Transport Global Practice

The Container Port Performance Index 2022

A Comparable Assessment of Performance based on Vessel Time in Port

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Acknowledgements

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Abbreviations and Acronyms

AIS	Automatic Identification System
CI	Crane Intensity
COVID-19	Coronavirus Disease 2019
CPPI	Container Port Performance Index
EEZ	Exclusive Economic Zone
FA	Factor Analysis
GCI	Global Competitiveness Index
GCMPH	Moves per Gross Crane Hour
GDP	Gross Domestic Product
GRT	Gross Registered Tonnage
ITU	International Telecommunication Union
LLDC	Landlocked Developing Country
LPI	Logistics Performance Index
SIDS	Small Island Developing States
TEU	Twenty-foot Equivalent Unit
UNCTAD	United Nations Conference on Trade and Development

Glossary

All fast: The point when the vessel is fully secured at berth and all mooring lines are fast

Arrival time/hours: The total elapsed time between the vessel's automatic identification system (AIS) recorded arrival at the actual port limit or anchorage (whichever recorded time is the earlier) and its all lines fast at the berth

Berth hours: The time between all lines fast and all lines released

Berth idle: The time spent on berth without ongoing cargo operations. The accumulated time between all fast to first move plus last move to all lines released

Call size: The number of container moves per call, inclusive of discharge, load, and restowage

Cargo operations: When cargo is being exchanged, the time between first and last container moves

Crane intensity (CI): The quantity of cranes deployed to a ship's berth call. Calculated as total accumulated gross crane hours divided by operating (first to last move) hours

Factor analysis (FA): A statistical method used to describe variability among observed, correlated variables in terms of a potentially lower number of unobserved variables called factors

Finish: Total elapsed time between last container move and all lines released

Gross crane hours: Aggregated total working time for all cranes deployed to a vessel call without any deductions. Time includes breakdowns, inclement weather, vessel inspired delays, un/lashing, gantry, boom down/up plus hatch cover and gear-box handling.

Gross crane productivity (GCMPH): Call size or total moves divided by total gross crane hours.

Hub port: A port which is called at by deep-sea mainline container ships and serves as a transshipment point for smaller outlying, or feeder, ports within its geographical region. Typically, more than 35 percent of its total throughput would be hub and spoke or relay transshipment container activity.

Moves: Total container moves. Discharge + restowage moves + load. Excluding hatch covers, gearboxes, and other non-container related crane work. Breakbulk cargo lifts are excluded, however empty platform (tweendeck or flat-rack) handling moves are included.

Moves per crane: Total Moves for a call divided by the crane intensity.

Port call: A call to a container port/terminal by a container vessel where at least one container was discharged or loaded.

Port hours: The number of hours a ship spends at/in port, from arrival at the port limits to sailing from the berth.

Port limits: Either an anchorage zone or the location where pilot embarkation or disembarkation occurs and recorded as whichever activity is the earliest.

Port to berth hours: The time from when a ship first arrived at the port limits or anchorage zone (whichever activity occurs first) until it is all fast alongside the berth.

Relay transhipment: Containers transhipped between ocean going container ships.

Ship size: Nominal capacity in twenty foot equivalent units ("TEU's").

Start: The time elapsed from berthing (all lines fast) to first container move.

Steam in time: The time required to steam-in from the port limits and until all fast alongside the berth.

Twenty foot equivalent unit or TEU: A standard metric for container throughput, and the physical capacity of a container terminal. A 20-foot container is equal to 1 TEU, and a 40-foot or 45-foot container is equal to 2 TEUs. Regardless of container size (10 feet, 15 feet, 20 feet, 30 feet, 40 feet, or 45 feet), each is recorded as one move when being loaded or discharged from the vessel.

Vessel capacity: Nominal capacity in twenty foot equivalent Units ("TEU's").

Waiting time: Total elapsed time from when vessel enters anchorage zone to when vessel departs anchorage zone (vessel speed must have dropped below 0.5 knots for at least 15 mins within the zone).

Foreword

The challenges caused by the COVID-19 pandemic and its aftermath on the sector eased in 2022, an easing that has continued into early 2023. This has resulted in an improvement in both port congestion and a reduction in logistical disruption. The improvement in 2022 has had a positive impact on the performance and ranking of some ports; where the problem was systemic, as opposed to location specific, the inherent inefficiency remains. One of the 'silver linings' of the pandemic was greater awareness and focus on the resilience and efficiency of the maritime gateways, where any friction will result in tangible impacts on consumer choice, price and ultimately economic development.

However, one of the major challenges to stimulating improvement in the efficiency of ports has been the lack of a reliable, consistent, and comparable basis on which to compare operational performance across different ports. While modern ports collect data for performance purposes, the Quality, consistency, and availability of data, the definitions employed, and the capacity and willingness of the organizations to collect and transmit data to a collating body have all precluded the development of a robust comparable measure(s) to assess performance across ports and time.

The introduction of new technologies, increased digitalization, and the willingness on the part of industry stakeholders to work collectively toward systemwide improvements have now provided the opportunity to measure and compare container port performance in a robust and reliable manner. A partnership has resulted in this technical report, which is the third iteration of the Container Port Performance Index (CPPI), produced by the Transport Global Practice of the World Bank in collaboration with the Global Intelligence & Analytics division of S&P Global Market Intelligence.

The CPPI is intended, as in its earlier iterations, to serve as a reference point for improvement for key stakeholders in the global economy, including national governments, port authorities and operators, development agencies, supranational organizations, various maritime interests, and other public and private stakeholders in trade, logistics, and supply chain services. The performance of a port may be assessed based on a myriad of measurements, such as: terminal capacity or space utilization, cost, landside connectivity & services, or ship to shore interchange. The CPPI is based on available empirical objective data pertaining exclusively to time expended in a vessel stay in a port and should be interpreted as an indicative measure of container port performance, but not a definitive one.

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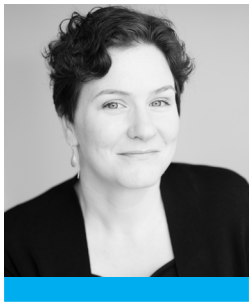

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Executive Summary

Maritime transport forms the foundation of global trade and the manufacturing supply chain. The maritime industry provides the most cost-effective, energy-efficient, and dependable mode of transportation for long distances. 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 emergence of containerization brought about significant changes in how and where goods are manufactured and processed, a trend that is likely to continue with digitalization. Container ports are critical nodes in global supply chains and essential to the growth strategies of many emerging economies. In numerous cases, the development of high-quality container port infrastructure operating efficiently has been a prerequisite for successful export-led growth strategies. Countries that follow such a strategy will have higher levels of economic growth than those that do not. Efficient, high quality port infrastructure can facilitate investment in production and distribution systems, engender expansion of manufacturing and logistics, create employment opportunities, and raise income levels.

However, ports and terminals, especially container terminals, can cause shipment delays, disruptions in supply chain, additional expenses, and reduced competitiveness. The negative effect of poor performance in a port can extend beyond the that port's hinterland to others as container shipping services follow a fixed schedule with specific berth windows at each port of call on the route. Therefore, poor performance at one port could disrupt the entire schedule. This, in turn, increases the cost of imports and exports, reduces the competitiveness of the country and its hinterland, and hinders economic growth and poverty reduction. The consequences are particularly significant for landlocked developing countries (LLDCs) and small island developing states (SIDS).

Comparing operational performance across ports has been a major challenge for improving global value chains due to the lack of a reliable, consistent, and comparable basis. Despite the data collected by modern ports for performance purposes, the quality, consistency, and availability of data, as well as the definitions used and the capacity and willingness of organizations to transmit data to a collating body, have hindered the development of a comparable measure(s) for assessing performance across ports and time. However, new technologies, increased digitalization, and industry interests' willingness to work collectively toward systemwide improvements now provide an opportunity to measure and compare container port performance in a robust and reliable manner. The World Bank's Transport Global Practice and the Global Intelligence & Analytics division of S&P Global Market Intelligence have collaborated to produce the third edition of the Container Port Performance Index (CPPI), presented in this technical paper.

The aim of the CPPI is to pinpoint areas for enhancement that can ultimately benefit all parties involved, ranging from shipping lines to national governments and consumers. It is designed to act as a point of reference for important stakeholders in the global economy, including port authorities and operators, national governments, supranational organizations, development agencies, various maritime interests, and other public and private stakeholders in trade, logistics, and supply chain services. The development of the CPPI rests on total container ship in port time in the manner explained in subsequent sections of the report, and as in earlier

iterations of the CPPI. This third iteration utilizes data for the full calendar year of 2022. One slight change in this iteration is that the CPPI 2022 only includes ports that had a minimum of 24 valid port calls within the 12-month period of the study, compared to 20 in earlier iterations. The number of ports included in the CPPI 2022 is 348.

In earlier iterations of the CPPI, the calculation of the ranking of the index employed two different methodological approaches, an administrative, or technical, approach, a pragmatic methodology reflecting expert knowledge and judgment; and a statistical approach, using factor analysis (FA). The rationale for using two approaches was to try and ensure that the ranking of container port performance reflects as closely as possible actual port performance, whilst also being statistically robust. And there has been a marked improvement in consistency between the rankings that result from the two approaches since the inaugural CPPI 2020, but some minor inconsistencies remained.

Accordingly, for CPPI 2022, the same methodological approaches are used and then a rank aggregation method applied to combine the results from the two different approaches and return one aggregate ranking. The aggregation methodology and the resulting ranking is detailed in the report, while the statistical and administrative approaches and their respective rankings are detailed in Appendix A. Table E.1 presents the resulting CPPI 2022.

The two top-ranked container ports in the CPPI 2022 are Yangshan Port (China) in first place, followed by the Port of Salalah (Oman) in second place. These two ports occupy the same positions in the rankings generated by both approaches. Port of Salalah was ranked second in both approaches in CPPI 2021. Yangshan Port ranked third and fourth in the statistical and administrative approaches, respectively, for CPPI 2021. Three ports in the Middle East are ranked in the top ten (Salalah, Kahlifa, Hamad), as are three of the large Chinese gateways (Yangshan, Ningbo and Guangzhou).

Of the top 10 ranked ports, 9 have either maintained or improved their position since CPPI 2021. The exception is Hamad Port, which moved down 5 and 3 places in the administrative and statistical rankings, respectively. Yokohama fell from 10th and 12th in CPPI 2021 to 15th place in CPPI 2022, and Jeddah fell from 8th place in CPPI 2021 to 29th place in CPPI 2022.

Table E.1 • The CPPI 2022: Global Ranking of Container Ports

Port Name	Overall Ranking
Yangshan	1
Salalah	2
Khalifa Port	3
Tanger-Mediterranean	4
Cartagena (Colombia)	5
Tanjung Pelepas	6
Ningbo	7
Hamad Port	8
Guangzhou	9
Port Said	10
Hong Kong	11
Cai Mep	12
Shekou	13
Mawan	14
Yokohama	15
Algeciras	16
King Abdullah Port	17
Singapore	18
Posorja	19
Tianjin	20
Buenaventura	21
Busan	22
Yeosu	23
Chiwan	24
Kaohsiung	25
Djibouti	26
Laem Chabang	27
Colombo	28
Jeddah	29
Pipavav	30
Dammam	31
Coronel	32
Xiamen	33
Barcelona	34
Callao	35
Port Klang	36
Incheon	37
Jebel Ali	38

Port Name	Overall Ranking
Fuzhou	39
Marsaxlokk	40
Yarimca	41
Dalian	42
Lazaro Cardenas	43
Wilmington (USA-N Carolina)	44
Kobe	45
Nagoya	46
Shimizu	47
Mundra	48
Sohar	49
Rio Grande (Brazil)	50
Piraeus	51
Port Of Virginia	52
Yantian	53
Tokyo	54
Altamira	55
Haifa	56
Ambarli	57
Jubail	58
Aqaba	59
Bremerhaven	60
Itapoa	61
Zeebrugge	62
Da Chan Bay Terminal One	63
Krishnapatnam	64
Zhoushan	65
Antwerp	66
Rio De Janeiro	67
Savona-Vado	68
Boston (USA)	69
Keelung	70
Santa Cruz De Tenerife	71
Paranagua	72
Khalifa Bin Salman	73
Siam Seaport	74
Diliskelesi	75
Balboa	76

Port Name	Overall Ranking
Shantou	77
Kattupalli	78
Kamarajar	79
Osaka	80
Colon	81
Jacksonville	82
Lianyungang	83
Karachi	84
Hazira	85
Jawaharlal Nehru Port	86
Puerto Limon	87
Cochin	88
Port Everglades	89
Muhammad Bin Qasim	90
Johor	91
Penang	92
Aarhus	93
Puerto Cortes	94
Fort-De-France	95
Pointe-A-Pitre	96
Tanjung Perak	97
Philadelphia	98
Veracruz	99
Nemrut Bay	100
Paita	101
Yokkaichi	102
Limassol	103
Naha	104
Ensenada	105
Malaga	106
Cat Lai	107
Imbituba	108
Hakata	109
Chennai	110
Gemlik	111
Mersin	112
New Orleans	113
Santos	114
Visakhapatnam	115
Pecem	116

Port Name	Overall Ranking
Danang	117
Wilhelmshaven	118
Puerto Barrios	119
Salvador	120
Shuaiba	121
Gothenburg	122
Gioia Tauro	123
Saigon	124
Taichung	125
Port Akdeniz	126
Sharjah	127
Noumea	128
Puerto Quetzal	129
San Juan	130
Santa Marta	131
Tanjung Emas	132
Omaezaki	133
Gijon	134
Batangas	135
Moji	136
Izmir	137
Vigo	138
Papeete	139
Haiphong	140
Lirquen	141
Shuwaikh	142
Cebu	143
Berbera	144
Port Tampa Bay	145
Quy Nhon	146
Puerto Bolivar (Ecuador)	147
Caucedo	148
Fredericia	149
Odessa	150
Helsingborg	151
Cadiz	152
Wellington	153
Nantes-St Nazaire	154
Chu Lai	155
Cagayan De Oro	156

Port Name	Overall Ranking
Ancona	157
Rio Haina	158
Casablanca	159
Bar	160
Ravenna	161
Puerto Progreso	162
Salerno	163
Barranquilla	164
Umm Qasr	165
Oslo	166
Gustavia	167
Borusan	168
Philipsburg	169
Vitoria	170
Qingdao	171
El Dekheila	172
Damietta	173
Buenos Aires	174
Leixoes	175
Brest	176
Latakia	177
Suape	178
Larvik	179
Burgas	180
Norrkoping	181
Sepetiba	182
Muuga-Port Of Tallinn	183
Bari	184
Civitavecchia	185
Sines	186
Copenhagen	187
Valparaiso	188
Conakry	189
Vila Do Conde	190
Bluff	191
Bell Bay	192
Subic Bay	193
Novorossiysk	194
Klaipeda	195
Dakar	196

Port Name	Overall Ranking
Matadi	197
Catania	198
Palermo	199
Rauma	200
Heraklion	201
Kristiansand	202
Apra Harbor	203
Nelson	204
Tema	205
Bilbao	206
Trapani	207
Tomakomai	208
Mariel	209
Rades	210
Caldera (Costa Rica)	211
La Guaira	212
Bordeaux	213
Belawan	214
Shanghai	215
Lisbon	216
Miami	217
Marseille	218
Tripoli (Lebanon)	219
Helsinki	220
Mogadiscio	221
Kotka	222
Beira	223
Alicante	224
Gdynia	225
Freetown	226
Toamasina	227
Panjang	228
Nassau	229
Batumi	230
Riga	231
Point Lisas Ports	232
Saint John	233
Teesport	234
Southampton	235
Manaus	236

Port Name	Overall Ranking
Arica	237
Mobile	238
Port Of Spain	239
Itajai	240
Varna	241
Hueneme	242
Bangkok	243
St Petersburg	244
Takoradi	245
Venice	246
Gavle	247
Maputo	248
Port Victoria	249
Timaru	250
Davao	251
Agadir	252
San Antonio	253
Durres	254
Puerto Cabello	255
Bejaia	256
San Vicente	257
Dublin	258
Corinto	259
Lagos (Nigeria)	260
London	261
Aden	262
Santo Tomas De Castilla	263
Felixstowe	264
Rotterdam	265
Kingston (Jamaica)	266
Mayotte	267
Alexandria (Egypt)	268
Sokhna	269
Naples	270
Monrovia	271
Mejillones	272
Melbourne	273
Lae	274
Owendo	275
Otago Harbour	276

Port Name	Overall Ranking
Adelaide	277
Halifax	278
Seattle	279
Iskenderun	280
Tanjung Priok	281
Manzanillo (Mexico)	282
Guayaquil	283
Iquique	284
Tarragona	285
Antofagasta	286
Brisbane	287
Acajutla	288
Gdansk	289
Poti	290
Port Elizabeth	291
Montreal	292
Walvis Bay	293
Constantza	294
Douala	295
San Pedro (Cote D'ivoire)	296
Ashdod	297
Port Reunion	298
Port Botany	299
Baltimore (USA)	300
Valencia	301
Onne	302
Qasr Ahmed	303
Montevideo	304
Cristobal	305
New York & New Jersey	306
Chattogram	307
Tin Can Island	308
Livorno	309
Fremantle	310
Dunkirk	311
Dar Es Salaam	312
Lyttelton	313
Tacoma	314
Pointe-Noire	315
Genoa	316

Port Name	Overall Ranking	Port Name	Overall Ranking
Freeport (Bahamas)	317	Abidjan	333
Lome	318	Rijeka	334
Le Havre	319	Houston	335
Beirut	320	Los Angeles	336
Thessaloniki	321	Luanda	337
Napier	322	Ngqura	338
Auckland	323	Trieste	339
Kribi Deep Sea Port	324	Charleston	340
Tauranga	325	Durban	341
Mombasa	326	Prince Rupert	342
Port Louis	327	Oakland	343
Hamburg	328	Cape Town	344
Manila	329	Koper	345
Cotonou	330	Long Beach	346
Nouakchott	331	Vancouver (Canada)	347
La Spezia	332	Savannah	348

Source: Original table produced for this publication, based on CPPI 2022 data.

There are 14 new entrants to the CPPI 2022, and several significant movers since the CPPI 2021. Over one hundred and ten ports improved their rankings in CPPI 2022 compared to CPPI 2021, with some of the largest improvers increasing their ranking by more than 200 positions.

1. Introduction

Since the start of maritime trade, ports have played a central role in the economic and social development of countries. The innovation of containerization by Malcom McLean in 1958 changed the course of the shipping industry and engendered significant changes to where and how goods are manufactured. Container ports remain vital nodes in global supply chains and are crucial to the growth strategies of many emerging economies. The development of high-quality port infrastructure, operated efficiently, has often been a prerequisite for successful growth strategies, particularly those driven by exports. When done correctly, it can attract investment in production and distribution systems and eventually, support the growth of manufacturing and logistics, create employment, and increase income levels.

In contrast, a poorly functioning or inefficient port can hinder trade growth, with a profound impact on LLDCs and SIDS. The port, along with the access infrastructure (inland waterways, railways, roads) to the hinterland, is a vital link to the global marketplace and needs to operate efficiently. Efficient performance encompasses several factors, such as the port's efficiency itself, the availability of sufficient draught, quay, and dock facilities, the quality of road and rail connections, the competitiveness of these services, and the effectiveness of the procedures utilized by public agencies for container clearance. Any inefficiencies or non-tariff barriers among these actors will result in higher costs, reduced competitiveness, and lower trade volumes (Kathuria 2018).

More specifically, the efficiency of port infrastructure has been identified as a key contributor to the overall port competitiveness and international trade costs. Micco et al. (2003) identified a link between port efficiency and the cost of international trade. Clark, Dollar, and Micco (2004) found a reduction in country inefficiency, specifically transport cost, from the 25th to 75th percentile, resulting in an increase in bilateral trade of around 25 percent. Wilmsmeier, Hoffmann, and Sanchez (2006) confirmed the impact of port performance

on international trade costs, finding that doubling port efficiency in a pair of ports had the same impact on trade costs as halving the physical distance between the ports. Hoffmann, Saeed, and Sødal (2020) analyzed the short- and long-term impacts of liner shipping bilateral connectivity on South Africa's trade flows, and showed that gross domestic product (GDP), the number of common direct connections, and the level of competition have a positive and significant effect on trade flows.

However, ports and terminals, particularly for containers, can often be the main sources of shipment delays, supply chain disruptions, additional costs, and reduced competitiveness. Poorly performing ports are characterized by limited spatial and operating efficiency, maritime and landside access, oversight, and coordination among the public agencies involved, which lower predictability and reliability. The result is that instead of facilitating trade, the port increases the cost of imports and exports, reduces competitiveness, and inhibits economic growth and poverty reduction. The effect on national and regional economies can be severe [see inter alia World Bank (2013)] and has driven numerous efforts to improve performance to strengthen competitiveness.

