimization of the berth allocation in a container terminal with flexible vessel priority management. *Maritime Policy & Management*, 47(6), 833-848.
29. Zavitsas, K.; Zis, T.; Bell, M.G. (2018), The impact of flexible environmental policy on maritime supply chain resilience. *Transp. Policy* 2018.
30. Zhang, X., Lin, J., Guo, Z., & Liu, T. (2016). Vessel transportation scheduling optimization based on channel–berth coordination. *Ocean Engineering*, 112, 145-152.