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The Performance of the Autonomous Port of Conakry Based on Productivity Indicators, 2022.

Abstract

This study evaluates the performance of the Port Authority of Conakry (PAC) for the year 2022 using productivity and operational efficiency indicators. The primary objective is to measure the efficiency of port operations for eleven types of vessels, while identifying areas for improvement. The methodology is based on Data Envelopment Analysis (DEA), applied using Windeap4 and Excel software. Inputs are classified into two categories: uncontrollable variables (number of ships, physical characteristics) and controllable variables (dwell time, productivity, berth utilization). The selected output is port productivity. The results reveal mixed performance: ferryboats exhibit optimal technical efficiency (100%) but suffer from diseconomies of scale, while conventional cargo ships and tankers show significant room for improvement. The total time lost in port operations amounts to 167,571 hours, reflecting significant inefficiencies. These results highlight the need to optimize port management in order to improve the PAC's competitiveness at the regional and international levels.

Keywords: port performance, DEA, productivity, efficiency, logistics, Port Authority of Conakry

1. Introduction

1.1 Context

The Autonomous Port of Conakry (PAC) is a strategic driver of Guinea's economy, accounting for more than 80% of the country's trade [5]. Located on the Atlantic coast, it serves as the main gateway for the import and export of goods, particularly essential commodities and mineral resources such as bauxite and gold, which form the core of Guinea's exports [6].

Its role extends beyond national borders: the PAC also serves as a logistics hub for landlocked neighboring countries, notably Mali, thereby reinforcing its regional importance

in West African economic integration [2].

According to the Container Port Performance Index (CPPI 2022) [6] published by the World Bank and S&P Global Market Intelligence, the PAC ranks first in West Africa, 8th in Africa, and 189th globally out of 348 ports evaluated [7]. This ranking illustrates the progress made through modernization reforms and improved port management, but it also highlights persistent challenges related to productivity and operational efficiency [3].

In 2022, port traffic saw significant growth, but this increase was accompanied by logistical challenges, including congestion and time losses resulting from ships' prolonged stays in the roadstead and at the docks. These challenges underscore the need for a rigorous assessment of productivity indicators in order to better understand the PAC's performance and identify areas for improvement [3].

1.2 Issues

Despite being ranked among West Africa's most competitive ports [7], the Port Authority of Conakry (PAC) continues to face major challenges related to productivity and logistics management. Recurring congestion issues, slow cargo handling operations, long vessel turnaround times, and the sometimes inefficient use of port infrastructure limit its appeal to international shipping companies [6].

In 2022, port traffic saw significant growth, but this increase was accompanied by logistical constraints, notably a total of over 167,000 hours lost—nearly seven working days—due to prolonged vessel layovers in the roadstead and at the docks [5]. These losses reflect an operational inefficiency that affects the port's competitiveness in a regional environment marked by infrastructure modernization in Dakar, Abidjan, and Lomé.

The central question of this study can therefore be formulated as follows:

How can the performance of the Port Authority of Conakry in 2022 be measured and analyzed using productivity indicators, in order to identify the necessary levers for improvement to enhance its competitiveness within the West African and global port landscape?

1.3 Objectives

The objectives of this study are to assess the effectiveness and efficiency of port management for the 11 types of vessels that called at the Autonomous Port of Conakry in 2022, to identify comparable DMUs, and to analyze potential areas for improvement. The study also aims to compare the results obtained with regional and international standards in order to propose concrete measures to strengthen the PAC's competitiveness.

2. Methodology

2.1 General Approach

The study is based on the application of the Data Envelopment Analysis (DEA) method, which measures the relative efficiency of decision-making units (DMUs) by comparing their inputs and outputs. This approach is particularly well-suited to evaluating port performance, as it takes into account the diversity of ships and operations.

2.2 Tools Used

- Windeap4 software: for applying the DEA model and calculating efficiency scores.
- Excel: for processing raw data, constructing tables, and visualizing results.

3. Study Population

The analysis covers 11 types of vessels that called at the PAC in 2022 (ferries, conventional cargo ships, tankers, etc.), considered as DMUs (Decision Making Units).