Port performance is also a key consideration for container shipping lines that operate liner services on fixed schedules, based on agreed pro-forma berth windows. Delays at any of the scheduled ports of call on the route served by the vessel would have to be made good before the vessel arrives at the next port of call, to avoid an adverse impact on the efficient operations of the service. As such, port efficiency and port turnaround time at all the ports of call are important subjects for operators, and monitoring port performance has become an increasingly important undertaking in the competitive landscape.

One of the major challenges to improving efficiency has been the lack of reliable measures to compare operational performance across different ports. The old management idiom, 'you cannot manage what you cannot measure,' is reflective of the historical challenge of both managing and overseeing the sector. While modern ports collect data for performance purposes, it is difficult to benchmark the outcomes against leading ports or ports with similar profiles due to the lack of comparative data.

Unsurprisingly, there is a long history of attempts to identify a comparative set of indicators to measure port or terminal performance. A brief review of the literature was provided in The Container Port Performance Index 2020: A Comparable Assessment of Container Port Performance (World Bank 2021), CPPI 2020, which illustrated the broad approaches identified and commented on the merits and demerits of each. The measures fell into three broad categories: Firstly, measures of operational and financial performance; secondly, measures of economic efficiency; and thirdly, measures that rely, predominately, on data from sources exogenous to the port. This review is not replicated in CPPI 2021, and interested readers are directed to CPPI 2020 (World Bank 2021), or the extant literature. One of the general challenges of nearly all the approaches has been the quality, consistency, and availability of data; the standardization of definitions employed; and the capacity and willingness of organizations to collect and transmit the data to a collating body.

At a slightly higher level, there are several aggregate indicators that provide an indication of the comparative quality and performance of maritime gateways. The World Bank Logistics Performance Index (LPI) (Arvis et al. 2018) and the World Economic Forum's Global Competitiveness Index (GCI) 4.0 both report on the perceived efficiency of seaport services and border clearance processes and indicate the extent to which inefficiencies at a nation's sea borders can impact international trade competitiveness. But the aggregate nature of the indicators, and the fact that they are perception based, means that they offer at best an indication of comparative performance and offer little to guide

spatial or operating performance improvements at the level of the individual port. The United Nations Conference on Trade and Development's (UNCTAD's) Liner Shipping Connectivity Index (LSCI) provides an indicator of a port's position within the liner shipping network, which is partly a result of the port's performance, but does not directly measure it. Like the CPPI, the LSCI is limited to container ports.

Digitalization offers an opportunity to measure and compare container port performance in a robust and reliable manner. New technologies, increased digitalization and digitization, and growing willingness on the part of industry stakeholders to work collectively toward system-wide improvements have created the capacity and opportunity to measure and compare container port performance. The data used to compile the CPPI 2022 is from S&P's Global Port Performance Program, which commenced in 2009 to drive efficiency improvements in container port operations and supporting programs to optimize port calls. It includes 10 of the world's largest liner shipping companies, which collectively operate close to 80 percent of the global container ship fleet capacity.

The liner shipping companies provide the program with a series of operational time stamps for each individual port call. The data are provided monthly and cover the full global networks of each liner shipping company and their subsidiaries. In 2022, performance time stamp data and other information for the 348 ports comprising the main index were captured for 156,813 port calls involving 243.9 million container moves. The nature, source, and scope of the data are discussed in the subsequent chapter.

The aim of CPPI was to utilize the existing empirical data to establish an unbiased metric for comparing container port performance among different ports, over time. The performance of container ports is most relevant in terms of customer experience, specifically the speed and efficiency with which customer assets are handled. In this third edition of CPPI, the focus remains exclusively on quayside performance, which reflects the experience of a container ship operator - the port's primary customer - and its fundamental value stream. The operational efficiency of how ports receive, and handle container ships is critically important in a carrier's decision to choose a port over other options.

This year, we have streamlined the computation of the CPPI using an additional method that aggregates the two methodologies used in the former editions. This will catalyze and stimulate improvements as the ranking is now more reliable, consistent, and comparable across different ports. The three methodologies employed in this study, and the justification for their use, are presented in the subsequent chapters. The results are presented in chapter 3, with further details provided in appendixes A and B.

The purpose of the CPPI is to help identify opportunities to improve a terminal or a port that will ultimately benefit all public and private stakeholders. The CPPI is intended to serve as a benchmark for important stakeholders in the global economy, including national governments, port authorities and operators, development agencies, supranational organizations, various maritime interests, and other public and private stakeholders engaged in trade, logistics, and supply chain services. The joint team from the World Bank and S&P Global Market Intelligence intends to enhance the methodology, scope, and data in future annual iterations, reflecting refinement, stakeholder feedback, and improvements in data scope and quality.

References

- Arvis, Jean-François, Lauri Ojala, Christina Wiederer, Ben Shepherd, Anasuya Raj, Karlygash Dairabayeva, and Tuomas Kiiski. 2018. Connecting to Compete 2018: Trade Logistics in the Global Economy. Washington DC: World Bank. https://openknowledge.worldbank.org/bitstream/handle/10986/29971/LPI2018.pdf.

- Clark, Ximena, David Dollar, and Alejandro Micco. 2004. "Port Efficiency, Maritime Transport Costs, and Bilateral Trade." Journal of Development Economics 75 (2): 417–450. https://doi.org/10.1016/j.jdeveco.2004.06.005.

- Hoffmann, Jan, Naima Saeed, and Sigbjørn Sødal. 2020. "Liner Shipping Bilateral Connectivity and Its Impact on South Africa's Bilateral Trade Flows." Maritime Economics & Logistics 2020, 22 (3): 473–499. DOI: 10.1057/s41278-019-00124-8.

- Kathuria, Sanjay. 2018. A Glass Half Full: The Promise of Regional Trade in South Asia. Washington DC: World Bank. https://openknowledge.worldbank.org/handle/10986/30246.

- Levinson, Marc. 2006. The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger. Princeton, New Jersey, United States: Princeton University Press.

- Micco, Alejandro, Ricardo J. Sanchez, Georgina Pizzolitto, Jan Hoffmann, Gordon Wilmsmeier, and Martin Sgut. 2003. "Port Efficiency and International Trade: Port Efficiency as a Determinant of Maritime Transport Costs." Maritime Economics & Logistics, 5 (2): 199–218. DOI:10.1057/palgrave.mel.9100073.

- UNCTAD (United Nations Conference on Trade and Development). 2021. Review of Maritime Transport 2021. Geneva: UNCTAD. https://unctad.org/webflyer/review-maritime-transport-2021.

- Wilmsmeier, Gordon, Jan Hoffmann, and Ricardo J. Sanchez. 2006. "The Impact of Port Characteristics on International Maritime Trade Costs." Research in Transportation Economics, 16 (1): 117–140. DOI:10.1016/S0739-8859(06)16006-0.

- World Bank. 2013. "Opening the Gates: How the Port of Dar es Salaam Can Transform Tanzania." Tanzania Economic Update 3, May 21, 2013. https://www.worldbank.org/en/country/tanzania/publication/opening-the-gates-how-the-port-of-dar-es-salaam-can-transform-tanzania-backup#:~:text=US%241%2C759%20million%20%E2%80%93%20the%20total,port%20of%20Dar%20es%20Salaam.

- World Bank. 2022. The Container Port Performance Index 2021: A Comparable Assessment of Container Port Performance. Washington, DC: World Bank.

2. The Approach and Methodology

Introduction

Container (liner) shipping services are generally highly structured service rotations. They are typically set up with weekly departure frequencies, a fixed sequence of port calls, and standard pro forma day and time-specific berthing windows. Once a service has been defined or adjusted, it will usually remain intact for many months, or even years. The berthing windows are pre-agreed with the terminal and port operators, usually based on a slightly higher than expected average quantity of container exchange moves, and ideally modest buffers in the sea legs between ports.

The clear advantages of this model are that shippers can make long-term supply decisions and ports and terminals schedule and balance their resources to meet expected demand. With a well-planned and well-executed pro forma schedule, they can achieve higher levels of reliability and predictability. This, in turn, can lead to more effective supply chain operations and planning as container ships spend around 15 percent to 20 percent of their total full rotation time in ports, with the balance being spent at sea. Reduced port time can allow ship operators to reduce vessel speed between port calls, thereby conserving fuel, reducing emissions, and lowering costs in the process.

Conversely, for every unplanned additional hour in port or at anchorage, the ships need to increase speed to maintain the schedule, resulting in increased fuel consumption, costs, and emissions. In extreme cases, ships that fall many hours behind their pro forma schedule will start to arrive at ports outside of their agreed windows, causing berth availability challenges for ports and terminals, particularly those with high berth utilization rates. This, in turn, causes delay to shipments and disruption to supply chains. A service recovery can involve significantly higher sailing speeds, and therefore, higher fuel consumption, emissions, and costs, or the omission of a port or ports from the service rotation.

Time is valuable for stakeholders, and so it is logical to measure port performance based on the total amount of time ships are required to spend in port. The CPPI 2022 has been developed based on the total port time in the manner explained in subsequent sections. This iteration has utilized data from the full calendar year of 2022 and has employed the same two approaches as the earlier editions, an administrative approach and a statistical approach. The resulting ranking of container port performance reflects as closely as possible actual port performance, while being statistically robust. The approaches are discussed in this chapter, with further details on the statistical methodology provided in Appendix B. The results are presented in chapter 3, and in more details in Appendix A.

The Port Performance Program

The data used to compile the CPPI is from S&P Global's Port Performance Program. The program was started in 2009 with the goal of supporting efficiency improvements in container port operations and to support projects to optimize container port calls. The program includes 10 of the world's largest liner shipping companies that collectively operate close to 80 percent of global fleet capacity.

The liner shipping companies provide the program with a series of data points comprising operational time stamps and other bits of information such as move counts for each individual port call undertaken globally. The data are provided monthly and cover the full global networks of each liner shipping company and their subsidiaries. In 2022, performance time stamp data were captured for 157,704 port calls involving 243.9 million container moves at 765 container terminals in 434 ports worldwide.

Following receipt from the shipping lines, the port call data undergo several validation and quality checks before mapping to historical AIS vessel movement data, which enables tracking and verification of the shipping line data. The geo-fencing of port and terminal zones within the AIS system supports the creation of several of the performance metrics tracked in the program. Most of the port performance metrics are constructed from the combined AIS and liner shipping data. The combination of empirical shipping line data and AIS movement data enables the construction of more accurate and granular metrics to measure container port performance. Many of the metrics consist of a time component cross-referenced with workload achieved in that time, either in the form of move counts or a specific task within the container port call process. Time stamps, definitions, and methods to calculate metrics are fully standardized in collaboration with the shipping line partners in the program.

The Automatic Identification System and Port Zoning

AIS technology is used to track and monitor vessels in near real time. It sends information on a vessel's movement, speed, direction, and other particulars via satellite and terrestrial stations. The system's function as a localized service, and indeed global tracking, was initially considered secondary. The AIS primarily functions as a navigational safety aid, to ensure the safety and efficiency of navigation, safety of life at sea, and maritime environmental protection.[1] AIS was designed for the avoidance of vessel collision, as outlined in the Safety of Life at Sea (SOLAS) Convention.[2]

All ships of net tonnage of at least 300 gross register tonnage (GRT) performing international voyages, all cargo ships of at least 500 GRT not performing international voyages, and all passenger ships, regardless of size, should be equipped with AIS. This allows vessels to automatically transfer data and a plethora of navigational and identification information to other nearby ships and relevant port authorities in the form of structured messages.[3] The technical requirements for AIS are specified by the International Telecommunication Union (ITU) Recommendation ITU-R M.1371-5(02/2014).[4]

For maritime domain awareness and safety purposes, the use of continuous 24/7, near-real-time online AIS data makes it possible to monitor areas, vessels, and routes; generate shore-based alerts; and provide useful positional and navigational information in general (IALA 2005). Satellite-based AIS receivers offer coverage outside the land-based antennas' range by covering the whole globe from pole to pole. Satellite AIS coverage can extend to the entire exclusive economic zone (EEZ) or globally, including remote coastal areas (IALA 2016).

In the case of ports[5], the usage of 'zones' helps in recording a vessel's navigational status and positioning. AIS zones offer different indicators activated automatically by the vessel's signal reporting its position. Every port has at least one zone created in a way that captures the arrivals and sailings of vessels at cargo-handling facilities but avoids spurious reports being recorded from passing traffic. Where a subject port is geographically spread out with terminals located remotely, it is likely that there will be more than one zone, with all zones linked by a standard port identification number.

Ports that straddle a river or another similar body of water will often have zones along opposing shorelines with a track separating them, thus avoiding the capture of AIS reports from traffic navigating through a fairway or channel. Once again, the individual zones will be linked to their common port using the port's unique identification number.

Zones also cover anchorages to record vessels arriving at a port but awaiting authority to enter, or vessels laid up awaiting orders. Additional zones cover the arrival of vessels at repair yards or those navigating locks. Anchorage zones may be created on an ad hoc basis. Not all ports have anchorage areas and among those that do, not all are shown in nautical charts. Whenever possible, S&P Global uses its own tracking and observation tools to determine where vessels anchor and create zones accordingly. Each anchorage zone is linked to the relevant port using the subject port's unique identification number.

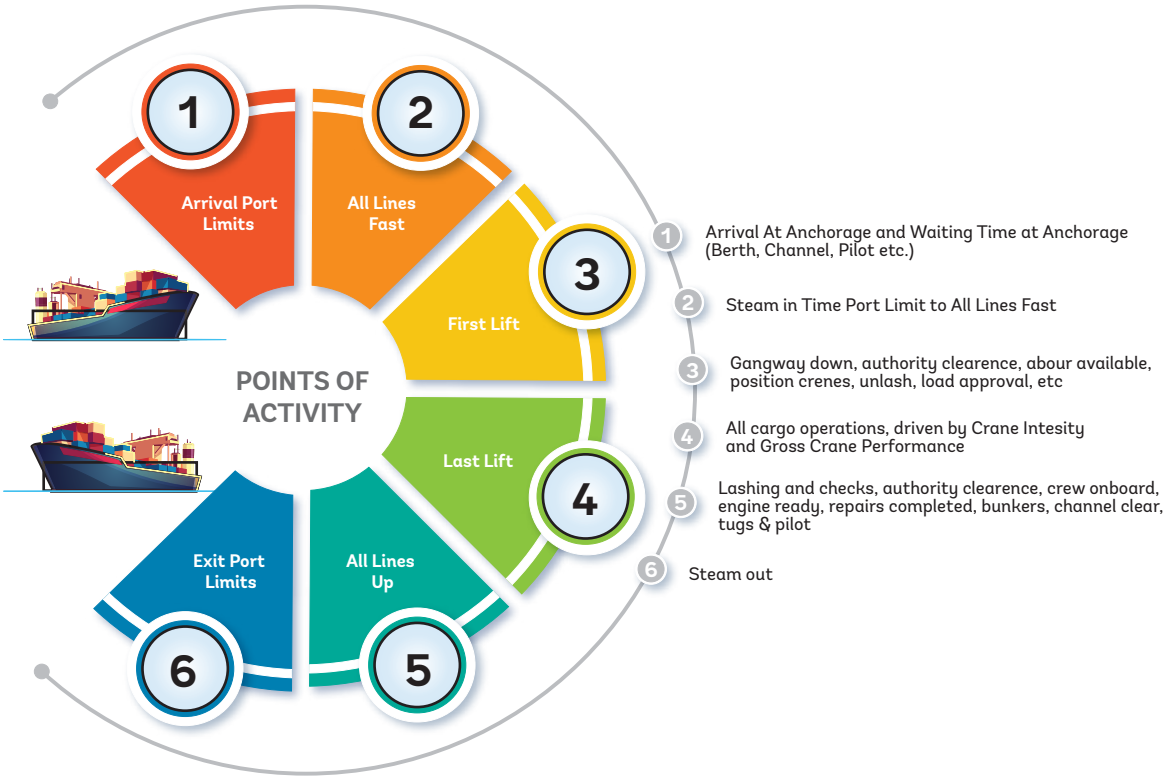
AIS is generally reliable, but it also has limitations that can impact the transmission and quality of the data captured. Some factors that may affect the signal could be the AIS transponder being turned off deliberately, problematic reception, high traffic density areas, weather conditions, or anomalous positions.

The Anatomy of a Port Call

Every container ship port call can be broken down into six distinct steps. These individual steps are illustrated in Figure 2.1. 'Total port hours' is defined as the total time elapsed between when a ship reaches a port (either port limits, pilot station, or anchorage zone, whichever event occurs first) to when it departs from the berth after having completed its cargo exchange.

The time spent from berth departure (All Lines Up) to the departure from the port limits is excluded. This is because any port performance loss that pertains to departure delays, such as pilot or tug availability, readiness of the mooring gang, channel access and water depths, forecasting completion time, communication, and ship readiness will be incurred while the ship is still alongside the berth. Additional time resulting from these causes will, therefore, be captured during the period between 4. Last Lift and 5. All Lines Up ("berth departure).

Figure 2.1 • The Anatomy of a Port Call



Source: Original figure produced for this publication

Ships may spend extra time in a port after the departure from a berth, but the time associated with these additional activities is excluded from the CPPI, as they are not influenced by the operational performance of the terminal or port. Ships may dwell within a port's limits for bunkering, repairs, or simply waiting in a safe area if they are unable to berth on arrival at their next port. Apart from bunkering being performed simultaneously with cargo operations, these causes of additional port time are not necessarily reflective of poor performance and hence, are excluded from the CPPI.

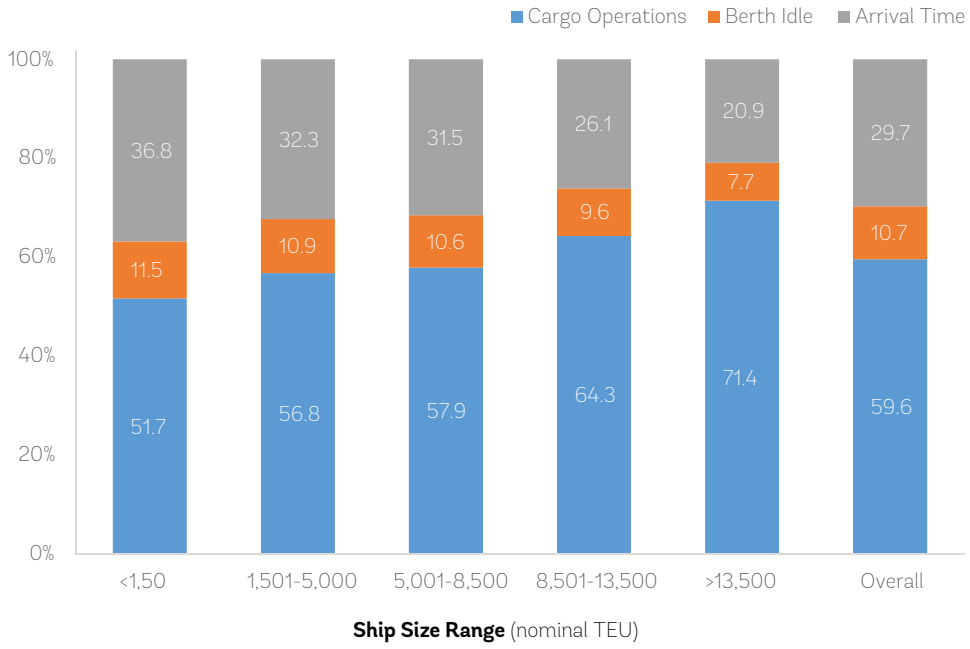
Although none of these factors necessarily indicate port inefficiency, they can contribute to additional time spent in the port. For instance, clearance authorities' delays can result in delays in the first lift and idle time after cargo operations have concluded. However, the data available do not provide enough detail to identify the root causes of such delays. It is assumed that only a small percentage of ships idle at the berth after cargo operations due to factors unrelated to port performance, and their inclusion does not significantly affect the CPPI rankings.

The other four components of the port call can logically be grouped into two distinct blocks of time. The first comprises elapsed time between Arrival Port Limits and All Lines Fast (steps 1 and 2 in Figure 2.1); the second comprises time elapsed between All Lines Fast and All Lines Up (steps 2 to 5, also commonly referred to as 'berth time' or 'berth hours'). The logic behind this division is that while there will always need to be time consumed between steps 2 and 5, the bulk of time between steps 1 and 2, excluding actual sailing in time, is waiting time, which can be eliminated.

Overall Port Time Distribution

The time stamps in the source data allow us to break down and summarize total port time into three categories: Arrival Time, Berth Idle, and Cargo Operations. Expressed as a percentage of total port hours recorded, the distribution of port time per ship size range and globally aggregated is shown in Figure 2.2.