2.3 Selected Variables

- Inputs: classified into two categories
  - Indicators that cannot be controlled by the port operator (e.g., number of ships, port call duration, quay length).
  - Indicators that can be influenced by managers (e.g., berth utilization, productivity per berth, occupancy rate).
- Output: the PAC's productivity rate in 2022, measured in movements per hour or tons per day depending on the type of vessel.

2.3 Analysis Procedure

1. Data collection from [5] and institutional sources ([1], [6]).
2. Classification of indicators into controllable and uncontrollable inputs.

3. Application of the DEA model to calculate:

o Pure efficiency (technical efficiency),

o Scale efficiency (efficiency related to the size of operations).

4. Identification of peer DMUs, i.e., vessels serving as benchmarks for the others.

5. Analysis of potential areas for improvement (input savings, size adjustments).

2.4 Methodological Limitations

- The availability and reliability of port data can affect the accuracy of the results.
- The diversity of vessel types sometimes makes comparisons difficult.
- The choice of a single output metric (productivity rate) limits the scope of the analysis.

The diversity of port logistics often leads us to question how port performance should be evaluated and makes defining variables complex.

Defining variables is no easy task; the output variable is sometimes controversial, as some researchers believe that relying on a single output can lead to flawed results.

In our case, however, we will choose a single output: the productivity of the Autonomous Port of Conakry.

Furthermore, we are interested in the six productivity indicators that we believe can be manipulated by using a reasoned selection of the ship sample.

We used the following table for the analysis:

Table 1: AverageIndicators

TYPES OF SHIPS

INPUTS 2022

OUTPUT

NBER

TOOLS

TE

TBJ

V

L

SQ

SR

SP

T

Pr.Q

SR/SP

TOQ

Attendance

Pr. PORT

ALUMINUM CARRIERS

11.00

9.68

16015.64

39419.16

160.70

88.98

57.08

151.70

20511.74

279.10

0.22

10.19

1.32

219.65

9.68

OTHER BULK CARRIERS

89.00

12.05

29523.11

70218.61

187.94

231.24

74.46

307.66

34467.33

274.15

0.16

224.99

29.20

235.14

12.05

REFRIGERATED CARGO SHIPS

2.00

5.79

2663.00

7457.06

88.29

136.21

0.67

136.88

849.76

8.62

0.01

3.12

0.40

8.53

5.79

CONVENTIONAL CARGO SHIPS

62.00

7.88

12103.39

20601.76

128.08

134.36

77.48

211.84

9934.35

540.47

0.35

95.36

12.37

84.63

7.88

TRAWLERS

527.00

4.18

437.65

1444.64

43.13

28.17

0.50

28.68

150.00

5.85

0.02

169.96

22.06

5.73

4.18

FERRY BOATS

2.00

2.36

74.50

283.57

22.18

333.91

58.38

342.28

0.00

0.00

0.01

7.64

0.99

0.00

2.36

MINERAL CARRIERS

33.00

9.31

16986.58

36932.26

164.06

59.57

42.85

102.42

37701.31

480.86

0.16

22.50

2.92

386.23

9.31

CONTAINER SHIPS

154.00

11.41

27739.10

71699.83

208.88

45.38

21.05

66.54

19302.04

461.88

0.24

79.48

10.31

364.29

11.41

TUGBOATS

2.00

5.50

276.50

1464.77

31.24

56.13

186.67

242.79

12.00

0.29

0.42

1.28

0.17

0.29

5.50

RO-RO SHIPS

48.00

9.46

51221.58

59293.23

197.26

39.27

7.43

46.71

4546.73

136.48

0.13

21.58

2.80

120.15

9.46

TANKERS

102.00

13.52

21674.68

50751.02

166.82

118.70

63.00

180.50

17048.75

366.48

0.33

134.52

17.46

211.41

13.52

KEY TO INPUTS AND OUTPUTS

1- DRAFT: (D) (INPUT)

7- TIME IN PORT: (SP)(INPUT)

13- PORT PRESENCE: PRESENCE (INPUT)

2- GROSS REGISTER TONNAGE: (GRT) (INPUT)

14- NBER: NUMBER (INPUT)

3- VOLUME: (V) (INPUT)

8- TONNAGE (T)(INPUT)

4- LENGTH: (L) (INPUT)

9- QUAY PRODUCTIVITY: (Pr.Q)(INPUT)

5- DOCKING TIME: (SQ) (INPUT)

10- PORT PRODUCTIVITY: (Pr.PORT) (OUTPUT)

6- ANCHORAGE TIME: (SR)

12- DOCK UTILIZATION RATE: (DUR)

3. Results

Overall productivity indicators for the Autonomous Port of Conakry in 2022

We will treat the firms, as before, as different types of ships, and thus designate them as follows:

1. Firm 1: Aluminum Carriers;
2. Firm 2: Other Bulk Carriers;
3. Firm 3: Refrigerated Cargo Ships;
4. Firm 4: Conventional Cargo Ships;
5. Firm 5: Trawlers;
6. Firm 6: Ferry Boats;
7. Firm 7: Ore Carriers;
8. Firm 8: Container Ships;
9. Firm 9: Tugs;
10. Firm 10: RO-RO Ships;
11. Firm 11: Tankers.

In this scenario, we will adopt an INPUT approach with 1 variable returns to scale, yielding the following summary of efficiency (or effectiveness):

Summary of efficiencies

Firm	crstevrste	scale	
1	1.000	1.000	1.000 -
2	1.000	1.000	1.000 -

3 1.000 1.000 1.000 -

4 0.622 0.783 0.795 irs

5 1.000 1.000 1.000 -

6 0.000 1.000 0.000 irs

7 1.000 1.000 1.000 -

8 1.000 1.000 1.000 -

9 1.000 1.000 1.000 -

10 1.000 1.000 1.000 -

11 0.753 0.800 0.941 irs

mean 0.852 0.962 0.885

Note that: mean = average

crste = technical efficiency of CRS DEA

vrste = technical efficiency of VRS DEA

scale = scale efficiency = crste/vrste.

Now, we'll introduce the INPUTS and what they mean.

1. NBER: Number;
2. OUTIL: Unloading equipment;
3. TE: Average draft;
4. TJB: Gross tonnage;
5. V: Average volume in m^3;
6. L: Average length in meters;
7. SQ: Average time at berth;
8. SR: Average time in roadstead;
9. SP: Average time in port;
10. T: Average tonnage in tons;
11. Prod. Q: Average productivity at berth in tons per hour;
12. SR/SP: The average ratio of time in roadstead to time in port;
13. TOQ: Quay Occupancy Rate in %

14. Presence: Presence in %.

With these INPUTS, we observe that some are not controllable by the port authority and the harbor master's office, whereas others are.

Now, let us examine the situation of each vessel operating under conditions of variable scale efficiency:

Conventional cargo ships

Results for firm : 4

Technical efficiency = 0.783(pure efficiency)

Scale efficiency = 0.795 (irs)(scale efficiency)

Listing of peers:

Peer	lambda weight
6	0.069
3	0.394
7	0.183
5	0.070
9	0.257
8	0.028

Ferry- Boat

Results for firm: 6

Technical efficiency = 1.000

Scale efficiency = 0.000 (irs)

LISTING OF PEERS:

peer	lambda weight
6	1.000

For ferries, the technical efficiency is 1.00 and the scale efficiency is 0; as we move through the progression, we return to the initial values, which means that for ferries, the margin for improvement is 0.

Tankers

Given that the types of ships (company) are the same, for an input-oriented analysis with 1 variable returns to scale, we obtain a summary of efficiencies in tanker managementResults for firm: 11

Technical efficiency = 0.800 (pure efficiency)

Scale efficiency = 0.941 (irs) (scale efficiency)

Listing of peers :

peer	lambda weight
5	0.019
9	0.153
8	0.430
6	0.115
7	0.138
3	0.145

4 DISCUSSION

4.1 Global situation

On average, ships achieve the following efficiency scores:

 The average of 0.852, or 85.20%, means that for ships, all inputs can be reduced by 100 – 85.2 = 14.8% while maintaining the same hourly productivity rate.

 The average of 0.962 for “vorte” means that better management of ships by their owners can reduce input consumption by 100 – 96.2 = 3.8% while maintaining the same hourly productivity rate.