Figure 2.2 • In-Port Time Consumption



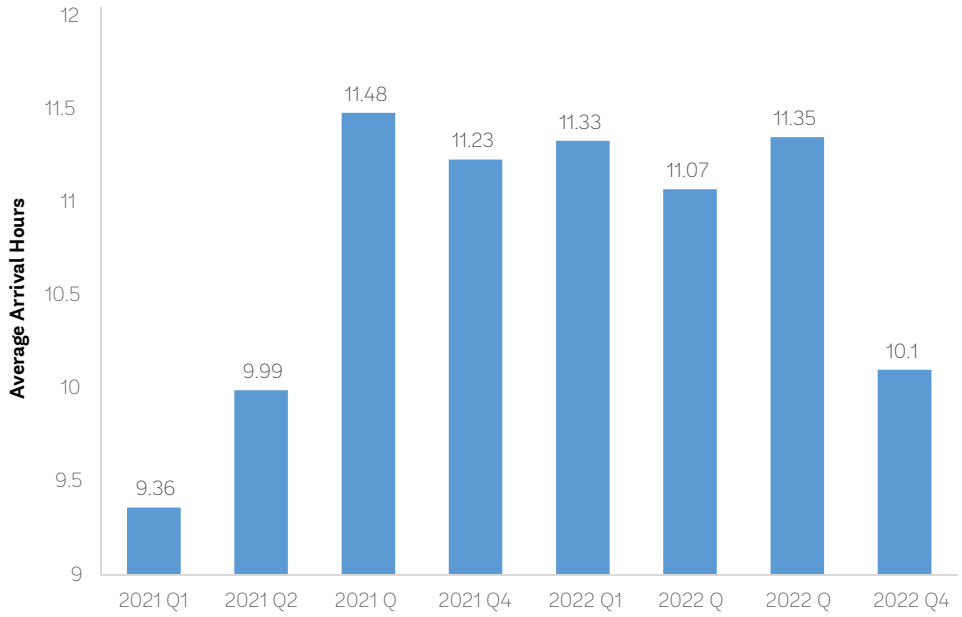
Source: Original figure produced for this publication, based on CPPI 2022 data

As there is naturally some correlation between ship size and call size, a higher percentage of time is required for cargo operations for the larger ships, and this will be explored in detail later in this report. What is interesting, and surprising at the same time is that only 60 percent of the total port time is attributable to cargo operations, meaning there is potentially a lot of 'wastage' in terms of excess time in the system.

The average duration of a port call in 2022 was 36.8 hours, which was a slight increase over the global average of 36.3 hours in 2021. About 10.8 percent (or 3.96 hours) was consumed at the berth immediately before and after cargo operations. Also known as the 'Start-Up' and 'Finish' sub-processes of a port call, each activity does not necessarily need to take more than 30 minutes to complete safely. There are 33,787 examples of Start-Up recorded as 30 minutes or less and a further 29,367 actual cases of the Finish consuming 30 minutes or less. There were 12,784 port calls in 2022 where both the Start-Up and Finish took 30 minutes or less. There is, therefore, an opportunity to eliminate almost three hours per call of port time globally simply through better planning, preparation, communication, and process streamlining. This time saved equates to more hours at sea, leading to slower sailing speeds, lower GHG emissions, and cost savings for the ship operator, which would be significant for each port call.

In the second half of 2020, there was a rebound in the global sales of durable goods, most prominently in the US, and a sharp increase in the overall container volume demand. This coincided with continued COVID-19 restrictions and resulted in the emergence of severe port congestion. In 2021, this port congestion was still manifesting itself, reaching a peak in the third quarter of 2021 and the average arrival time per port call globally remained above 11 hours until the third quarter of 2022. The fourth quarter of 2022 saw reducing volumes and many ports were able to clear backlogs and reduce average arrival times to close to 10 hours per port call. The expectation is that the average port arrival time globally in 2023 will continue to decline to levels prior to the start of 2021. (see Figure 2.3)

Figure 2.3 • Global Average Arrival Time Development



Source: Original figure produced for this publication, based on CPPI 2022 data

At a regional level and broken down by ship size groups, the change in average arrival time per region and per ship size group over the 2021-2022 period is illustrated in Table 2.1. The column 'All' shows the aggregate change in quantity of hours from arrival at port limits or start of anchorage time, to berthing for cargo operations to commence for each region, across all ship size groups.

Table 2.1 • Average Arrival Time Development per Region and Ship Size, 2021-2022

Change (Hr)	Ship Size Range					
Region	1 <1,500	2 1,501-5,000	3 5,001-8,500	4 8,501-13,500	5 >13,500	All
AFR	5.0	(10.4)	(3.7)	(7.0)	(8.8)	(8.0)
LAM	0.1	1.2	1.3	0.8	3.9	1.0
MED	0.8	1.3	1.5	1.4	5.2	1.5
MEI	8.1	(1.0)	0.3	1.4	2.6	0.6
NAM	3.1	(0.8)	11.2	6.5	10.8	6.0
NEA	(1.4)	(0.9)	0.7	(1.2)	(0.9)	(0.7)
NEU	0.2	(0.7)	3.7	5.4	2.5	1.7
OCE	8.9	1.2	2.9	(2.3)		1.8
SEA	0.4	(1.5)	(3.6)	(2.5)	0.3	(1.5)
Global	1.1	(0.7)	2.4	0.5	1.4	0.4

Source: Original table produced for this publication, based on CPPI 2022 data.

At a global level, on average each port arrival increased by 0.4 hours, as illustrated in Figure 2.3 where there were two peak quarters in 2021 compared with three in 2022. The largest increase in average arrival time was witnessed in North America (USA and Canada) with an average increase in time of 6.0 hours over all vessel sizes. By contrast, performance improved in Africa (Sub-Sahara) with an average 8.0-hour reduction in arrival time across all vessel sizes. Improvements in East Asia and Southeast Asia were also recorded.

At the ship size level, ships within the 1,501 TEU-5,000 TEU range consumed less time entering ports in 2022 compared to 2021, but the opposite was true for ships in the 5,001 TEU-8,500 TEU range where an average additional time per call of 2.4 hours was recorded.

At a port level, the top 20 most improving or deteriorating average arrival time developments are reflected in the following tables. The numbers per port and ship size range are the actual average arrival hours recorded in 2022. The comparison with 2021 is made for the average arrival hours for all ship sizes combined.

Table 2.2 • Top 20 Ports that Most Reduced Average Arrival Times, 2021-2022

	Ship Size Range									
Port	1 <1,500	2 1,501-5,000	3 5,001-8,500	4 8,501-13,500	5 >13,500	All	Calls	2021FY	Ch Hrs	Ch %
Dar Es Salaam	42.3	104.7				104.3	151	239.6	(135.30)	-56.5%
Los Angeles	2.8	20.2	22.6	26.2	36.5	24.7	634	119.3	(94.55)	-79.3%
Long Beach	21.3	117.2	13.3	17.7	18.1	27.0	282	119.3	(92.30)	-77.4%
Aden	15.2	13.1				13.8	26	60.6	(46.79)	-77.2%
Monrovia	6.7	7.2				7.0	26	53.4	(46.40)	-87.0%
Douala	35.6	38.2				37.9	189	77.1	(39.19)	-50.9%
Pointe-Noire	22.1	24.0	31.2	16.0		24.1	388	51.8	(27.70)	-53.4%
Tema	13.3	9.3	7.1	12.0	19.1	9.3	587	30.2	(20.91)	-69.3%
Luanda	18.5	29.3	44.8	71.9		32.9	291	49.8	(16.97)	-34.0%
Lome		28.0	46.2			30.9	175	43.7	(12.85)	-29.4%
Lagos (Nigeria)	3.2	4.7	7.0			4.7	192	16.9	(12.17)	-72.0%
Port Victoria		8.9				8.9	45	21.0	(12.08)	-57.6%
Yantian	38.5	10.1	11.5	14.4	10.3	11.8	2,954	21.5	(9.71)	-45.2%
Dakar	31.7	17.8	8.9			16.7	398	26.3	(9.64)	-36.6%
LAE	9.5	12.8				11.0	28	20.5	(9.44)	-46.2%
Chattogram	36.0	52.3				49.4	212	58.4	(8.95)	-15.3%
Shanghai	24.4	23.9	23.8	24.4		23.9	2,371	31.3	(7.46)	-23.8%
Haifa	9.6	6.4	5.3	2.8	12.0	7.7	734	14.7	(7.01)	-47.6%
Ngqura	37.2	21.7	18.4	12.9	2.9	18.2	213	25.0	(6.83)	-27.3%
Beirut	9.5	6.9	4.1	3.6	2.8	7.2	382	13.7	(6.53)	-47.5%

Source: Original table produced for this publication, based on CPPI 2022 data.

Table 2.3 • Top 20 Ports that Most Increased Average Arrival Times, 2021-2022

	Ship Size Range									
Port	1 <1,500	2 1,501-5,000	3 5,001-8,500	4 8,501-13,500	5 >13,500	All	Calls	2021FY	Ch Hrs	Ch %
Prince Rupert		124.6	95.0	8.3	2.1	65.6	90	13.4	52.17	389.1%
Savannah	25.3	96.1	105.2	165.5	206.3	130.4	1,115	45.11	85.03	52.9%
Houston	4.0	20.5	44.7	93.0		39.3	800	2.8	36.58	1327.3%
Charleston	5.6	21.9	35.3	54.2	58.1	37.3	1,161	6.9	30.38	437.3%
Manila	76.8	58.2	62.3			59.0	612	30.1	28.98	96.4%
Vancouver (Canada)		35.3	66.1	64.2	124.2	60.7	318	41.6	19.10	45.9%
New York & New Jersey	12.1	31.2	26.6	40.8	18.2	30.3	1,382	12.5	17.72	141.3%
Poti	26.9	27.5				26.9	69	9.6	17.30	179.3%
Cape Town		60.0	111.7	48.3		74.9	185	57.7	17.16	29.7%
La Spezia	16.4	31.9	15.7	14.9	44.8	31.1	159	14.6	16.53	113.4%
San Pedro (Cote D'ivoire)		43.1				43.1	54	27.4	15.69	57.2%
Abidjan	117.9	78.5	44.7			69.0	292	53.4	15.59	29.2%
Mersin	31.8	28.1	7.6	16.2	8.4	25.6	885	10.5	15.15	144.3%
Mombasa	24.8	19.2	18.2			19.8	254	4.6	15.13	325.9%
Qingdao	33.3	27.5	29.0	33.0	18.6	27.4	2,705	12.8	14.64	114.5%
Trieste	16.8	18.6	32.2	22.8	37.4	22.9	353	8.6	14.31	166.6%
Napier	61.9	26.5	35.4			31.1	144	17.1	14.07	82.4%
Hamburg	12.0	16.7	26.1	27.2	35.7	22.8	1,670	10.5	12.32	117.0%
Koper	15.5	18.1	77.0	20.1	39.0	21.1	462	8.8	12.30	139.6%
Acajutla	53.7	18.3				19.1	43	8.2	10.92	133.7%

Source: Original table produced for this publication, based on CPPI 2022 data.

Both Los Angeles and Long Beach dramatically reduced their average arrival times. This might have been at the expense of six of the seven ports with the highest quantity of additional hours incurred and could potentially be the result of cargo and ship re-routings.

The overall improvements and reductions in average arrival hours in African ports has been driven by Dar Es Salaam, Monrovia, Douala, Pointe-Noire, Tema, Luanda, Lomé, Lagos, Port Victoria, Dakar, and Ngqura. The increase is slightly offset by increased average arrival time in Cape Town, San Pedro, Abidjan, and Mombasa. In East Asia, improvements were seen in Yantian and Yangshan but countered by increased time in Manila and Qingdao. There are no European ports in the top 20 improvers. Poti, La Spezia, Mersin, Trieste, Hamburg, and Koper all experienced longer average arrival times.

Waiting time, defined as the period between 'Arrival Port Limits' or when the ship enters an anchorage zone, and 'All Lines Fast' can generally be regarded as wasted time. As such, in the construction of the CPPI, one possibility was to apply a penalty to waiting time. The decision was taken not to do so, as the introduction of a penalty of this type would be a normative judgement inconsistent with the overall aim of the study to create bean objective quantitative index.

There was consideration as to whether to apply a discount to waiting time for the smallest segment of ships. Smaller ships generally suffer less priority than larger ones, and in some hub ports might be purposely idled at anchorage waiting to load cargo which is arriving from off-schedule ocean going ships. However, after reviewing average arrival time for the various ship size segments on a regional basis, the data did not support applying a discount to waiting time for the smallest segment of ships. (see Table 2.4).

Table 2.4 • Average Arrival Time Performance per Ship Size Range per Region

2022	Ship Size Range					
Region	<1,500	1,501-5,000	5,001-8,500	8,501-13,500	>13,500	Average
AFR	27.8	27.6	32.9	20.0	13.7	27.8
LAM	8.0	7.3	8.7	7.7	10.5	7.7
MED	9.7	8.3	7.1	7.3	11.1	8.7
MEI	13.6	7.4	5.7	6.7	7.2	7.2
NAM	9.2	17.3	31.7	43.7	54.2	30.8
NEA	6.3	8.2	8.4	7.1	6.1	7.6
NEU	8.8	8.0	13.5	15.0	16.9	11.7
OCE	17.4	14.3	14.2	8.6		13.9
SEA	10.2	10.2	6.5	6.2	4.3	8.7
Average	10.1	10.2	12.9	11.6	10.6	10.9

Source: Original table produced for this publication, based on CPPI 2022 data.

Regions that host major hub ports, and where smaller sized ships expended more time to arrive than the average of all ships, are the Mediterranean, the Middle East, India, and Southeast Asia. Further study reveals that the following hub ports in these regions did record significantly higher average arrival times for smaller ships versus the average for all vessel sizes.

Table 2.5 • Smaller Vessel Average Arrival Times

Port	Arrival Hours (ships < 1,500 TEU)	Arrival Hours (ships > 1,500 TEU	Additional Arrival Hours (as a percentage)	Original Overall Rank	Overall Rank after Simulation
Jeddah	40.2	8.8	+ 357.6%	28	27
King Abdullah	7.8	3.9	+ 101.4%	16	16
Khalifa Port	9.3	5.5	+ 68.6%	3	4
Singapore	10.4	6.3	+ 63.9%	19	20
Marsaxlokk	15.5	9.6	+ 61.3%	42	43
Tanger-Mediterranean	9.7	6.3	+ 54.4%	5	6

Source: Original table produced for this publication, based on CPPI 2022 data.

To test the significance of purposely delayed smaller feeder vessels on the overall ranking, we conducted a simulation within the overall CPPI model. For all ports (not only the focus ports), we reduced the quantity of arrival hours by 50 percent for all ship calls where the capacity of the ship is 1,500 TEU or less in size. The quantity of berth hours for all ships was maintained at 100 percent, as was the average arrival hours for all other ship size groups.

Table 2.5 displays the original overall rank without any adjustment to feeder ship arrival hours. The last column presents what the overall rank would have been with 50 percent of arrival hours for ships of 1,500 TEU or less capacity eliminated. The conclusion from the simulation is that such an adjustment does not materially alter the overall CPPI 2022 rankings, and four of the six focus ports dropped in rankings during the simulation (Khalifa Port, Singapore, Marsaxlokk, and Tanger-Mediterranean), although only by one place.

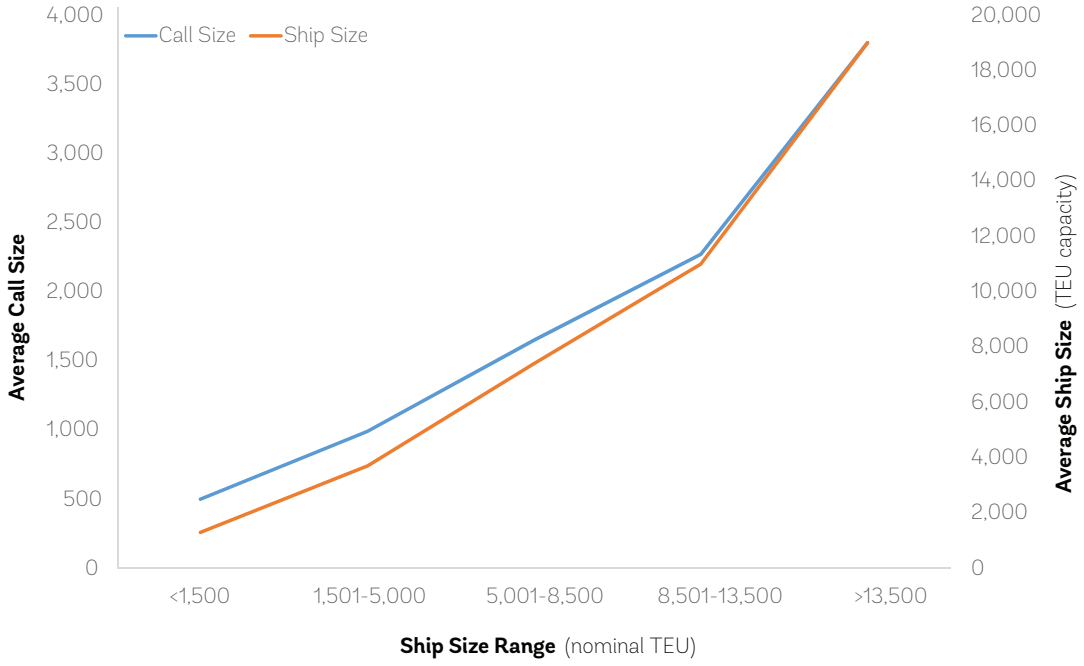
Since it is not possible to see from the data whether waiting time is voluntary or forced, it is difficult to find a suitable level at which to discount waiting time in this scenario. The port calls of ships with less than 1,500 TEUs of capacity comprise just 10 percent of the total calls in the CPPI. Therefore, the disparity in waiting times between ships with less than 1,500 TEUs of nominal capacity and other segments, as simulated, has only a small impact to the overall CPPI. To keep the data pure and avoid normative judgment that is inconsistent with an objective quantitative index, the rankings published in this iteration are not influenced by adjustments made to empirically recorded port hours.

The Significance of Call Size

As illustrated in Figure 2.2, over 60 percent of a port call is consumed through cargo operations, for the handling of containers. In this aspect of the call, call size is of great significance. Call size is far less significant when it comes to arrival time, which is more likely to be influenced by ship size.

There have been several earlier studies, in which ships are grouped into size segments (ranges) based upon their size or capacity and port calls are ranked based on the time elapsed in port or on the berth. While these studies provide an indication, the optimum outcome requires the workload for each call to be taken into consideration. In this index, workload is represented by 'Call Size,' defined as the total quantity of containers (regardless of size), which were physically discharged, loaded, or restowed during a port call.

Figure 2.4 • The Aggregated Correlation between Ship and Call Size



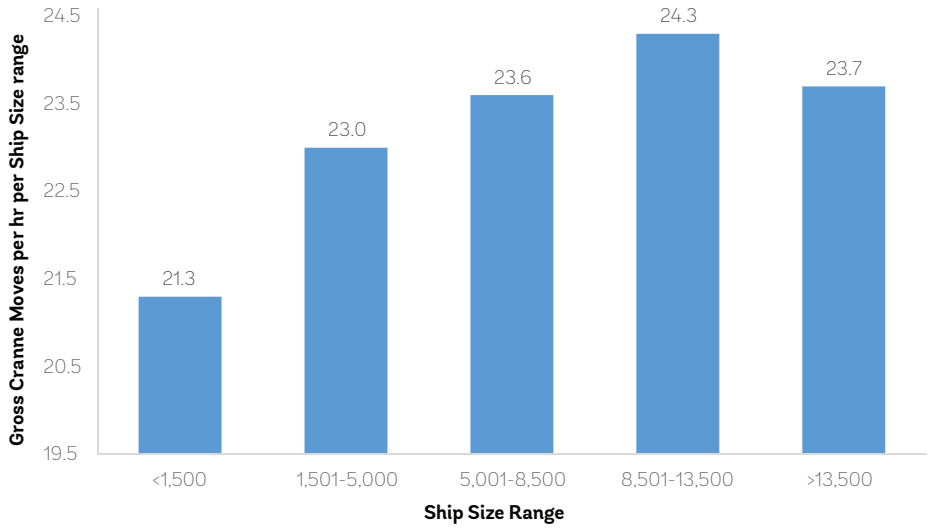
Source: Original figure produced for this publication, based on CPPI 2022 data

Although there will be some level of correlation between the ship and call size, it is not a perfect correlation. For example, an 18,000 TEU capacity ship calling at a port in Thailand or southern Vietnam might exchange 1,000-2,000 containers per call, but that same ship in Yangshan or Singapore might exchange more than 4,000 containers. Similarly, in the Thai or southern Vietnamese ports, a 3,000 TEU ('feeder' ship) might exchange more than 3,000 containers, potentially twice that of an 18,000 TEU mainline ship at the same port.

The 60 percent of a port call, during which containers are exchanged, is influenced by two sub-factors:

1. The quantity of cranes deployed
2. The speed at which the cranes, especially the long crane (the crane with the highest workload in terms of cycles), operate

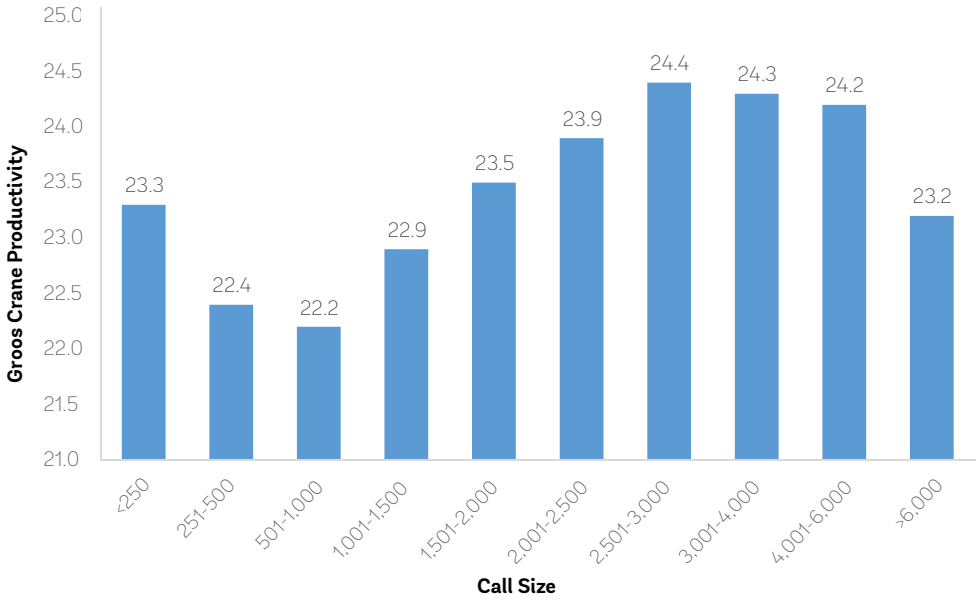
Figure 2.5 • Container Moves Performed per gross Crane Hour across Various Ship Sizes



Source: Original figure produced for this publication, based on CPPI 2022 data

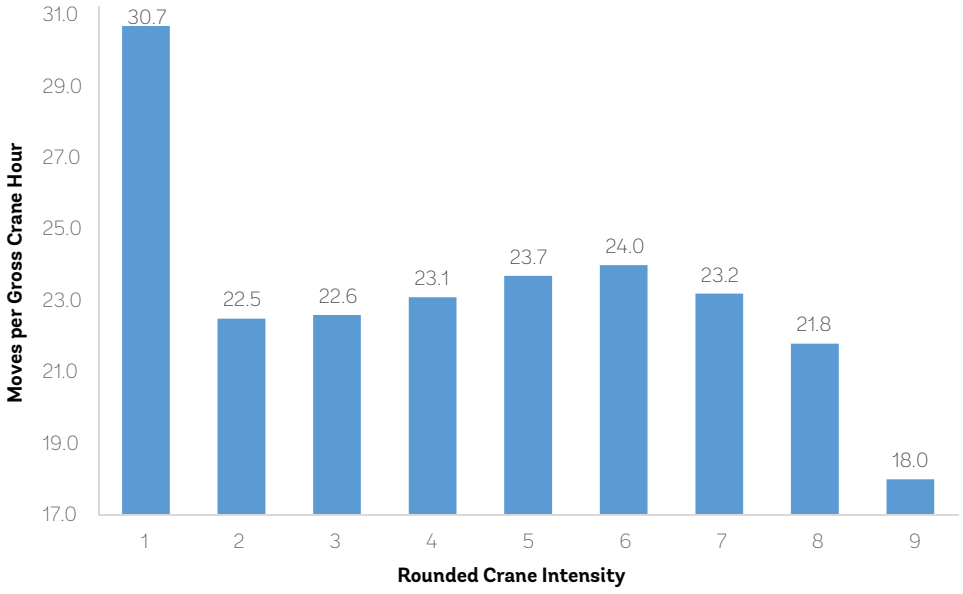
The variation in containers handled per gross crane hour across all ship sizes is statistically minor. The global average for all ships is 23.5 moves per hour, so the smallest ships are 9.4 percent less efficient than the average, whereas ships in the 8,501 TEU-13,500 TEU range are 3.6 percent more efficient than the average. It is often implied that larger ships are more difficult to work, but the data says otherwise. On the larger ships, the crane operator has higher hoists and longer trolley distances, which increases cycle time, but this is offset by more moves per bay and hatch, resulting in more containers handled per gantry or hatch-cover move. The smaller ships can often encounter list or trim issues, making it harder for the operator to hit the cell-guides and the hatch-cover and lashing systems.

Figure 2.6 • Gross Crane Productivity by Call Size



Source: Original figure produced for this publication, based on CPPI 2022 data

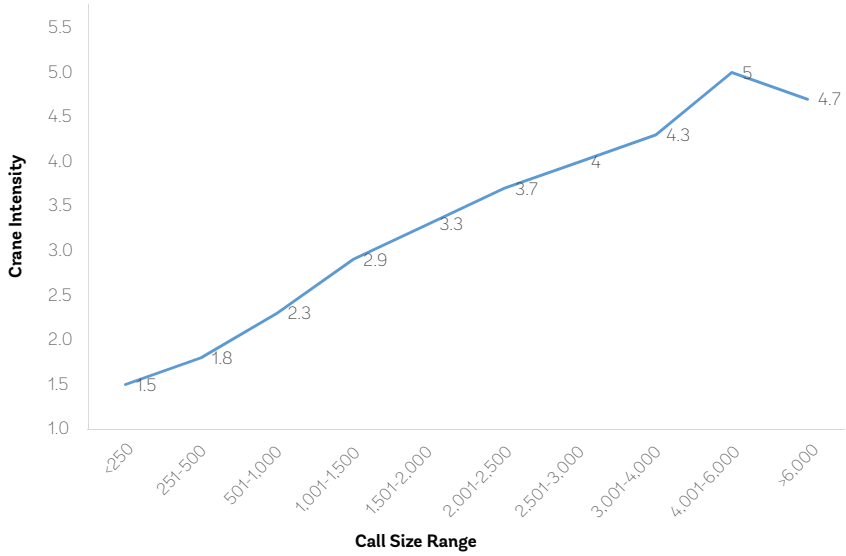
Figure 2.7 • Crane Productivity by Crane Intensity



Source: Original figure produced for this publication, based on CPPI 2022 data

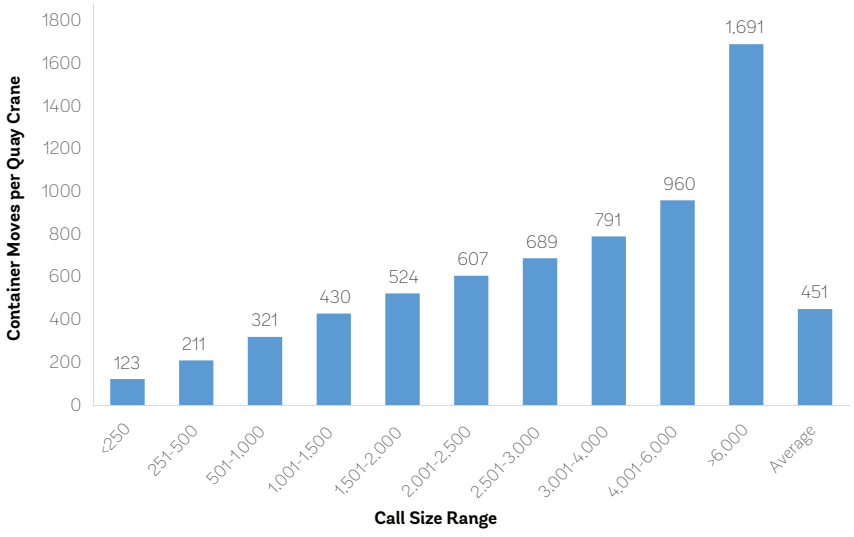
A review of gross crane productivity versus call size and crane intensity reveals no strong increases or decreases through the ranges. Assessed on call size ranges, there is a -5.2 percent to 3.8 percent variation to the average. Meanwhile, an assessment of crane intensity reveals that the first and last segments have extremely high and low performances, respectively, but in the mid-range, there is little difference in crane productivity across the seven ranges. This implies that crane speed (productivity) does not gradually increase (or decrease) as ship size, call size, or crane intensity increases. It is therefore statistically not a key determinant of operating hours. The far more significant influencer of operating time is the quantity of cranes deployed (crane intensity).

Figure 2.8 • Call Size versus Crane Intensity



Source: Original figure produced for this publication, based on CPPI 2022 data

Figure 2.9 • Average Moves per Crane



Source: Original figure produced for this publication, based on CPPI 2022 data

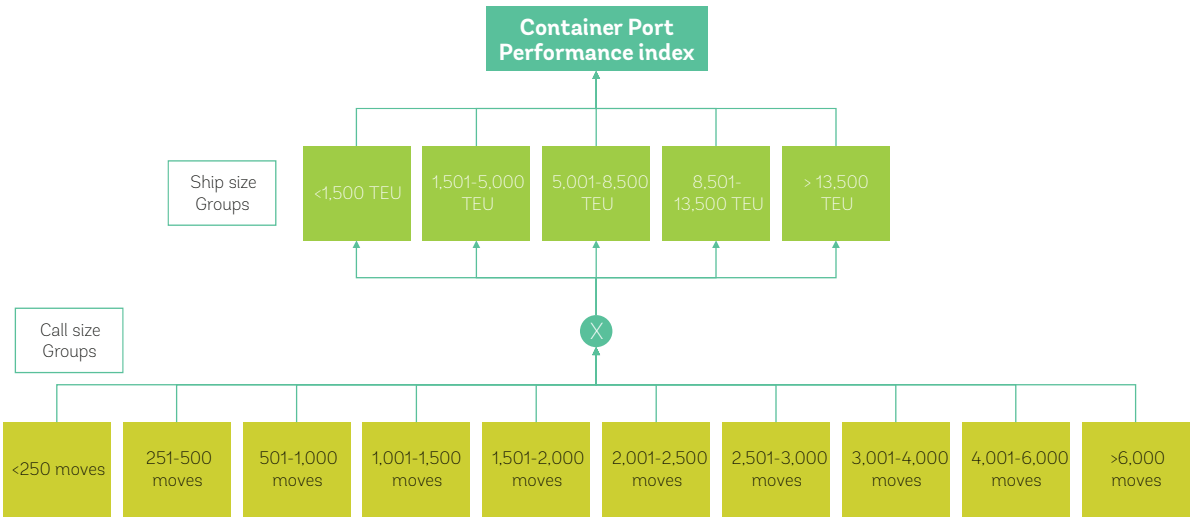
As might be expected, the more container moves are to be handled, the more cranes must be deployed. However, crane intensity lags call size growth, which means that as the call size grows, each crane is required to handle more containers. Theoretically, if a call with 1,000 moves was assigned 2 cranes, then one with 5,000 moves would require 10 cranes for a status quo, and that does not happen often, if at all. Since the exchange rate per crane does not increase progressively with ship size, call size, or crane intensity growth, the overall operating time increases. This makes call size differentiation the critical factor to consider when attempting port performance benchmarking and ranking.

Construction of the CPPI

Moving on to the construction of the CPPI, for a port to qualify for inclusion in the CPPI it must have registered at least 24 valid port calls where port hours can be calculated within the full calendar year. Of the 434 ports for which S&P Global received port call information, 348 are included in the main index of CPPI 2022. There were 156,813 distinct port calls recorded in the data over the period at those 348 main ports. A further 86 ports registered less than 24 calls each, accumulatively accounting for 891 port calls (0.6 percent of the total), these ports are excluded from the CPPI 2022.

The CPPI is based solely on the average port hours per port call, with port hours being the total time elapsed from when a ship first entered a port to when it departed from the berth. Due to the large volume of data, it was possible and prudent to break it down into ship size and call size groups or ranges. However, too much fragmentation would have diluted the data to the extent that more assumptions than actual empirical data would be present in the index. Therefore, the data was grouped into five distinct ship sizes, and then within each ship size group by call size group, as reflected in Figure 2.10 below.

Figure 2.10 • The Structure of the CPPI



Source: Original figure produced for this publication

The number of ship size groups was limited to five, and the number of call size groups to 10. That results in a 50 (5 x 10) matrix for the qualifying ports for the main index of CPPI 2022. However, there were insufficient port calls in the larger five call size groups for the less than 1,500 TEU ship size group and similarly for the two larger call size groups for the 1,501 TEU-5,000 TEU ship size group. In total, the data was distributed into 43 ship-call size groups.

Table 2.6 • Port Calls Distribution

	Call Size Group									
Ship Size Group	<250	251-500	501-1000	1001-1500	1501-2000	2001-2500	2501-3000	3001-4000	4001-6000	>6000
1 <1,500	20.5%	37.2%	36.9%	5.0%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%
2 1,501-5,000	6.1%	20.1%	36.0%	20.1%	9.9%	4.7%	1.8%	1.1%	0.2%	0.0%
3 5,001-8,500	1.3%	6.5%	20.9%	23.1%	18.6%	12.0%	7.2%	6.8%	2.9%	0.6%
4 8,501-13,500	0.8%	4.0%	13.8%	16.7%	15.0%	13.7%	10.9%	13.4%	8.4%	3.3%
5 >13,500	0.2%	0.9%	4.6%	7.1%	8.7%	9.6%	9.5%	18.8%	26.5%	14.1%

Source: Original table produced for this publication, based on CPPI 2022 data.

The five ship size groups were based on where they might be deployed and the similarities of ships within each group. Although a sixth group for ships more than 18,000 TEU or 24,000 TEU could have been added, it would have highly diluted the data in the two larger ship size groups.

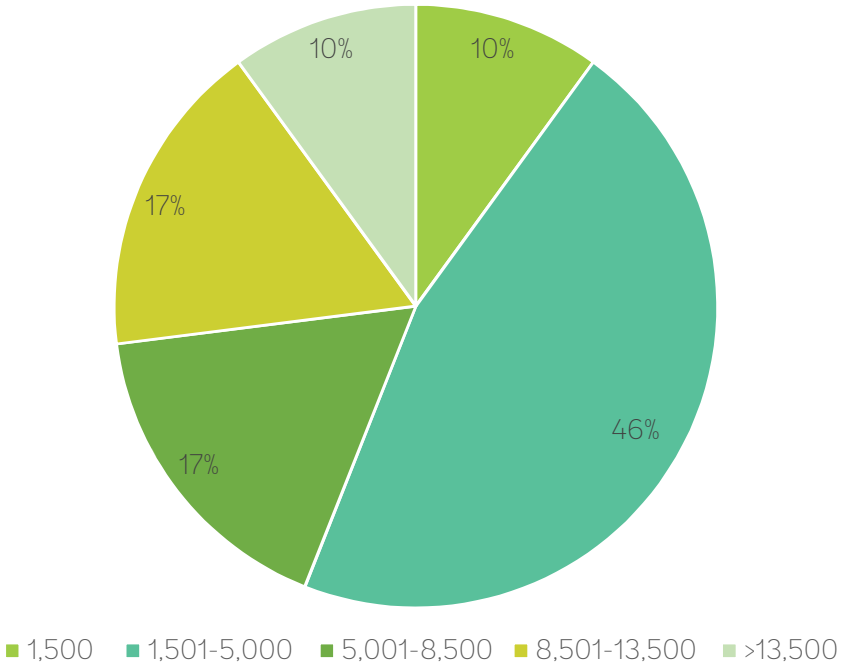
Table 2.7 • Ship Size Group Definitions

Nominal TEU Capacity Range	Description
Less than 1,500	Almost exclusively feeder vessels, often connecting small outlying ports with regional hub ports. Some intra-regional services will also have ships in this size range.
1,500 to 5,000	A vast quantity of these classic Panamax ships are deployed on intra-regional trades. They are found on North-South trades to and from Africa, Latin America, and Oceania, as well as Transatlantic services.
5,000 to 8,500	Vessels within this size group are mainly deployed on the North-South trade lanes. Vessel cascading and improving port capabilities has seen them start to emerge as stock vessels for Africa, Latin America, and Oceania trades. There is some presence on Transatlantic and Asia–Middle East trades as well.
8,500 to 13,500	These Neo-Panamax vessels are largely deployed on East-West trades, particularly Trans-Pacific, both to North America's west coast as well as via either the Panama or Suez Canals to North America's east coast. They also feature on Asia–Middle East trades, with some deployed on Asia–Mediterranean rotations.
Greater than 13,500	These ultra-large container ships (ULCS) are mainly deployed on Asia–Europe (serving both North Europe and the Mediterranean) and Asia–United States trades, especially on Trans-Pacific services calling at North America's west coast ports.

Source: Original table produced for this publication, based on CPPI 2022 data.

The application of ship size groups is less important than call size groups, particularly since the call data is already split into 10 call size groups. However, the objective of the CPPI is to highlight through comparison the performance gaps and opportunities to save fuel and reduce emissions. The analysis should, therefore, consider that the larger the ship, the more fuel it consumes, and the higher the potential to save fuel and reduce emissions.

Figure 2.11 • Percentage of Port Calls per Ship Size Group - 2022



Source: Original figure produced for this publication, based on CPPI 2022 data

Almost 50 percent of all ship port calls in 2022 were from the Panamax (1,501-5,000 TEU) size of ships. With just 10 percent of port calls made by ships more than 13,500 TEU, it was decided not to disaggregate these further. As the main participants of the Port Performance Program are primarily deep-sea operators, there was a relatively small number of calls in the feeder segment (less than 1,500 TEU capacity).

An attempt has been made to make the 10 call size groups as narrow as possible by grouping together calls in instances where they are most likely to have received similar crane intensity provisions. The analysis then compares all qualifying ports on how close (or far) the individual call size is to the average call size within each call size group.

Table 2.8 • Call Size Sensitivity

Call Size Sensitivity	Call Size Group									
	<250	251-500	501-1000	1001-1500	1501-2000	2001-2500	2501-3000	3001-4000	4001-6000	>6000
Average	179	381	736	1,234	1,732	2,228	2,735	3,445	4,785	8,061
Median	188	386	730	1,226	1,725	2,222	2,727	3,420	4,638	7,065
Lower Range	160	328	620	1,042	1,466	1,888	2,318	2,907	3,942	6,005
Upper Range	216	443	839	1,410	1,984	2,555	3,136	3,933	5,334	8,125
Total Ports	290	338	339	289	244	211	183	163	116	65
Within Range	220	318	304	280	244	211	183	162	114	52
Percentage in Range	75.9%	94.1%	89.7%	96.9%	100.0%	100.0%	100.0%	99.4%	98.3%	80.0%

Source: Original table produced for this publication, based on CPPI 2022 data

To assess the sensitivity within each call size group across all 348 qualifying ports, the median call size between all ports within a call size group was taken and a tolerance range of 15 percent above and below the median created (see Table 2. 8). In the six call size groups from the 1,001–1,500 to 4,001–6,000 moves groups, more than 96.9 percent of ports have an average call size well within this tolerance range.

Beyond the threshold of 6,000 moves per call, the call size has a much lower impact on crane intensity. This is because the number of cranes that can be deployed is limited by the overall number of cranes available or stowage splits. The quantity of ports with an average call size within the tolerance range in the three smallest call size groups is not as high as the quantity in the six call size groups from the 1,001–1,500 to 4,001–6,000 moves groups. However, for ports with an average call size above the tolerance range, it would be possible to increase crane intensity to match the slightly higher call sizes, and, therefore, the conclusion is that objective comparisons can be made within all 10 call size groups.

Imputing Missing Values: the Administrative Approach

The handicap of missing values can be addressed in two different ways in the administrative approach and the statistical approach. The former involves assigning values to empty categories based on data that are available when a port has registered a data point within a specific ship size range.

Table 2.9 • Quantity of Ports Included per Ship Size Group

Ship Size Range	Quantity of Ports Included	Base Call Size
Less than 1,500 TEUs	276	251–500
1,500–5,000 TEUs	330	501–1,000
5,000–8,500 TEUs	220	1,001–1,500
8,500–13,500 TEUs	178	1,501–2,000
More than 13,500 TEUs	105	3,001–4,000

Source: Original table produced for this publication, based on CPPI 2022 data

For each ship size group, the call size group that has the largest quantity of data representation is selected (see Table 2.9) as the Base Call Size group. Ideally, this is a mid-range call size group because the lowest and highest groups can demonstrate some uniqueness. In cases where there is no actual data for the base call size group, the next highest group is examined to find an actual data set. If none is found, then the approach involves looking at the immediately lower call size band. At the end of this exercise, every port has a value assigned for the base call size group.