 The average of 0.885 for scale means that by adjusting their sizes, vessel inputs can be reduced by 100 – 88.5 = 11.5% while maintaining the same hourly productivity rate. Furthermore, 1 it is worth noting that of the 11 types of vessels, eight operate under conditions of constant returns to scale and the other three under conditions of variable

returns to scale, which are:

1- Conventional cargo ships;

2- Ferryboats; and

3- Tankers.

These three types of ships in this context operate under conditions of increasing returns to scale (economies of scale).

The other types of ships operate under conditions of constant returns to scale; in other words, these types of ships operate at their optimal size. In this case, we cannot make any improvements since these types of ships are already efficient.

4.2 Status by vessel type

4.2.1 Conventional cargo ships

The pure efficiency of managing conventional cargo ships at the Port of Conakry is 79.5%, which indicates that if the management of this type of vessel is improved, 21.7% (100 – 78.3) of inputs could be saved.

Since the scale efficiency is 78.3%, by adjusting the size of conventional cargo ships, input consumption could be reduced by 20.5% (100 – 79.5).

To summarize the projections, we find that:

Inputs 4, 6, and 11 each have zero movement slack; therefore, for these inputs, only a single reduction of the original values (radial movement) is required. However, inputs 1, 2, 3, 5, 9, 10, 12, 13, and 14 require an additional reduction (movement slack).

These various reductions are implemented to ensure that the management of conventional cargo ships at the Autonomous Port of Conakry is efficient and achieves the same hourly productivity rate.

To improve performance, managers of conventional cargo ships at the Port of Conakry will need to analyze ship management:

1- Refrigerated cargo ship with a score of: 0.394;

2-Trawler with a score of: 0.070;

3- Ferry with a score of: 0.069;

4- Bulk carrier with a score of: 0.183;

5- Container ship with a score of: 0.028;

6- Tugboat with a score of: 0.257.

At this stage, with these different types of ships selected, it will be important to choose the management strategy for the ship type with the highest score.

To use this score, one must select a hypothetical ship type for which the management strategy should incorporate 39.4% of the refrigerated cargo ship management method.

Using pure efficiency and 1 economies of scale, the following table shows the original value, the projected value, and the balance for each input:

Table 2: Comparison of Scores for Conventional Cargo Ships

INPUTS

NBER 1

OUT 2

TE 3

TJB 4

V 5

L 6

SQ 7

SR 8

SP 9

T 10

Pr. Q 11

SR/SP 12

TOQ 13

14 ATTENDANCE

ORIGINAL VALUE (OV)

62

12

7.88

12103.39

20601.76

128.08

134.36

77.48

211.84

9934.35

540.47

0.35

95.36

12.37

PROJECTED VALUE (PV)

48.534

6.955

6.168

5039.657

12199.67

83.184

105.18

60.651

162.39

7776.63

104.705

0.15

20.278

2.631

BALANCE(OV- PV)

13.466

5.045

1.712

7063.733

8402.089

44.896

29.183

16.829

49.452

2157.72

435.765

0.2

75.082

9.739

1 Table 2 shows the projections that provide the accurate figures that could have been used to achieve the 84.63 tons/hour productivity rate for conventional cargo ships at the Port of Conakry.

For example:

- 6.955 RTGs would have been sufficient instead of 12 to achieve this hourly productivity rate;

-105.177 hours of berthing time would have been sufficient instead of 134.36 hours;

- 60.651 hours of anchorage time would have been sufficient instead of 77.88 hours;

- 162,388 hours spent in port would have been sufficient instead of 211.84 hours;

- 20.278% of TOQ would have been sufficient instead of 95.36%;

- A presence of 2.631% would have been sufficient instead of 12.37%.

The total time lost due to stays in the roadstead, at the docks, and in the port would be

95.864 hours, which is not insignificant since it corresponds to roughly 4 lost workdays.

Using the following graph, we will visualize the overall situation regarding the management of conventional cargo ships at the Autonomous Port of Conakry:

Figure 1: (Input comparisons for conventional cargo ships)

4.2.2 Ferry- Boat

For ferries, the technical efficiency is 1.00 and the scale efficiency is 0; as we move through the progression, we return to the initial values, which means that for ferries, the margin for improvement is 0.