Imputing vessel arrival values. Where a call size group does not have an arrival hours value, it is populated using the overall average arrival time for all vessels registered at that port across all call size groups within each specific ship size group. This is logical as call size is a less important determinant of waiting time than ship size.

Imputing berth hours. From the base call size group, moving left toward the lowest group and right toward the highest group, in groups where no value exists, a value is determined on a pro rata basis given the adjacent call size group value, actual data or imputed. The rationale is that if within one call size group a port has either higher or lower berth hours than the average, the adjacent call size group too is likely to show similar trends.

Table 2.10 provides an example. In this case, port A had a higher quantity of hours in the base call size group than the group average. It is assumed that would also have been the case had the port registered actual calls in the 501–1,000 and 1,501–2,000 call size groups. The opposite is true for port B, which achieved a lower quantity of hours in the base call size group. The calculation for port A in the 501–1,000 call size group is actual hours within the group 1,001–1,500 (12.0) multiplied by the group average factor (0.9) for a prorated quantity of average berth hours of (10.8).

Table 2.10 • Example of Imputing Missing Values

Port	Call Size Group		
	501–1,000	1,001–1,500	1,501–2,000
Port A	10.8	12.0	14.4
Port B	7.2	8.0	9.6
Group Average	9.0	10.0	12.0
Factor Multiplier	0.9	Base	1.2

Source: Original table produced for this publication, based on CPPI 2022 data

Note: The numbers in the green highlighted cells have been imputed by multiplying the base cells by the factor multiplier determined by the overall group average.

The inherent risk with this approach is that poor or good performance within just one group will cascade across all call size groups. It also assumes that a port can add cranes to larger call size groups, which might not be true in all cases. On the other hand, it would be illogical to assume that any port would simply achieve the average of the entire group or that a port performing below average in one call size group would perform much better than average in others where it did not record any actual calls.

Imputing Missing Values: the Statistical Approach

A more rigorous approach is used for the statistical approach through the use of a likelihood-based method to impute those missing values. With respect of the current data set, the expectation-maximization (EM) algorithm can be utilized to provide a maximum-likelihood estimator for each missing value. This approach relies on two critical assumptions: The first one is that the missing values are random, that is, it is not due to some bias in the sample selection; and the second one is that the variables under consideration are all normally distributed. These assumptions are not considered unrealistic in the context of the data set. EM then computes the maximum likelihood estimator for the mean and variance of the normal distribution given the observed data. Knowing the distribution that generates the missing data, one can then sample from it to impute the missing values.[6]

Constructing the CPPI 2022 Index Using a Ranking Aggregation Method

The CPPI has in previous iterations utilized two distinct methodologies: the administrative, or technical approach that employs expert knowledge and judgment to produce a practical methodology, and a statistical approach that utilizes factor analysis (FA). CPPI 2022 goes a step further to aggregate the two rankings to produce one index that to present the performance of ports via both methodologies.

Borda-type approach for index aggregation

Rank aggregation, that is the process of combining multiple rankings into a single ranking, is an important problem arising in many areas (Langville and Meyer 2012). For example, in a ranked voting system, citizens rank candidates in their order of preference and a single winner needs to be determined. Similarly, recommender systems and search engines can produce many different rankings of items that are likely to be of interest to a given user. Such rankings can naturally be aggregated to produce a more robust list of items (Pappa et al. 2020).

Many strategies were proposed in the literature to combine several rankings into one that is as consistent as possible with the individual rankings (Langville and Meyer 2012, Fagin et al. 2003, Dwork et al. 2001, Dwork et al. 2012, Oliveira et al. 2020) and references therein. The Borda count (Langville and Meyer 2012, Chapter 14) provides a simple and effective approach for aggregating rankings, wherein each item to rank is given points according to the number of items it outranks in its segment. These points are added and then used to produce a new ranking. Our approach to combine the administrative and the statistical rankings is inspired by the Borda count, but also considers the index values for attributing the number of points.

The process is as follows: First, each index is scaled to take values into the interval [0,1]. This is accomplished by applying the following linear transformation:

$$f(x) = \frac{x}{M-m} - \frac{m}{M-m},$$

where m is the minimum value of the index and M the maximum value. Observe that the port with the smallest index is always given a scaled value of 0 and the port with largest index a scaled value of 1. The other ports get a scaled value between 0 and 1. Once the indices are scaled, they are added to produce a combined index. Finally, a ranking is obtained by sorting the ports according to the combined index in decreasing order. Thus, the port with the largest combined index is ranked first and the port with the smallest combined index is ranked last.

Table 2.11 • An Example of Aggregated Rankings for Four Ports with Randomly Generated Administrative and Statistical Index Values

Ports	Administrative Index	Statistical Index	Scaled Administrative Index	Scaled Statistical Index	Combined Index	Final Ranking
Port 1	1.45	1.97	1.000	1.000	2.000	1
Port 2	1.26	1.21	0.678	0.392	1.070	3
Port 3	1.23	1.31	0.627	0.472	1.099	2
Port 4	0.86	0.72	0.000	0.000	0.000	4

Source: Original table produced for this publication, based on CPPI 2022 data.

For example, the scaled administrative index value of Port 2 (x = 1.26) is computed as follows: the minimum and maximum values of the administrative index are m = 0.86 and M = 1.45. Thus, the scaled value is

$$f(x) = \frac{1.26}{1.45-0.86} - \frac{0.86}{1.45-0.86} = 0.678$$

References

- Langville, Amy N., and Carl D. Meyer. Who's# 1?: the Science of Rating and Ranking. Princeton University Press, 2012.
- Fagin, Ronald, Ravi Kumar, and Dakshinamurthi Sivakumar. Comparing Top k lists. SIAM Journal on Discrete Mathematics 17, no. 1 (2003): 134-160.
- Dwork, Cynthia, Ravi Kumar, Moni Naor, and D. Sivakumar. Rank Aggregation Revisited. (2001): 613-622.
- Dwork, Cynthia, Ravi Kumar, Moni Naor, and Dandapani Sivakumar. Rank Aggregation Methods for the Web. In Proceedings of the 10th International Conference on World Wide Web, pp. 613-622. 2001.
- Ali, Alnur, and Marina Meilă. Experiments with Kemeny Ranking: What Works When? Mathematical Social Sciences 64, no. 1 (2012): 28-40.
- Oliveira, Samuel EL, Victor Diniz, Anisio Lacerda, Luiz Merschmanm, and Gisele L. Pappa. Is Rank Aggregation Effective in Recommender Systems? An Experimental Analysis. ACM Transactions on Intelligent Systems and Technology (TIST) 11, no. 2 (2020): 1-26.

3. The Container Port Performance Index 2022

Introduction

The rankings of container port performance, based on the ranking aggregation approach, are presented in this chapter. The following section presents the rankings for the top 100 best performing container ports, with the full rankings of all ports by both approaches presented in Appendix A. The subsequent sections present a summary by region and port throughput (large, medium, small), so ports in the same region, or with the same throughput within broad categories, can be easily compared.

The CPPI 2022

Table 3.1 presents the rankings of container port performance in the CPPI 2022. It reflects the aggregation of the scores from the results from the administrative approach and the statistical approach in the manner described in the previous section.

In the aggregate index, the two top-ranked container ports in the CPPI 2022 are Yangshan Port (China) in first place, followed by the Port of Salalah (Oman) in second place. These two ports occupy the same positions in the rankings generated by the constituent approaches. The Port of Salalah was ranked second in both approaches in CPPI 2021, while the Yangshan Port ranked third and fourth in the statistical and administrative approaches, respectively, in CPPI 2021.

Three ports in the Middle East have secured positions among the top 10 spots. Three of the large Chinese gateways–Shanghai (Yangshan), Ningbo, and the southern port of Guangzhou–maintained places in the top 10. Of the top 10 ranked ports, nine have either maintained or improved their position since CPPI 2021. The exception is Hamad Port, which moved down five and three places (provide the rankings, sincethey're specified for Yokohama and Jeddah) in the administrative and statistical rankings, respectively. Yokohama fell from the 10th and 12th ranks in CPPI 2021 to the 15th in CPPI 2022, and Jeddah fell from the 8th (provide both administrative and statistical rankings) to 29th.

There are 14 new entrants to the CPPI 2022, and several significant gainers in terms of ranking. Over 110 ports improved their rankings in CPPI 2022 over CPPI 2021, with some of the largest gainers moving up more than 200 positions. In contrast, 200 ports fell in the CPPI 2022 rankings, some falling nearly 260 positions, which is 40 positions fewer than the biggest fall in the previous CPPI edition.

Table 3.1 • The CPPI 2022

Port Name	Overall Ranking	Port Name	Overall Ranking
Yangshan	1	Jeddah	29
Salalah	2	Pipavav	30
Khalifa Port	3	Dammam	31
Tanger-Mediterranean	4	Coronel	32
Cartagena (Colombia)	5	Xiamen	33
Tanjung Pelepas	6	Barcelona	34
Ningbo	7	Callao	35
Hamad Port	8	Port Klang	36
Guangzhou	9	Incheon	37
Port Said	10	Jebel Ali	38
Hong Kong	11	Fuzhou	39
Cai Mep	12	Marsaxlokk	40
Shekou	13	Yarimca	41
Mawan	14	Dalian	42
Yokohama	15	Lazaro Cardenas	43
Algeciras	16	Wilmington (USA-N Carolina)	44
King Abdullah Port	17	Kobe	45
Singapore	18	Nagoya	46
Posorja	19	Shimizu	47
Tianjin	20	Mundra	48
Buenaventura	21	Sohar	49
Busan	22	Rio Grande (Brazil)	50
Yeosu	23	Piraeus	51
Chiwan	24	Port Of Virginia	52
Kaohsiung	25	Yantian	53
Djibouti	26	Tokyo	54
Laem Chabang	27	Altamira	55
Colombo	28	Haifa	56

Port Name	Overall Ranking
Ambarli	57
Jubail	58
Aqaba	59
Bremerhaven	60
Itapoa	61
Zeebrugge	62
Da Chan Bay Terminal One	63
Krishnapatnam	64
Zhoushan	65
Antwerp	66
Rio De Janeiro	67
Savona-Vado	68
Boston (USA)	69
Keelung	70
Santa Cruz De Tenerife	71
Paranagua	72
Khalifa Bin Salman	73
Siam Seaport	74
Diliskelesi	75
Balboa	76
Shantou	77
Kattupalli	78

Port Name	Overall Ranking
Kamarajar	79
Osaka	80
Colon	81
Jacksonville	82
Lianyungang	83
Karachi	84
Hazira	85
Jawaharlal Nehru Port	86
Puerto Limon	87
Cochin	88
Port Everglades	89
Muhammad Bin Qasim	90
Johor	91
Penang	92
Aarhus	93
Puerto Cortes	94
Fort-De-France	95
Pointe-A-Pitre	96
Tanjung Perak	97
Philadelphia	98
Veracruz	99
Nemrut Bay	100

Source: Original table produced for this publication, based on CPPI 2022 data

The CPPI 2022 shows reduced discrepancies between the two approaches compared to its previous edition. In CPPI 2022, 40 percent of all ports (140 ports) are ranked within three places or less from themselves in the dual rankings (a 2 percent improvement). In CPPI 2021, 38 percent of all ports (139 ports) are ranked within three places or less from themselves in the dual rankings (a 20 percent improvement). In CPPI 2020, just under 18 percent of all ports (61 ports) were ranked within three places or less from themselves in the dual rankings. The reduction in discrepancies contributes significantly to having a well-balanced aggregated index.

Ranking by Region

This section presents an overview of the outcomes from the CPPI 2022 report. The first edition of CPPI was modified based on requests for the presentation of results and rankings by region and throughput for an improved comparison of ports within the same region and those with similar throughput. The subsequent sections include a concise tabulation of the results and ranking (from Table 3.2) for the designated regions.

- North America (United States and Canada)
- Central America, South America, and the Caribbean Region
- West, Central, and South Asia (Saudi Arabia to Bangladesh)
- East Asia (Myanmar to Japan)
- Oceania (Australia, New Zealand, and the Pacific Islands)
- Sub-Saharan Africa
- Europe and North Africa

Table 3.2 • The CPPI by Region: North America

Port Name	Region	Overall Ranking
Wilmington (USA-N Carolina)	NAM	44
Port Of Virginia	NAM	52
Boston (USA)	NAM	69
Jacksonville	NAM	82
Port Everglades	NAM	89
Philadelphia	NAM	98
New Orleans	NAM	113
Port Tampa Bay	NAM	145
Apra Harbor	NAM	203
Miami	NAM	217
Saint John	NAM	233
Mobile	NAM	238
Hueneme	NAM	242
Halifax	NAM	278
Seattle	NAM	279
Montreal	NAM	292
Baltimore (USA)	NAM	300
New York & New Jersey	NAM	306

Port Name	Region	Overall Ranking
Tacoma	NAM	314
Houston	NAM	335
Los Angeles	NAM	336
Charleston	NAM	340
Prince Rupert	NAM	342
Oakland	NAM	343
Long Beach	NAM	346
Vancouver (Canada)	NAM	347
Savannah	NAM	348

Source: Original table produced for this publication, based on CPPI 2022 data

Table 3.3 • The CPPI by Region: Central America, South America, and the Caribbean Region

Port Name	Region	Overall Ranking
Cartagena (Colombia)	Lac	5
Posorja	Lac	19
Buenaventura	Lac	21
Coronel	Lac	32
Callao	Lac	35
Lazaro Cardenas	Lac	43
Rio Grande (Brazil)	Lac	50
Altamira	Lac	55
Itapoa	Lac	61
Rio De Janeiro	Lac	67
Paranagua	Lac	72
Balboa	Lac	76
Colon	Lac	81
Puerto Limon	Lac	87
Puerto Cortes	Lac	94
Fort-De-France	Lac	95
Pointe-A-Pitre	Lac	96
Veracruz	Lac	99
Paita	Lac	101
Ensenada	Lac	105
Imbituba	Lac	108
Santos	Lac	114
Pecem	Lac	116
Puerto Barrios	Lac	119

Port Name	Region	Overall Ranking
Salvador	Lac	120
Puerto Quetzal	Lac	129
San Juan	Lac	130
Santa Marta	Lac	131
Lirquen	Lac	141
Puerto Bolivar (Ecuador)	Lac	147
Caucedo	Lac	148
Rio Haina	Lac	158
Puerto Progreso	Lac	162
Barranquilla	Lac	164
Gustavia	Lac	167
Philipsburg	Lac	169
Vitoria	Lac	170
Buenos Aires	Lac	174
Suape	Lac	178
Sepetiba	Lac	182
Valparaiso	Lac	188
Vila Do Conde	Lac	190
Mariel	Lac	209
Caldera (Costa Rica)	Lac	211
La Guaira	Lac	212
Nassau	Lac	229
Point Lisas Ports	Lac	232
Manaus	Lac	236

Port Name	Region	Overall Ranking
Arica	Lac	237
Port Of Spain	Lac	239
Itajai	Lac	240
San Antonio	Lac	253
Puerto Cabello	Lac	255
San Vicente	Lac	257
Corinto	Lac	259
Santo Tomas De Castilla	Lac	263
Kingston (Jamaica)	Lac	266

Port Name	Region	Overall Ranking
Mejillones	Lac	272
Manzanillo (Mexico)	Lac	282
Guayaquil	Lac	283
Iquique	Lac	284
Antofagasta	Lac	286
Acajutla	Lac	288
Montevideo	Lac	304
Cristobal	Lac	305
Freeport (Bahamas)	Lac	317

Source: Original table produced for this publication, based on CPPI 2022 data

Table 3.4 • The CPPI by Region: West, Central, and South Asia (Saudi Arabia to Bangladesh)

Port Name	Region	Overall Ranking
Salalah	WCSA	2
Khalifa Port	WCSA	3
Hamad Port	WCSA	8
King Abdullah Port	WCSA	17
Colombo	WCSA	28
Jeddah	WCSA	29
Pipavav	WCSA	30
Dammam	WCSA	31
Jebel Ali	WCSA	38
Mundra	WCSA	48
Sohar	WCSA	49
Jubail	WCSA	58
Aqaba	WCSA	59
Krishnapatnam	WCSA	64
Khalifa Bin Salman	WCSA	73
Kattupalli	WCSA	78
Kamarajar	WCSA	79
Karachi	WCSA	84
Hazira	WCSA	85
Jawaharlal Nehru Port	WCSA	86
Cochin	WCSA	88
Muhammad Bin Qasim	WCSA	90
Chennai	WCSA	110

Port Name	Region	Overall Ranking
Visakhapatnam	WCSA	115
Shuaiba	WCSA	121
Sharjah	WCSA	127
Shuwaikh	WCSA	142
Umm Qasr	WCSA	165
Aden	WCSA	262
Chattogram	WCSA	307

Source: Original table produced for this publication, based on CPPI 2022 data

Table 3.5 • The CPPI by Region: East Asia (Myanmar to Japan)

Port Name	Region	Overall Ranking
Yangshan	EAS	1
Tanjung Pelepas	EAS	6
Ningbo	EAS	7
Guangzhou	EAS	9
Hong Kong	EAS	11
Cai Mep	EAS	12
Shekou	EAS	13
Mawan	EAS	14
Yokohama	EAS	15
Singapore	EAS	18
Tianjin	EAS	20
Busan	EAS	22
Yeosu	EAS	23
Chiwan	EAS	24
Kaohsiung	EAS	25
Laem Chabang	EAS	27
Xiamen	EAS	33
Port Klang	EAS	36
Incheon	EAS	37
Fuzhou	EAS	39
Dalian	EAS	42
Kobe	EAS	45
Nagoya	EAS	46
Shimizu	EAS	47
Yantian	EAS	53
Tokyo	EAS	54
Da Chan Bay Terminal One	EAS	63

Port Name	Region	Overall Ranking
Zhoushan	EAS	65
Keelung	EAS	70
Siam Seaport	EAS	74
Shantou	EAS	77
Osaka	EAS	80
Lianyungang	EAS	83
Johor	EAS	91
Penang	EAS	92
Tanjung Perak	EAS	97
Yokkaichi	EAS	102
Naha	EAS	104
Cat Lai	EAS	107
Hakata	EAS	109
Danang	EAS	117
Saigon	EAS	124
Taichung	EAS	125
Tanjung Emas	EAS	132
Omaezaki	EAS	133
Batangas	EAS	135
Moji	EAS	136
Haiphong	EAS	140
Cebu	EAS	143
Quy Nhon	EAS	146
Chu Lai	EAS	155
Cagayan De Oro	EAS	156
Qingdao	EAS	171
Subic Bay	EAS	193

Port Name	Region	Overall Ranking	Port Name	Region	Overall Ranking
Tomakomai	EAS	208	Bangkok	EAS	243
Belawan	EAS	214	Davao	EAS	251
Shanghai	EAS	215	Tanjung Priok	EAS	281
Panjang	EAS	228	Manila	EAS	329

Source: Original table produced for this publication, based on CPPI 2022 data

Table 3.6 • The CPPI by Region: Oceania (Australia, New Zealand, and the Pacific Islands)

Port Name	Region	Overall Ranking
Noumea	OCE	128
Papeete	OCE	139
Wellington	OCE	153
Bluff	OCE	191
Bell Bay	OCE	192
Nelson	OCE	204
Timaru	OCE	250
Melbourne	OCE	273
Lae	OCE	274
Otago Harbour	OCE	276
Adelaide	OCE	277
Brisbane	OCE	287
Port Botany	OCE	299
Fremantle	OCE	310
Lyttelton	OCE	313
Napier	OCE	322
Auckland	OCE	323
Tauranga	OCE	325

Source: Original table produced for this publication, based on CPPI 2022 data

Table 3.7 • The CPPI by Region: Sub-Saharan Africa

Port Name	Region	Overall Ranking
Djibouti	SSA	26
Berbera	SSA	144
Conakry	SSA	189
Dakar	SSA	196
Matadi	SSA	197
Tema	SSA	205
Mogadiscio	SSA	221
Beira	SSA	223
Freetown	SSA	226
Toamasina	SSA	227
Takoradi	SSA	245
Maputo	SSA	248
Port Victoria	SSA	249
Lagos (Nigeria)	SSA	260
Mayotte	SSA	267
Monrovia	SSA	271
Owendo	SSA	275
Port Elizabeth	SSA	291
Walvis Bay	SSA	293
Douala	SSA	295
San Pedro (Cote D'ivoire)	SSA	296
Port Reunion	SSA	298
Onne	SSA	302
Tin Can Island	SSA	308
Dar Es Salaam	SSA	312
Pointe-Noire	SSA	315
Lome	SSA	318
Kribi Deep Sea Port	SSA	324
Mombasa	SSA	326
Port Louis	SSA	327
Cotonou	SSA	330
Nouakchott	SSA	331
Abidjan	SSA	333
Luanda	SSA	337
Ngqura	SSA	338
Durban	SSA	341
Cape Town	SSA	344