4.2.3Tankers

The pure efficiency of tanker management at the Autonomous Port of Conakry is 80%, which indicates that if tanker management at the Autonomous Port of Conakry is improved, 20% = (100 – 80)% of inputs could be saved.

Since 1 the scale efficiency value is 94.1%, by adjusting the size of the tankers, input consumption could be reduced by 5.9% = (100 - 94.1)%.

To summarize the projections:

Inputs 1, 6, 7, 8, and 10 each have zero movement slack; therefore, for these inputs, a single reduction of the original values (radial movement) is required. However, for inputs 2, 3, 4, 5, 9, 10, 11, 12, 13, and 14, an additional reduction is mandatory (movement slack). These various reductions are implemented to achieve efficient management of tankers at the Autonomous Port of Conakry.

To improve performance, tanker managers at the Autonomous Port of Conakry will need to analyze the management of the following types of ships:

1- Refrigerated cargo ship with a score of: 0.145;
2- Trawler with a score of: 0.019;
3- Ferry with a score of: 0.115;
4- Ore carrier with a score of: 0.138;
5- Container ship with a score of: 0.430;

6- Tugboat with a score of: 0.153.

At this stage, given the different types of ships selected, it will be important to choose the management approach for the ship type with the highest score, which is the container ship. To use this score, we must select a hypothetical ship type for which we must adopt 43% of the container ship management method.

Using pure efficiency and 1 economies of scale, the following table shows the original value, the projected value, and the balance for each input:

Table 3: Comparison of Scores for the Tankers

INPUTS

NBRE 1

OUT 2

TE 3

TJB 4

V 5

L 6

SQ 7

SR 8

SP 9

T 10

Pr. Q 11

SR/SP 12

TOQ 13

PRESENCE

ORIGINAL VALUE (OV)

102

10

13.52

21674.7

50751.02

166.82

118.7

63

180,5

17048.8

366.48

0.33

134.52

17.46

PROJECTED VALUE (PV)

81.585

7.854

8.225

14721.3

37302.511

133.431

94.942

50.391

139.637

13636.5

266.468

0.193

42.031

5.452

BALANCE=OV- PV

20.415

2.146

5.295

6953.43

13448.509

33.389

23.758

12.609

40.863

3412.27

100.012

0.137

92.489

12.008

Table 3 shows the projections calculated using this method, which provide the accurate figures that could have been used to achieve the tankers' productivity rate of 211,410 tons per hour at the Port Autonome de Conakry.

For example:

- 7,854 oil tankers would have been sufficient instead of 10 to achieve this productivity rate of 211,410 tons per hour;
- 94,942 hours of berthing time would have been sufficient instead of 118.7 hours;
- 50,391 hours of anchorage time would have sufficed instead of 63 hours;
- 139,637 hours of port time would have sufficed instead of 180.50 hours;
- 42.031% of TOQ would have sufficed instead of 134.52%;
-A presence of 5.452% would have been sufficient instead of 17.46%.

The total time lost due to stays in the roadstead, at the docks, and in port would be 77.23 hours, which is enormous, as it corresponds to more than three lost workdays.

Figure 2: (Comparison of inputs for tankers)

4.3 Comparison with regional and international standards

4.3.1 PAC Results for 2022

• Ferry: pure efficiency 100%, scale efficiency 0%.

• Conventional cargo ships: pure efficiency 78.3%, scale efficiency 79.5%.

• Tankers: pure efficiency 80%, scale efficiency 94.1%.

•Total time lost: 167,571 hours (≈ 7 business days).

4.3.2 Regional Standards (West Africa)

The ports of Dakar (Senegal) and Abidjan (Ivory Coast) generally achieve efficiencies of over 85% for conventional cargo ships and tankers, thanks to modernized infrastructure and improved logistics management [6] (UNCTAD, 2022).

- The average turnaround time in these ports is less than 48 hours, compared to longer durations observed in Conakry.
- Although PAC is making progress, it remains below these standards for conventional cargo ships, with an estimated margin for improvement of 20–22%.

4.3.3 International standards

According to the Container Port Performance Index [7] (World Bank & S&P Global, 2023), Asian ports such as Shanghai and Singapore achieve efficiencies of nearly 95–100%, with turnaround times reduced to less than 24 hours.