Source: Original table produced for this publication, based on CPPI 2022 data

Table 3.8 • The CPPI by Region: Europe and North Africa

Port Name	Region	Overall Ranking
Tanger-Mediterranean	ENA	4
Port Said	ENA	10
Algeciras	ENA	16
Barcelona	ENA	34
Marsaxlokk	ENA	40
Yarimca	ENA	41
Piraeus	ENA	51
Haifa	ENA	56
Ambarli	ENA	57
Bremerhaven	ENA	60
Zeebrugge	ENA	62
Antwerp	ENA	66
Savona-Vado	ENA	68
Santa Cruz De Tenerife	ENA	71
Diliskelesi	ENA	75
Aarhus	ENA	93
Nemrut Bay	ENA	100
Limassol	ENA	103
Malaga	ENA	106
Gemlik	ENA	111
Mersin	ENA	112
Wilhelmshaven	ENA	118
Gothenburg	ENA	122
Gioia Tauro	ENA	123
Port Akdeniz	ENA	126
Gijon	ENA	134
Izmir	ENA	137
Vigo	ENA	138
Fredericia	ENA	149
Odessa	ENA	150
Helsingborg	ENA	151
Cadiz	ENA	152
Nantes-St Nazaire	ENA	154
Ancona	ENA	157
Casablanca	ENA	159
Bar	ENA	160
Ravenna	ENA	161
Salerno	ENA	163
Oslo	ENA	166

Port Name	Region	Overall Ranking
Borusan	ENA	168
El Dekheila	ENA	172
Damietta	ENA	173
Leixoes	ENA	175
Brest	ENA	176
Latakia	ENA	177
Larvik	ENA	179
Burgas	ENA	180
Norrkoping	ENA	181
Muuga-Port Of Tallinn	ENA	183
Bari	ENA	184
Civitavecchia	ENA	185
Sines	ENA	186
Copenhagen	ENA	187
Novorossiysk	ENA	194
Klaipeda	ENA	195
Catania	ENA	198
Palermo	ENA	199
Rauma	ENA	200
Heraklion	ENA	201
Kristiansand	ENA	202
Bilbao	ENA	206
Trapani	ENA	207
Rades	ENA	210
Bordeaux	ENA	213
Lisbon	ENA	216
Marseille	ENA	218
Tripoli (Lebanon)	ENA	219
Helsinki	ENA	220
Kotka	ENA	222
Alicante	ENA	224
Gdynia	ENA	225
Batumi	ENA	230
Riga	ENA	231
Teesport	ENA	234
Southampton	ENA	235
Varna	ENA	241
St Petersburg	ENA	244
Venice	ENA	246

Port Name	Region	Overall Ranking
Gavle	ENA	247
Agadir	ENA	252
Durres	ENA	254
Bejaia	ENA	256
Dublin	ENA	258
London	ENA	261
Felixstowe	ENA	264
Rotterdam	ENA	265
Alexandria (Egypt)	ENA	268
Sokhna	ENA	269
Naples	ENA	270
Iskenderun	ENA	280
Tarragona	ENA	285
Gdansk	ENA	289
Poti	ENA	290

Port Name	Region	Overall Ranking
Constantza	ENA	294
Ashdod	ENA	297
Valencia	ENA	301
Qasr Ahmed	ENA	303
Livorno	ENA	309
Dunkirk	ENA	311
Genoa	ENA	316
Le Havre	ENA	319
Beirut	ENA	320
Thessaloniki	ENA	321
Hamburg	ENA	328
La Spezia	ENA	332
Rijeka	ENA	334
Trieste	ENA	339
Koper	ENA	345

Source: Original table produced for this publication, based on CPPI 2022 data

Ranking by Throughput

This section presents the CPPI 2022 by throughput. It offers a summary tabulation (from Table 3.9) by throughput using the following defined ranges:

- Large: more than 4 million TEUs per year
- Medium: between 0.5 million and 4 million TEUs per year
- Small: less than 0.5 million TEUs per year

Table 3.9 • The CPPI by Throughput: Large Ports (More than 4 million TEUs per Year)

Port Name	Region	Overall Ranking
Yangshan	Large	1
Salalah	Large	2
Khalifa Port	Large	3
Tanger-Mediterranean	Large	4
Tanjung Pelepas	Large	6
Ningbo	Large	7
Guangzhou	Large	9
Hong Kong	Large	11

Port Name	Region	Overall Ranking
Cai Mep	Large	12
Shekou	Large	13
Algeciras	Large	16
Singapore	Large	18
Tianjin	Large	20
Busan	Large	22
Chiwan	Large	24
Kaohsiung	Large	25

Port Name	Region	Overall Ranking
Laem Chabang	Large	27
Colombo	Large	28
Jeddah	Large	29
Xiamen	Large	33
Port Klang	Large	36
Jebel Ali	Large	38
Dalian	Large	42
Mundra	Large	48
Piraeus	Large	51
Yantian	Large	53
Tokyo	Large	54
Bremerhaven	Large	60
Zhoushan	Large	65
Antwerp	Large	66
Colon	Large	81
Lianyungang	Large	83
Jawaharlal Nehru Port	Large	86

Port Name	Region	Overall Ranking
Tanjung Perak	Large	97
Cat Lai	Large	107
Santos	Large	114
Saigon	Large	124
Qingdao	Large	171
Shanghai	Large	215
Rotterdam	Large	265
Kingston (Jamaica)	Large	266
Tanjung Priok	Large	281
Valencia	Large	301
New York & New Jersey	Large	306
Hamburg	Large	328
Manila	Large	329
Los Angeles	Large	336
Long Beach	Large	346
Savannah	Large	348

Source: Original table produced for this publication, based on CPPI 2022 data

Table 3.10 • The CPPI by Throughput: Medium Ports (between 0.5 million and 4 million TEUs per Year)

Port Name	Region	Overall Ranking
Cartagena (Colombia)	Medium	5
Hamad Port	Medium	8
Port Said	Medium	10
Mawan	Medium	14
Yokohama	Medium	15
King Abdullah Port	Medium	17
Posorja	Medium	19
Buenaventura	Medium	21
Yeosu	Medium	23
Djibouti	Medium	26
Pipavav	Medium	30
Dammam	Medium	31
Barcelona	Medium	34
Callao	Medium	35
Incheon	Medium	37
Fuzhou	Medium	39

Port Name	Region	Overall Ranking
Marsaxlokk	Medium	40
Lazaro Cardenas	Medium	43
Wilmington (USA-N Carolina)	Medium	44
Kobe	Medium	45
Nagoya	Medium	46
Shimizu	Medium	47
Sohar	Medium	49
Rio Grande (Brazil)	Medium	50
Port Of Virginia	Medium	52
Altamira	Medium	55
Haifa	Medium	56
Ambarli	Medium	57
Jubail	Medium	58
Aqaba	Medium	59
Zeebrugge	Medium	62
Da Chan Bay Terminal One	Medium	63

Port Name	Region	Overall Ranking
Krishnapatnam	Medium	64
Rio De Janeiro	Medium	67
Savona-Vado	Medium	68
Boston (USA)	Medium	69
Keelung	Medium	70
Paranagua	Medium	72
Siam Seaport	Medium	74
Diliskelesi	Medium	75
Balboa	Medium	76
Shantou	Medium	77
Kattupalli	Medium	78
Osaka	Medium	80
Jacksonville	Medium	82
Karachi	Medium	84
Hazira	Medium	85
Cochin	Medium	88
Port Everglades	Medium	89
Muhammad Bin Qasim	Medium	90
Johor	Medium	91
Penang	Medium	92
Aarhus	Medium	93
Veracruz	Medium	99
Limassol	Medium	103
Naha	Medium	104
Hakata	Medium	109
Chennai	Medium	110
Gemlik	Medium	111
Mersin	Medium	112
New Orleans	Medium	113
Danang	Medium	117
Wilhelmshaven	Medium	118
Gothenburg	Medium	122
Gioia Tauro	Medium	123
Taichung	Medium	125
Sharjah	Medium	127
Santa Marta	Medium	131
Tanjung Emas	Medium	132
Izmir	Medium	137
Vigo	Medium	138

Port Name	Region	Overall Ranking
Papeete	Medium	139
Haiphong	Medium	140
Shuwaikh	Medium	142
Cebu	Medium	143
Berbera	Medium	144
Puerto Bolivar (Ecuador)	Medium	147
Caucedo	Medium	148
Odessa	Medium	150
Wellington	Medium	153
Ancona	Medium	157
Casablanca	Medium	159
Umm Qasr	Medium	165
Oslo	Medium	166
El Dekheila	Medium	172
Damietta	Medium	173
Buenos Aires	Medium	174
Leixoes	Medium	175
Latakia	Medium	177
Civitavecchia	Medium	185
Sines	Medium	186
Valparaiso	Medium	188
Conakry	Medium	189
Subic Bay	Medium	193
Novorossiysk	Medium	194
Klaipeda	Medium	195
Dakar	Medium	196
Catania	Medium	198
Palermo	Medium	199
Apra Harbor	Medium	203
Tema	Medium	205
Bilbao	Medium	206
Rades	Medium	210
La Guaira	Medium	212
Belawan	Medium	214
Miami	Medium	217
Marseille	Medium	218
Helsinki	Medium	220
Mogadiscio	Medium	221
Kotka	Medium	222

Port Name	Region	Overall Ranking
Gdynia	Medium	225
Freetown	Medium	226
Toamasina	Medium	227
Panjang	Medium	228
Batumi	Medium	230
Teesport	Medium	234
Southampton	Medium	235
Manaus	Medium	236
Mobile	Medium	238
Port Of Spain	Medium	239
Itajai	Medium	240
Varna	Medium	241
Bangkok	Medium	243
St Petersburg	Medium	244
Takoradi	Medium	245
Venice	Medium	246
Gavle	Medium	247
Timaru	Medium	250
Davao	Medium	251
Agadir	Medium	252
San Antonio	Medium	253
Durres	Medium	254
Puerto Cabello	Medium	255
Bejaia	Medium	256
Dublin	Medium	258
Lagos (Nigeria)	Medium	260
London	Medium	261
Aden	Medium	262
Santo Tomas De Castilla	Medium	263
Felixstowe	Medium	264
Alexandria (Egypt)	Medium	268
Sokhna	Medium	269
Naples	Medium	270
Monrovia	Medium	271
Melbourne	Medium	273
Owendo	Medium	275
Otago Harbour	Medium	276
Adelaide	Medium	277
Halifax	Medium	278

Port Name	Region	Overall Ranking
Seattle	Medium	279
Iskenderun	Medium	280
Manzanillo (Mexico)	Medium	282
Guayaquil	Medium	283
Iquique	Medium	284
Brisbane	Medium	287
Acajutla	Medium	288
Gdansk	Medium	289
Poti	Medium	290
Port Elizabeth	Medium	291
Montreal	Medium	292
Constantza	Medium	294
Douala	Medium	295
San Pedro (Cote D'ivoire)	Medium	296
Ashdod	Medium	297
Port Reunion	Medium	298
Port Botany	Medium	299
Baltimore (USA)	Medium	300
Onne	Medium	302
Qasr Ahmed	Medium	303
Montevideo	Medium	304
Cristobal	Medium	305
Chattogram	Medium	307
Tin Can Island	Medium	308
Livorno	Medium	309
Fremantle	Medium	310
Dar Es Salaam	Medium	312
Lyttelton	Medium	313
Tacoma	Medium	314
Pointe-Noire	Medium	315
Genoa	Medium	316
Freeport (Bahamas)	Medium	317
Lome	Medium	318
Le Havre	Medium	319
Beirut	Medium	320
Napier	Medium	322
Auckland	Medium	323
Tauranga	Medium	325
Mombasa	Medium	326

Port Name	Region	Overall Ranking
Port Louis	Medium	327
Cotonou	Medium	330
La Spezia	Medium	332
Abidjan	Medium	333
Houston	Medium	335
Luanda	Medium	337
Ngqura	Medium	338
Trieste	Medium	339

Port Name	Region	Overall Ranking
Charleston	Medium	340
Durban	Medium	341
Prince Rupert	Medium	342
Oakland	Medium	343
Cape Town	Medium	344
Koper	Medium	345
Vancouver (Canada)	Medium	347

Source: Original table produced for this publication, based on CPPI 2022 data

Table 3.11 • The CPPI by Throughput: Small Ports (Less than 0.5 million TEUs per Year)

Port Name	Region	Overall Ranking
Coronel	Small	32
Yarimca	Small	41
Itapoa	Small	61
Santa Cruz De Tenerife	Small	71
Khalifa Bin Salman	Small	73
Kamarajar	Small	79
Puerto Limon	Small	87
Puerto Cortes	Small	94
Fort-De-France	Small	95
Pointe-A-Pitre	Small	96
Philadelphia	Small	98
Nemrut Bay	Small	100
Paita	Small	101
Yokkaichi	Small	102
Ensenada	Small	105
Malaga	Small	106
Imbituba	Small	108
Visakhapatnam	Small	115
Pecem	Small	116
Puerto Barrios	Small	119
Salvador	Small	120
Shuaiba	Small	121
Port Akdeniz	Small	126
Noumea	Small	128
Puerto Quetzal	Small	129
San Juan	Small	130

Port Name	Region	Overall Ranking
Omaezaki	Small	133
Gijon	Small	134
Batangas	Small	135
Moji	Small	136
Lirquen	Small	141
Port Tampa Bay	Small	145
Quy Nhon	Small	146
Fredericia	Small	149
Helsingborg	Small	151
Cadiz	Small	152
Nantes-St Nazaire	Small	154
Chu Lai	Small	155
Cagayan De Oro	Small	156
Rio Haina	Small	158
Bar	Small	160
Ravenna	Small	161
Puerto Progreso	Small	162
Salerno	Small	163
Barranquilla	Small	164
Gustavia	Small	167
Borusan	Small	168
Philipsburg	Small	169
Vitoria	Small	170
Brest	Small	176
Suape	Small	178
Larvik	Small	179

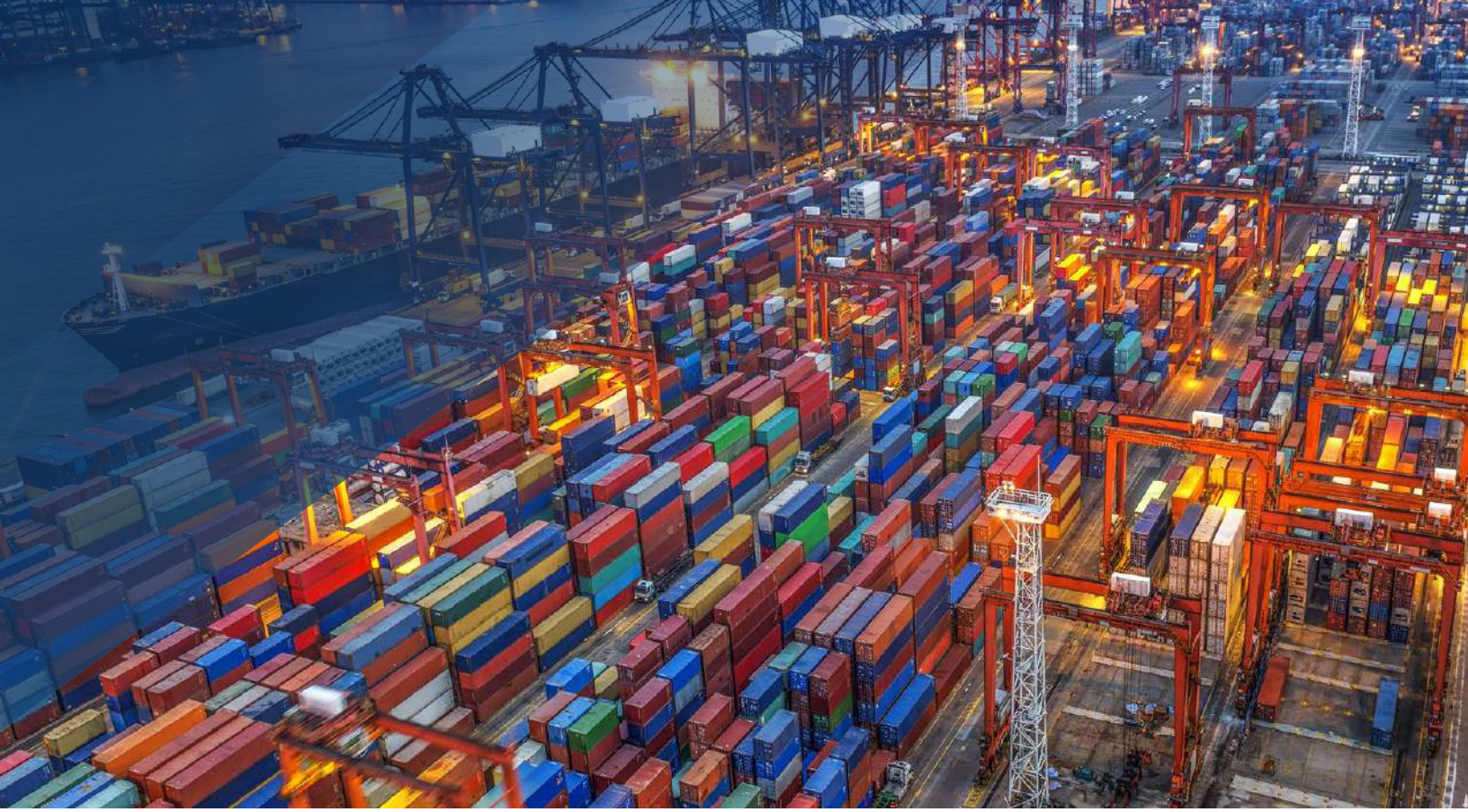
Port Name	Region	Overall Ranking	Port Name	Region	Overall Ranking
Burgas	Small	180	Alicante	Small	224
Norrkoping	Small	181	Nassau	Small	229
Sepetiba	Small	182	Riga	Small	231
Muuga-Port Of Tallinn	Small	183	Point Lisas Ports	Small	232
Bari	Small	184	Saint John	Small	233
Copenhagen	Small	187	Arica	Small	237
Vila Do Conde	Small	190	Hueneme	Small	242
Bluff	Small	191	Maputo	Small	248
Bell Bay	Small	192	Port Victoria	Small	249
Matadi	Small	197	San Vicente	Small	257
Rauma	Small	200	Corinto	Small	259
Heraklion	Small	201	Mayotte	Small	267
Kristiansand	Small	202	Mejillones	Small	272
Nelson	Small	204	Lae	Small	274
Trapani	Small	207	Tarragona	Small	285
Tomakomai	Small	208	Antofagasta	Small	286
Mariel	Small	209	Walvis Bay	Small	293
Caldera (Costa Rica)	Small	211	Dunkirk	Small	311
Bordeaux	Small	213	Thessaloniki	Small	321
Lisbon	Small	216	Kribi Deep Sea Port	Small	324
Tripoli (Lebanon)	Small	219	Nouakchott	Small	331
Beira	Small	223	Rijeka	Small	334

Source: Original table produced for this publication, based on CPPI 2022 data.

4. Conclusions and Next Steps

The primary objective of developing the CPPI by utilizing existing empirical data was to create an impartial benchmark to assess and compare container port performance across different ports, over time. This was done to facilitate the identification of gaps and opportunities for improvement in a standardized manner, which could ultimately benefit all stakeholders, including shipping lines, national governments, and consumers. The CPPI was intended to serve as a crucial point of reference for various stakeholders in the global economy, such as port authorities and operators, national governments, development agencies, supranational organizations, and other public and private entities involved in trade, logistics, and supply chain services.

In the future, the CPPI is expected to undergo further refinement in subsequent editions, incorporating stakeholder feedback, advancements in data scope and quality, and additional trend analysis. The World Bank-S&P Global Market Intelligence team will continue to improve the methodologies, expand the scope by potentially including more ports, and enhance the data. The next version, CPPI 2023, will be comparable to the current edition, facilitating trend analysis of container port performance across the aggregate index. Specifically, subsequent releases will also contain indices aggregated from the statistical and administrative approaches. CPPI 2022 considers the dissimilarities between the two approaches while simultaneously gaining a deeper understanding of the vital factors that affect container port performance. The goal remains to identify opportunities for improvement to benefit all stakeholders, including ports, shipping lines, governments, line agencies, businesses, and consumers.



Appendix A: The CPPI 2022

Table A.1. • Aggregated Rankings Using Borda-type Approach

Port Name	Overall Ranking	Port Name	Overall Ranking
Yangshan	1	King Abdullah Port	17
Salalah	2	Singapore	18
Khalifa Port	3	Posorja	19
Tanger-Mediterranean	4	Tianjin	20
Cartagena (Colombia)	5	Buenaventura	21
Tanjung Pelepas	6	Busan	22
Ningbo	7	Yeosu	23
Hamad Port	8	Chiwan	24
Guangzhou	9	Kaohsiung	25
Port Said	10	Djibouti	26
Hong Kong	11	Laem Chabang	27
Cai Mep	12	Colombo	28
Shekou	13	Jeddah	29
Mawan	14	Pipavav	30
Yokohama	15	Dammam	31
Algeciras	16	Coronel	32

Port Name	Overall Ranking
Xiamen	33
Barcelona	34
Callao	35
Port Klang	36
Incheon	37
Jebel Ali	38
Fuzhou	39
Marsaxlokk	40
Yarimca	41
Dalian	42
Lazaro Cardenas	43
Wilmington (USA-N Carolina)	44
Kobe	45
Nagoya	46
Shimizu	47
Mundra	48
Sohar	49
Rio Grande (Brazil)	50
Piraeus	51
Port Of Virginia	52
Yantian	53
Tokyo	54
Altamira	55
Haifa	56
Ambarli	57
Jubail	58
Aqaba	59
Bremerhaven	60
Itapoa	61
Zeebrugge	62
Da Chan Bay Terminal One	63
Krishnapatnam	64
Zhoushan	65
Antwerp	66
Rio De Janeiro	67
Savona-Vado	68
Boston (USA)	69
Keelung	70
Santa Cruz De Tenerife	71
Paranagua	72

Port Name	Overall Ranking
Khalifa Bin Salman	73
Siam Seaport	74
Diliskelesi	75
Balboa	76
Shantou	77
Kattupalli	78
Kamarajar	79
Osaka	80
Colon	81
Jacksonville	82
Lianyungang	83
Karachi	84
Hazira	85
Jawaharlal Nehru Port	86
Puerto Limon	87
Cochin	88
Port Everglades	89
Muhammad Bin Qasim	90
Johor	91
Penang	92
Aarhus	93
Puerto Cortes	94
Fort-De-France	95
Pointe-A-Pitre	96
Tanjung Perak	97
Philadelphia	98
Veracruz	99
Nemrut Bay	100
Paita	101
Yokkaichi	102
Limassol	103
Naha	104
Ensenada	105
Malaga	106
Cat Lai	107
Imbituba	108
Hakata	109
Chennai	110
Gemlik	111
Mersin	112

Port Name	Overall Ranking	Port Name	Overall Ranking
New Orleans	113	Wellington	153
Santos	114	Nantes-St Nazaire	154
Visakhapatnam	115	Chu Lai	155
Pecem	116	Cagayan De Oro	156
Danang	117	Ancona	157
Wilhelmshaven	118	Rio Haina	158
Puerto Barrios	119	Casablanca	159
Salvador	120	Bar	160
Shuaiba	121	Ravenna	161
Gothenburg	122	Puerto Progreso	162
Gioia Tauro	123	Salerno	163
Saigon	124	Barranquilla	164
Taichung	125	Umm Qasr	165
Port Akdeniz	126	Oslo	166
Sharjah	127	Gustavia	167
Noumea	128	Borusan	168
Puerto Quetzal	129	Philipsburg	169
San Juan	130	Vitoria	170
Santa Marta	131	Qingdao	171
Tanjung Emas	132	El Dekheila	172
Omaezaki	133	Damietta	173
Gijon	134	Buenos Aires	174
Batangas	135	Leixoes	175
Moji	136	Brest	176
Izmir	137	Latakia	177
Vigo	138	Suape	178
Papeete	139	Larvik	179
Haiphong	140	Burgas	180
Lirquen	141	Norrkoping	181
Shuwaikh	142	Sepetiba	182
Cebu	143	Muuga-Port Of Tallinn	183
Berbera	144	Bari	184
Port Tampa Bay	145	Civitavecchia	185
Quy Nhon	146	Sines	186
Puerto Bolivar (Ecuador)	147	Copenhagen	187
Caucedo	148	Valparaiso	188
Fredericia	149	Conakry	189
Odessa	150	Vila Do Conde	190
Helsingborg	151	Bluff	191
Cadiz	152	Bell Bay	192

Port Name	Overall Ranking	Port Name	Overall Ranking
Subic Bay	193	Saint John	233
Novorossiysk	194	Teesport	234
Klaipeda	195	Southampton	235
Dakar	196	Manaus	236
Matadi	197	Arica	237
Catania	198	Mobile	238
Palermo	199	Port Of Spain	239
Rauma	200	Itajai	240
Heraklion	201	Varna	241
Kristiansand	202	Hueneme	242
Apra Harbor	203	Bangkok	243
Nelson	204	St Petersburg	244
Tema	205	Takoradi	245
Bilbao	206	Venice	246
Trapani	207	Gavle	247
Tomakomai	208	Maputo	248
Mariel	209	Port Victoria	249
Rades	210	Timaru	250
Caldera (Costa Rica)	211	Davao	251
La Guaira	212	Agadir	252
Bordeaux	213	San Antonio	253
Belawan	214	Durres	254
Shanghai	215	Puerto Cabello	255
Lisbon	216	Bejaia	256
Miami	217	San Vicente	257
Marseille	218	Dublin	258
Tripoli (Lebanon)	219	Corinto	259
Helsinki	220	Lagos (Nigeria)	260
Mogadiscio	221	London	261
Kotka	222	Aden	262
Beira	223	Santo Tomas De Castilla	263
Alicante	224	Felixstowe	264
Gdynia	225	Rotterdam	265
Freetown	226	Kingston (Jamaica)	266
Toamasina	227	Mayotte	267
Panjang	228	Alexandria (Egypt)	268
Nassau	229	Sokhna	269
Batumi	230	Naples	270
Riga	231	Monrovia	271
Point Lisas Ports	232	Mejillones	272

Port Name	Overall Ranking	Port Name	Overall Ranking
Melbourne	273	Dunkirk	311
Lae	274	Dar Es Salaam	312
Owendo	275	Lyttelton	313
Otago Harbour	276	Tacoma	314
Adelaide	277	Pointe-Noire	315
Halifax	278	Genoa	316
Seattle	279	Freeport (Bahamas)	317
Iskenderun	280	Lome	318
Tanjung Priok	281	Le Havre	319
Manzanillo (Mexico)	282	Beirut	320
Guayaquil	283	Thessaloniki	321
Iquique	284	Napier	322
Tarragona	285	Auckland	323
Antofagasta	286	Kribi Deep Sea Port	324
Brisbane	287	Tauranga	325
Acajutla	288	Mombasa	326
Gdansk	289	Port Louis	327
Poti	290	Hamburg	328
Port Elizabeth	291	Manila	329
Montreal	292	Cotonou	330
Walvis Bay	293	Nouakchott	331
Constantza	294	La Spezia	332
Douala	295	Abidjan	333
San Pedro (Cote D'ivoire)	296	Rijeka	334
Ashdod	297	Houston	335
Port Reunion	298	Los Angeles	336
Port Botany	299	Luanda	337
Baltimore (USA)	300	Ngqura	338
Valencia	301	Trieste	339
Onne	302	Charleston	340
Qasr Ahmed	303	Durban	341
Montevideo	304	Prince Rupert	342
Cristobal	305	Oakland	343
New York & New Jersey	306	Cape Town	344
Chattogram	307	Koper	345
Tin Can Island	308	Long Beach	346
Livorno	309	Vancouver (Canada)	347
Fremantle	310	Savannah	348

Source: Original table produced for this publication, based on CPPI 2022 data.

Table A.2. • The CPPI 2022 (the Administrative Approach)

				RANK PER SHIP SIZE RANGE						
Port Name	Rank	Index Points	Total Calls	<1,500	1,501-5,000	5,001-8,500	8,501-13,500	>13,500	2021	Change
Yangshan	1	215.01	3,664	11	5	3	4	4	4	3
Salalah	2	212.30	1,397		12	4	1	1	2	0
Khalifa Port	3	199.54	896	86	47	10	7	5	5	2
Cartagena (Colombia)	4	197.50	1,274	23	16	18	5	8	12	8
Tanger-Mediterranean	5	193.48	3,097	163	50	11	12	2	6	1
Tanjung Pelepas	6	188.19	3,935	142	104	26	9	3	18	12
Ningbo	7	184.53	4,274	39	27	17	11	13	7	0
Hamad Port	8	182.55	257		1	14	16	11	3	-5
Guangzhou	9	181.18	1,577	89	20	15	14	15	9	0
Hong Kong	10	178.10	3,743	99	58	29	25	7	50	40
Port Said	11	177.29	1,106	52	48	23	15	14	15	4
Yokohama	12	171.48	1,217	33	2	44	8	24	10	-2
Cai Mep	13	170.77	939	19	51	5	53	10	13	0
Shekou	14	169.53	852	125	64	35	19	12	16	2
Mawan	15	166.32	295	62	23	31	18	18	44	29
King Abdullah Port	16	165.14	164	83	6	158	2	6	1	-15
Posorja	17	163.88	203	7	22	2	27	30	66	49
Algeciras	18	162.03	2,078	71	59	30	22	17	11	-7
Singapore	19	157.54	6,370	192	88	59	32	9	31	12
Buenaventura	20	149.84	430		13	43	23	25	20	0
Yeosu	21	149.64	576	43	37	33	30	26	33	12
Busan	22	148.62	4,783	72	65	32	44	19	25	3
Chiwan	23	147.58	879	79	76	42	31	22	17	-6
Djibouti	24	145.91	248	40	39	22	42	32	19	-5
Tianjin	25	145.84	1,035	143	80	57	13	31	27	2
Kaohsiung	26	142.03	2,426	85	103	40	28	29	21	-5
Laem Chabang	27	139.95	1,098	101	81	37	35	27	57	30
Jeddah	28	132.06	1,292	265	172	21	10	23	8	-20
Colombo	29	130.76	1,677	181	69	61	57	21	24	-5
Coronel	30	124.69	160		98	25	47	36	39	9
Pipavav	31	119.04	250		4	1	3		26	-5
Xiamen	32	118.65	2,201	205	179	96	34	20	45	13
Dammam	33	116.21	290	6	83	80	37	41	14	-19
Incheon	34	114.10	185	27	24	8	6		52	18
Barcelona	35	110.00	1,546	139	62	51	48	47	22	-13
Port Klang	36	107.29	2,536	172	116	81	52	38	69	33

				RANK PER SHIP SIZE RANGE						
Port Name	Rank	Index Points	Total Calls	<1,500	1,501-5,000	5,001-8,500	8,501-13,500	>13,500	2021	Change
Lazaro Cardenas	37	107.00	725	165	87	63	58	40	92	55
Fuzhou	38	105.90	172	169	162	130	43	28	133	95
Yarimca	39	105.77	491	160	109	45	82	35	28	-11
Jebel Ali	40	102.66	1,931	201	129	67	39	43	38	-2
Wilmington (USA-N Carolina)	41	101.51	170		60	7	46	56	49	8
Marsaxlokk	42	99.25	1,322	212	146	84	50	39	74	32
Callao	43	98.02	833	255	158	99	38	34	258	215
Dalian	44	96.68	660	209	168	124	89	16	83	39
Sohar	45	94.66	148	28	70	54	54	54	47	2
Shimizu	46	94.31	340	15	11	69	17		41	-5
Kobe	47	91.38	1,058	42	15	24	41		40	-7
Nagoya	48	86.15	1,092	9	40	34	51		53	5
Port Of Virginia	49	83.17	1,313	64	63	73	64	55	23	-26
Mundra	50	82.64	690	233	36	48	21		48	-2
Yantian	51	81.91	2,954	259	149	103	73	33	266	215
Rio Grande (Brazil)	52	80.51	296	8	49	71	45		97	45
Piraeus	53	79.30	1,296	194	210	98	76	37	101	48
Tokyo	54	75.68	924	25	54	49	61		56	2
Altamira	55	74.93	576	153	110	82	20		85	30
Ambarli	56	73.76	800	69	135	115	66	51	43	-13
Aqaba	57	72.61	187	14	32	55	72	65	35	-22
Haifa	58	69.75	734	183	189	136	63	44	196	138
Savona-Vado	59	69.01	176	65	73	39	70		94	35
Bremerhaven	60	67.68	1,122	96	112	120	87	50	59	-1
Da Chan Bay Terminal One	61	67.65	227	97	56	78	59		142	81
Balboa	62	67.04	1,412		84	95	60	59	60	-2
Boston (USA)	63	66.36	86		86	56	55		117	54
Shantou	64	64.80	94	198	115	66	49		165	101
Jubail	65	64.54	173		66	60	80	60	249	184
Rio De Janeiro	66	64.12	533	67	85	64	69		93	27
Keelung	67	63.64	659	73	184	87	33		67	0
Zeebrugge	68	63.62	316	193	82	106	79	53	278	210
Itapoa	69	62.78	473		38	62	71		72	3
Paranagua	70	62.15	663	3	119	83	65		198	128
Krishnapatnam	71	61.72	60	2	28	13			95	24
Siam Seaport	72	61.42	346	4	26		36		103	31
Khalifa Bin Salman	73	60.52	120	12	21		40		62	-11
Diliskelesi	74	60.47	161	22	29	72	86		77	3

				RANK PER SHIP SIZE RANGE						
Port Name	Rank	Index Points	Total Calls	<1,500	1,501-5,000	5,001-8,500	8,501-13,500	>13,500	2021	Change
Santa Cruz De Tenerife	75	60.32	168	18	44	6			71	-4
Antwerp	76	60.31	3,121	131	145	133	75	52	96	20
Lianyungang	77	59.47	118		178	101	24		78	1
Zhoushan	78	57.11	382	230	206	147	68	42	136	58
Osaka	79	55.31	462	10	14	41			36	-43
Kamarajar	80	54.59	102		8	16			84	4
Penang	81	54.22	135		209	105	26		111	30
Kattupalli	82	53.95	142	21	31	28			106	24
Jacksonville	83	53.54	133		41	86	78		100	17
Cochin	84	53.12	33		10	19			99	15
Karachi	85	52.69	286		148	92	56		90	5
Hazira	86	50.37	97		7	36			68	-18
Puerto Limon	87	48.38	380		46	20			86	-1
Muhammad Bin Qasim	88	45.12	548	129	118	89	81		81	-7
Port Everglades	89	44.97	400	61	78	94	90		116	27
Johor	90	44.53	137	56	25	76			80	-10
Jawaharlal Nehru Port	91	42.74	963	224	91	102	74		54	-37
Puerto Cortes	92	42.33	193	100	97	52			144	52
Philadelphia	93	41.34	466	268	68	77	62		55	-38
Fort-De-France	94	41.17	82	94	139	38			122	28
Colon	95	41.03	1,238	80	138	74	100	64	73	-22
Aarhus	96	39.61	189	48	105	88		62	82	-14
Pointe-A-Pitre	97	39.31	177	92	137	50			109	12
Yokkaichi	98	39.24	213		18	79			91	-7
Tanjung Perak	99	38.97	273	78	96	70			107	8
Limassol	100	36.89	105	70	198	27			147	47
Naha	101	36.33	33			9			120	19
Paita	102	36.19	231		107	58			75	-27
Nemrut Bay	103	35.50	840	128	127	119	101	58	224	121
Veracruz	104	35.40	444	161	102	68			104	0
Pecem	105	33.11	109		99	109	91		121	16
Imbituba	106	32.19	57		140	91	95		51	-55
Chennai	107	30.88	79		94	85			79	-28
Hakata	108	28.34	214	26	3				128	20
Ensenada	109	28.26	166		35	97	115		102	-7
Cat Lai	110	28.04	626	5	9				145	35
Malaga	111	26.48	177	90	95	134	93	68	137	26
Visakhapatnam	112	26.25	59		30	121			98	-14

Port Name	Rank	Index Points	Total Calls	RANK PER SHIP SIZE RANGE					2021	Change
				<1,500	1,501-5,000	5,001-8,500	8,501-13,500	>13,500		
Gothenburg	113	25.96	235	202	187	188	29	57	118	5
Santos	114	24.91	1,193	93	202	132	85	66	188	74
Salvador	115	23.99	253		173	128	88		112	-3
Danang	116	23.31	127	16	43				161	45
Puerto Barrios	117	22.77	144	30	42				170	53
Puerto Quetzal	118	21.86	296		79	75	128		110	-8
Shuaiba	119	21.26	163	17	67				185	66
Sharjah	120	20.56	62	84	45				155	35
Saigon	121	19.94	270	24	74				140	19
Noumea	122	19.70	86	76	53				88	-34
Gijon	123	19.48	72	32	77				236	113
Lirquen	124	19.39	57	13	143	108	119		126	2
Taichung	125	19.35	372	46	72				125	0
Omaezaki	126	18.93	45		17				127	1
Santa Marta	127	18.75	231		19				143	16
Batangas	128	18.56	41	109	57				#N/A	#N/A
Port Tampa Bay	129	18.46	129	103	61	143	106		64	-65
Gemlik	130	18.27	709	51	52	53	144		113	-17
Port Akdeniz	131	18.04	95	20	101				152	21
Mersin	132	17.99	885	253	295	114	103	45	34	-98
Gioia Tauro	133	17.98	56	145		116	96		65	-68
San Juan	134	17.91	153	82	75				157	23
Moji	135	17.30	24		34				132	-3
Tanjung Emas	136	17.28	124	53	89				153	17
New Orleans	137	16.61	340		90	111	118		115	-22
Haiphong	138	15.79	557	141	123	93	126		63	-75
Quy Nhon	139	15.55	50	108	93				154	15
Vigo	140	15.51	284	37	114				149	9
Papeete	141	15.24	62	98	100				167	26
Puerto Bolivar (Ecuador)	142	15.12	97		55				156	14
Cebu	143	14.86	61	50	117				164	21
El Dekheila	144	14.78	182	112	165	135			139	-5
Wilhelmshaven	145	14.63	315	88	163	125	67	80	233	88
Berbera	146	14.62	47	44	124				184	38
Nantes-St Nazaire	147	14.36	154	114	220	112			105	-42
Wellington	148	14.27	82		180	118			151	3
Izmir	149	14.22	224	107	166	137			253	104
Helsingborg	150	13.89	72	81	120				168	18

				RANK PER SHIP SIZE RANGE						
Port Name	Rank	Index Points	Total Calls	<1,500	1,501-5,000	5,001-8,500	8,501-13,500	>13,500	2021	Change
Bar	151	13.52	101	59	130				183	32
Shuwaikh	152	13.33	185	68	132				189	37
Fredericia	153	13.31	57	63	134				176	23
Damietta	154	13.27	550	152	248	129	97	61	58	-96
Casablanca	155	12.98	262	226	270	47			262	107
Salerno	156	12.94	156	110	122				192	36
Puerto Progreso	157	12.91	34	35	152				200	43
Caucedo	158	12.77	559	171	199	140	92		114	-44
Rio Haina	159	12.70	76	134	111				158	-1
Oslo	160	12.61	53	38	153				146	-14
Cadiz	161	12.20	24	120	126				221	60
Philipsburg	162	12.02	51	157	108				177	15
Chu Lai	163	11.95	76	55	151				220	57
Odessa	164	11.67	35	29	71		121		209	45
Cagayan De Oro	165	11.52	42	66	155				208	43
Ancona	166	11.33	130	104	144				179	13
Ravenna	167	11.09	228	105	147				187	20
Buenos Aires	168	10.92	269	127	113	126	84	76	141	-27
Barranquilla	169	10.75	37	77	160				159	-10
Umm Qasr	170	9.65	141		224	113			150	-20
Gustavia	171	9.62	64	1					197	26
Leixoes	172	9.52	143	133	150				205	33
Borusan	173	9.42	88		121				148	-25
Burgas	174	9.41	92	54	175				195	21
Vitoria	175	8.64	62	45	185				217	42
Suape	176	8.50	189		201	122	109		280	104
Brest	177	8.28	24	147	159				#N/A	#N/A
Matadi	178	6.68	88	213	125				171	-7
Bari	179	6.61	51	121	183				193	14
Latakia	180	6.60	75	123	182				174	-6
Novorossiysk	181	6.49	140	136	186		102		172	-9
Norrkoping	182	6.48	42		157				182	0
Larvik	183	6.14	34	31					210	27
Dakar	184	5.23	398	238	222	107			303	119
Muuga-Port Of Tallinn	185	4.93	51	132	192				175	-10
Copenhagen	186	4.57	39	74					206	20
Civitavecchia	187	4.57	25	75					162	-25
Apra Harbor	188	4.41	29		176				199	11