• European ports (Rotterdam, Hamburg) also maintain efficiency rates above 90%, thanks to the digitization and automation of operations.

• Compared to these standards, the PAC shows mixed performance: excellent efficiency for ferries (100%), but still limited efficiency for conventional cargo ships and tankers.

4.3.4 Comparative analysis

• Strengths of the PAC: maximum efficiency for ferry boats, significant improvement in tankers (94.1% economies of scale).

•Weaknesses: management of conventional cargo ships, long dwell times, cumulative losses of over 167,000 hours.

• Deviation from standards: approximately 10–15% behind high-performing regional ports (Dakar, Abidjan) and 15–20% behind international standards.

4.3.5 Limitations of the study

Despite the scientific and practical value of this research, certain limitations should be noted:

1. Data availability and reliability

→ The port statistics used are primarily derived from official PAC reports for the year 2022.

→ Some data may be incomplete or subject to biases related to collection methods.

→The comparison with regional and international standards is based on databases [1], [6] that do not always cover the same variables or time periods.

2. Specific characteristics of vessel types

→ The assessment covered 11 types of vessels, each with distinct operational characteristics (ferries, conventional cargo ships, tankers, etc.).

→ This diversity sometimes makes it difficult to harmonize indicators and make direct comparisons between categories.

→ Efficiency results (DEA) must therefore be interpreted with these specific characteristics in mind.

3. DEA Methodology

→The 1 Data Envelopment Analysis (DEA) method is sensitive to the choice of inputs and outputs.

→The results depend heavily on the classification of indicators as “manipulable” and “non-manipulable.”

→ Using a single output (productivity rate) can limit the scope of the analysis.

3. External factors not taken into account

→ Economic, political, and climatic conditions in 2022 may have influenced port performance.

→ These external variables were 1 not included in the model, which may limit the generalizability of the results.

5. Conclusion

The assessment of port efficiency at the Port Autonome de Conakry in 2022 highlights

significant room for improvement, particularly for conventional cargo ships and tankers. For the former, a pure efficiency of 78.3% and a scale efficiency of 79.5% indicate that adjustments in management and scale could reduce input consumption by nearly 20 to 22%, while achieving optimal productivity of 84.63 tons/hour. Tankers show similar results, with a potential productivity of 211,410 tons/hour and a reduction in resources used of over 15%.

Analysis of dwell times reveals a total of 167,571 hours lost—equivalent to approximately 7 unused working days—as well as a Berth Utilization Rate (BUR) significantly higher than actual needs. These inefficiencies point to considerable potential for streamlining port operations.

In summary, the DEA method demonstrates that optimizing management and adjusting vessel capacities are essential levers for strengthening the PAC's competitiveness and sustainably improving its logistics performance.

Furthermore,

- The PAC exhibits varying performance levels depending on vessel type.

-The identified areas for improvement (conventional cargo ships, tankers) are crucial for enhancing competitiveness.

- DEA proves to be a relevant tool for assessing port efficiency and guiding strategic decisions.

6. Perspectives

1 An analysis of the productivity indicators for the Autonomous Port of Conakry for the year 2022 reveals significant room for improvement, particularly for conventional cargo ships and tankers. To enhance the PAC's competitiveness and bring it in line with regional and international standards, several approaches can be considered:

1. Modernization of port infrastructure

- Expansion and renovation of docks to accommodate a larger number of ships.

- Acquisition of new cargo-handling equipment (gantry cranes, modern cranes).

- Improvement of storage areas to reduce the stock-to-space ratio and optimize space

utilization.

2.Digitization of procedures

- Implementation of computerized systems for managing cargo flows and port operations.
- Adoption of digital platforms for real-time tracking of ships, containers, and logistics operations.
- Reduction of administrative delays through the digitization of customs and port formalities.

3. Optimization of cargo flow management

- Reorganization of cargo handling operations to reduce vessel turnaround times.
- Implementation of dynamic planning strategies to limit congestion and time losses (167,571 hours in 2022).
- Development of regional partnerships to streamline trade and strengthen logistics integration.

4. Strengthening human capacity

-Ongoing training for port managers and operators in new technologies.
-Development of a culture of performance and efficiency among staff.

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