Port Name	Rank	Index Points	Total Calls	RANK PER SHIP SIZE RANGE					2021	Change
				<1,500	1,501-5,000	5,001-8,500	8,501-13,500	>13,500		
Valparaiso	189	4.29	252		212	90	127		108	-81
Bluff	190	4.07	31	106	207				241	51
Klaipeda	191	3.51	82	111					186	-5
Bell Bay	192	3.45	28	113					218	26
Catania	193	3.23	58	116					191	-2
Palermo	194	3.21	24	117					204	10
Heraklion	195	3.14	34	119					216	21
Conakry	196	2.93	146	126	213				242	46
Sepetiba	197	2.93	59		154	46	147		123	-74
Subic Bay	198	2.92	71	214	170				181	-17
Vila Do Conde	199	2.86	90	34	228				244	45
Kristiansand	200	2.81	30	130					223	23
Rauma	201	2.60	73	138	208				201	0
Sines	202	2.50	28			150	142	46	30	-172
Trapani	203	2.21	29	140					213	10
Nelson	204	1.60	77	148	218				194	-10
Tripoli (Lebanon)	205	1.11	91	60	33		135		87	-118
Bilbao	206	1.02	108	87	229				202	-4
Miami	207	0.99	348	36	308	127	83		29	-178
Mariel	208	0.36	30	177					222	14
Rades	209	0.06	71	182					237	28
Bordeaux	212	(0.08)	28	187					228	16
Caldera (Costa Rica)	213	(0.44)	36		219				260	47
Qingdao	214	(0.45)	2,705	249	243	154	130	48	42	-172
La Guaira	215	(0.48)	86	173	221				265	50
Tomakomai	216	(1.08)	33	170	225				239	23
Belawan	217	(2.12)	87	219	204				250	33
Shanghai	218	(2.45)	2,371	215	217	139	112		316	98
Tema	219	(2.70)	587	240	174	131	99	70	354	135
Lisbon	220	(2.88)	39	155	232				215	-5
Freetown	221	(2.90)	123	122	246				268	47
Southampton	222	(3.51)	430		128	104	113	75	346	124
Helsinki	223	(3.62)	42	164	235				180	-43
Nassau	224	(3.63)	108	47	259				212	-12
Mogadiscio	225	(3.79)	74		230				259	34
Kotka	226	(4.34)	65	166	241				243	17
Alicante	227	(4.52)	66	146	247				229	2
Marseille	228	(4.77)	473	158	167	145	107	71	315	87

				RANK PER SHIP SIZE RANGE						
Port Name	Rank	Index Points	Total Calls	<1,500	1,501-5,000	5,001-8,500	8,501-13,500	>13,500	2021	Change
Beira	229	(5.02)	93	184	239				270	41
Panjang	230	(5.44)	43		242				246	16
Toamasina	231	(5.93)	141	124	260				279	48
Arica	232	(6.58)	125	159	164	170			297	65
Saint John	233	(7.37)	81	220	236				240	7
Manaus	234	(7.82)	101		253				263	29
Gdynia	235	(8.03)	266	156	194	117	111	73	255	20
Batumi	236	(8.05)	68	186	254				245	9
Varna	237	(8.18)	47	180	257				225	-12
Itajai	238	(8.91)	462	191	211	142	122		207	-31
Takoradi	239	(9.07)	27	196	256				281	42
Teesport	240	(9.37)	34	206	252				257	17
St Petersburg	241	(9.62)	95	137	272				256	15
Port Of Spain	242	(10.01)	103	176	266				254	12
Hueneme	243	(10.08)	44		264				269	26
Point Lisas Ports	244	(10.56)	45	254					295	51
Mobile	245	(10.75)	339	57	169	149	133		163	-82
Bangkok	246	(11.11)	198	207	262				299	53
Timaru	247	(12.23)	47		273				310	63
Riga	248	(12.70)	56	248	233				214	-34
Gavle	249	(13.00)	52	229	263				252	3
Santo Tomas De Castilla	250	(14.25)	48	251	237				273	23
Port Victoria	251	(14.34)	45		282				289	38
Maputo	252	(14.77)	66		284				321	69
Davao	253	(15.09)	124	199	255	153			274	21
Venice	254	(15.37)	139	154	292				235	-19
Durres	255	(15.46)	72	151	293				309	54
Agadir	256	(15.69)	79	218	276				261	5
Corinto	257	(15.74)	25		286				286	29
Dublin	258	(17.01)	24	208	285				300	42
Bejaia	259	(17.33)	38	231	277				285	26
San Vicente	260	(18.03)	81		136	65	162		166	-94
Puerto Cabello	261	(18.24)	36	41	303				287	26
Felixstowe	262	(18.38)	540	245	200	165	105	67	334	72
Lagos (Nigeria)	263	(18.46)	192	135	250	169			358	95
Manzanillo (Mexico)	264	(19.80)	938	256	133	110	94	83	89	-175
San Antonio	265	(20.44)	319	115	188	144	116	74	320	55
Aden	266	(22.28)	26	211	299				305	39

Port Name	Rank	Index Points	Total Calls	RANK PER SHIP SIZE RANGE					2021	Change
				<1,500	1,501-5,000	5,001-8,500	8,501-13,500	>13,500		
Rotterdam	267	(22.58)	2,096	236	216	159	129	63	291	24
Kingston (Jamaica)	268	(24.42)	828	223	275	138	125		131	-137
Mayotte	269	(25.10)	30		304				294	25
Alexandria (Egypt)	270	(27.34)	215	237	191	180			277	7
Monrovia	271	(28.29)	26	246	300				#N/A	#N/A
Lae	272	(28.70)	28	210	307				301	29
Mejillones	273	(28.78)	98		177	171	134		231	-42
Naples	274	(29.42)	139	49	203	162	139		283	9
Owendo	275	(30.89)	126	234	306				302	27
Melbourne	276	(31.45)	748	144	193	177	132		308	32
Sokhna	277	(34.32)	138	174	197	151	120	77	353	76
Otago Harbour	278	(34.79)	110		245	186			298	20
Adelaide	279	(35.40)	224		195	146	149		264	-15
Guayaquil	280	(36.20)	498		196	148	123	79	296	16
Iquique	281	(37.83)	136	175	238	100	161		319	38
Tanjung Priok	282	(39.19)	834	118	205	123	170	49	124	-158
Antofagasta	283	(39.65)	30		161		159		234	-49
Acajutla	284	(39.72)	43	270	294				271	-13
Tarragona	285	(40.44)	82	203	141	172	146		160	-125
Halifax	286	(42.58)	239	167	142	163	124	82	46	-240
Poti	287	(45.01)	69	243	315				226	-61
Brisbane	288	(45.42)	660	222	215	161	148		288	0
London	289	(45.86)	1,181	149	106	156	108	86	347	58
Iskenderun	290	(46.11)	204	227	131	205	77		70	-220
Port Elizabeth	291	(46.91)	75		281	190			312	21
Gdansk	292	(49.28)	318	235	171	12		92	203	-89
Seattle	293	(50.45)	152		214	160	153	69	336	43
Walvis Bay	294	(50.72)	104		297	183	117		328	34
Montreal	295	(52.54)	190		290	191			311	16
San Pedro (Cote D'ivoire)	296	(55.86)	54		322				318	22
Douala	297	(57.40)	189	261	316				340	43
Qasr Ahmed	298	(59.98)	56	225	323				282	-16
Constantza	299	(60.31)	262	195	231		164		272	-27
Port Reunion	300	(63.27)	242	179	269	174	150		333	33
Baltimore (USA)	301	(65.01)	358	91	156	173	131	84	76	-225
Valencia	302	(65.27)	810	239	267	179	110	78	135	-167
Port Botany	303	(66.12)	770	200	234	176	157		324	21
Onne	304	(70.19)	66		271	202			342	38

				RANK PER SHIP SIZE RANGE						
Port Name	Rank	Index Points	Total Calls	<1,500	1,501-5,000	5,001-8,500	8,501-13,500	>13,500	2021	Change
Montevideo	305	(71.47)	531	58	249	152	104	89	284	-21
Cristobal	306	(72.38)	718	252	223	182	155		134	-172
Ashdod	307	(80.92)	469	190	288	155	145	81	329	22
Dunkirk	308	(81.08)	212	102	92	157		94	350	42
New York & New Jersey	309	(82.87)	1,382	204	279	164	156	72	251	-58
Chattogram	310	(83.90)	212	273	325				341	31
Livorno	311	(87.26)	286	168	244	168	165		338	27
Tin Can Island	312	(92.78)	94	197	278	209			339	27
Fremantle	313	(95.23)	247		226	197	158		335	22
Lyttelton	314	(97.18)	216	266	302	200			314	0
Pointe-Noire	315	(101.50)	388	250	301	196	143		362	47
Dar Es Salaam	316	(103.26)	151	264	328				361	45
Freeport (Bahamas)	317	(105.05)	139		310	194	152		352	35
Beirut	318	(106.59)	382	162	181	178	114	93	357	39
Lome	319	(109.51)	175		298	215			349	30
Thessaloniki	320	(111.05)	177	257	287	212			331	11
Genoa	321	(111.41)	730	178	258	175	137	88	337	16
Napier	322	(114.79)	144	274	312	201			290	-32
Auckland	323	(115.66)	153	271	311	203			351	28
Tauranga	324	(118.93)	489	269	296	211	98		325	1
Mombasa	325	(119.08)	254	241	313	210			293	-32
Kribi Deep Sea Port	326	(120.92)	159	262	321	198			355	29
Tacoma	327	(122.69)	103		190	184	163	85	345	18
Hamburg	328	(126.65)	1,670	185	227	181	141	91	232	-96
Le Havre	329	(128.31)	853	188	251	187	136	90	292	-37
Port Louis	330	(142.19)	370	232	261	167	138	95	323	-7
Nouakchott	331	(142.77)	62	276	327				356	25
Cotonou	332	(146.42)	359	272	317	206			348	16
Manila	333	(150.75)	612	267	320	207			327	-6
La Spezia	334	(190.11)	159	228	309	166	140	97	313	-21
Abidjan	335	(200.23)	292	275	324	213			360	25
Rijeka	336	(218.88)	245	217	289	141	174	87	190	-146
Los Angeles	337	(252.55)	634	95	283	195	171	96	370	33
Houston	338	(253.08)	800	189	240	185	177		119	-219
Luanda	339	(268.05)	291	244	305	208	175		366	27
Ngqura	340	(272.15)	213	263	291	192	154	101	363	23
Charleston	341	(278.09)	1,161	150	274	193	167	100	130	-211
Trieste	342	(284.33)	353	247	268	199	166	99	326	-16

Port Name	Rank	Index Points	Total Calls	RANK PER SHIP SIZE RANGE					2021	Change
				<1,500	1,501-5,000	5,001-8,500	8,501-13,500	>13,500		
Durban	343	(316.33)	389	260	318	216	173		364	21
Prince Rupert	344	(353.43)	90		330	218	151		344	0
Oakland	345	(365.00)	377	216	280	189	172	102	359	14
Koper	346	(371.36)	462	221	265	219	168	98	129	-217
Cape Town	347	(427.36)	185		319	220	176		365	18
Long Beach	348	(498.13)	282	242	329	204	160	103	369	21
Vancouver (Canada)	349	(593.37)	318		314	214	169	104	368	19
Savannah	350	(941.80)	1,115	258	326	217	178	105	367	17

Source: Original table produced for this publication, based on CPPI 2022 data.

Table A.3. • The CPPI 2022 (the Statistical Approach)

Port Name	2022 Rank	Index Points	2021 Rank	Change
Yangshan	1	93.891159	3	2
Salalah	2	91.866199	2	0
Khalifa Port	3	88.783069	5	2
Tanger-Mediterranean	4	84.345303	6	2
Tanjung Pelepas	5	81.404458	16	11
Cartagena (Colombia)	6	80.7642	15	9
Hamad Port	7	80.579775	4	-3
Ningbo	8	80.349495	7	-1
Guangzhou	9	79.285176	9	0
Port Said	10	78.23557	13	3
Hong Kong	11	77.648186	38	27
Cai Mep	12	73.411131	11	-1
Algeciras	13	73.089835	10	-3
Mawan	14	72.78143	110	96
Shekou	15	72.422481	17	2
Tianjin	16	70.245532	26	10
Yokohama	17	70.033099	12	-5
Singapore	18	69.546328	31	13
King Abdullah Port	19	67.653064	1	-18
Posorja	20	65.563411	65	45
Buenaventura	21	65.480099	23	2
Busan	22	65.271824	25	3
Kaohsiung	23	62.883753	21	-2

Port Name	2022 Rank	Index Points	2021 Rank	Change
Chiwan	24	61.748811	20	-4
Yeosu	25	61.424749	29	4
Djibouti	26	61.219598	24	-2
Colombo	27	58.021452	22	-5
Laem Chabang	28	57.88501	48	20
Callao	29	52.181198	186	157
Jeddah	30	51.426625	8	-22
Pipavav	31	50.992508	34	3
Dammam	32	50.942405	14	-18
Barcelona	33	50.575247	19	-14
Xiamen	34	48.913154	40	6
Port Klang	35	46.897259	59	24
Coronel	36	46.714878	49	13
Jebel Ali	37	46.129933	42	5
Fuzhou	38	44.013292	96	58
Incheon	39	43.875315	53	14
Marsaxlokk	40	43.083907	74	34
Kobe	41	40.89719	37	-4
Dalian	42	40.540729	81	39
Yarimca	43	39.982902	30	-13
Nagoya	44	37.529667	43	-1
Wilmington (USA-N Carolina)	45	36.774971	#N/A	#N/A
Mundra	46	36.409572	46	0
Lazaro Cardenas	47	35.023765	109	62
Rio Grande (Brazil)	48	34.72914	91	43
Piraeus	49	34.516997	82	33
Shimizu	50	33.684835	45	-5
Haifa	51	33.68135	247	196
Jubail	52	33.535813	191	139
Tokyo	53	33.192474	51	-2
Altamira	54	32.481599	76	22
Port Of Virginia	55	32.125287	27	-28
Yantian	56	31.993295	270	214
Ambarli	57	31.934733	36	-21
Itapoa	58	31.914238	60	2
Zeebrugge	59	31.055198	291	232
Zhoushan	60	30.754019	228	168
Bremerhaven	61	29.912465	54	-7
Antwerp	62	29.273182	78	16
Da Chan Bay Terminal One	63	29.044824	122	59
Krishnapatnam	64	29.038774	87	23

Port Name	2022 Rank	Index Points	2021 Rank	Change
Sohar	65	28.832647	47	-18
Colon	66	28.737558	64	-2
Aqaba	67	28.660159	32	-35
Rio De Janeiro	68	26.736563	83	15
Kattupalli	69	25.480878	95	26
Boston (USA)	70	25.129463	115	45
Jawaharlal Nehru Port	71	24.52839	50	-21
Santa Cruz De Tenerife	72	24.384752	88	16
Keelung	73	24.140515	77	4
Savona-Vado	74	24.02082	111	37
Kamarajar	75	23.869578	71	-4
Khalifa Bin Salman	76	23.665701	61	-15
Paranagua	77	23.565968	166	89
Diliskelesi	78	23.313358	70	-8
Siam Seaport	79	23.124017	100	21
Osaka	80	22.970532	44	-36
Hazira	81	22.680683	69	-12
Jacksonville	82	22.603662	94	12
Puerto Limon	83	22.050489	80	-3
Karachi	84	21.867136	90	6
Port Everglades	85	21.459083	102	17
Shantou	86	21.28065	151	65
Muhammad Bin Qasim	87	20.424853	75	-12
Balboa	88	20.392186	55	-33
Johor	89	19.896225	79	-10
Cochin	90	19.844555	98	8
Aarhus	91	19.570453	67	-24
Lianyungang	92	19.231782	73	-19
Puerto Cortes	93	17.732475	141	48
Tanjung Perak	94	16.469817	103	9
Pointe-A-Pitre	95	16.4253	#N/A	#N/A
Fort-De-France	96	16.161755	127	31
Gemlik	97	16.092142	105	8
Veracruz	98	15.990696	85	-13
Nemrut Bay	99	15.746314	242	143
Ensenada	100	15.680764	86	-14
Paita	101	15.435808	84	-17
Malaga	102	15.414967	140	38
Penang	103	15.412607	116	13
New Orleans	104	14.640183	108	4
Philadelphia	105	14.521186	58	-47

Port Name	2022 Rank	Index Points	2021 Rank	Change
Mersin	106	14.482174	28	-78
Yokkaichi	107	14.088427	101	-6
Cat Lai	108	13.752034	132	24
Hakata	109	13.302854	117	8
Wilhelmshaven	110	13.23886	204	94
Limassol	111	13.039884	172	61
Naha	112	12.952755	126	14
Imbituba	113	11.977288	106	-7
Chennai	114	11.54741	92	-22
Gioia Tauro	115	10.935035	112	-3
Santos	116	10.133248	147	31
Danang	117	10.036422	156	39
Shuaiba	118	9.9966817	177	59
Saigon	119	9.9070327	125	6
Port Akdeniz	120	9.6068699	139	19
Puerto Barrios	121	9.4983004	196	75
Visakhapatnam	122	9.4912918	97	-25
Taichung	123	9.3591441	135	12
Salvador	124	8.8773066	130	6
San Juan	125	8.6750957	143	18
Noumea	126	8.5331801	93	-33
Izmir	127	8.4696178	246	119
Tanjung Emas	128	8.3960203	144	16
Qingdao	129	8.321523	33	-96
Sharjah	130	8.2674761	148	18
Santa Marta	131	7.9974024	137	6
Gothenburg	132	7.8368006	152	20
Shuwaikh	133	7.6920939	179	46
Omaezaki	134	7.6414656	120	-14
Vigo	135	7.4942362	138	3
Papeete	136	7.3557644	158	22
Moji	137	7.2633952	121	-16
Gijon	138	7.2546795	224	86
Batangas	139	7.1806229	#N/A	#N/A
Haiphong	140	7.0953581	63	-77
Puerto Quetzal	141	7.0730406	134	-7
Cebu	142	7.0085755	171	29
Berbera	143	6.9834428	165	22
Pecem	144	6.5441976	129	-15
Puerto Bolivar (Ecuador)	145	6.4609276	153	8
Quy Nhon	146	6.4548038	146	0

Port Name	2022 Rank	Index Points	2021 Rank	Change
Odessa	147	6.2193002	164	17
Caucedo	148	5.9831249	99	-49
Cadiz	149	5.7500438	217	68
Ancona	150	5.7374415	168	18
Cagayan De Oro	151	5.6934303	226	75
Fredericia	152	5.6819122	183	31
Chu Lai	153	5.6630756	216	63
Lirquen	154	5.4025422	118	-36
Ravenna	155	5.3971409	188	33
Port Tampa Bay	156	5.2737755	66	-90
Helsingborg	157	5.1685519	167	10
Rio Haina	158	4.9524185	155	-3
Casablanca	159	4.8162144	262	103
Umm Qasr	160	4.7689205	136	-24
Wellington	161	4.7374077	192	31
Nantes-St Nazaire	162	4.6900003	#N/A	#N/A
Borusan	163	4.6430391	149	-14
Vitoria	164	4.5940646	#N/A	#N/A
Gustavia	165	4.5843749	190	25
Barranquilla	166	4.5062808	163	-3
Bar	167	4.4550329	182	15
Puerto Progreso	168	4.2702304	205	37
Salerno	169	3.6117234	195	26
Sepetiba	170	3.434285	119	-51
Oslo	171	3.4049691	142	-29
Philipsburg	172	3.3186682	174	2
Leixoes	173	3.0744614	#N/A	#N/A
Latakia	174	3.0369427	173	-1
Larvik	175	2.8861643	206	31
Sines	176	2.879663	35	-141
Buenos Aires	177	2.5092931	124	-53
Muuga-Port Of Tallinn	178	2.391828	160	-18
Brest	179	2.3599453	#N/A	#N/A
Norrkoping	180	2.2969698	184	4
Conakry	181	2.2887926	239	58
Tema	182	2.2611246	353	171
Vila Do Conde	183	2.258435	245	62
London	184	2.170447	355	171
Suape	185	2.1573978	287	102
Civitavecchia	186	2.1010276	161	-25
Subic Bay	187	2.0266372	178	-9

Port Name	2022 Rank	Index Points	2021 Rank	Change
Valparaiso	188	1.934846	113	-75
Copenhagen	189	1.8552597	227	38
Bell Bay	190	1.8267218	211	21
Bluff	191	1.7454775	234	43
Rauma	192	1.6600785	210	18
Klaipeda	193	1.6402489	170	-23
Damietta	194	1.5382355	56	-138
Catania	195	1.4882068	193	-2
Burgas	196	1.4835229	197	1
Palermo	197	1.4631996	198	1
El Dekheila	198	1.4627075	133	-65
Bari	199	1.2712493	194	-5
Heraklion	200	1.2697978	212	12
Kristiansand	201	1.1905867	221	20
Nelson	202	1.0345817	189	-13
Tomakomai	203	1.0019976	237	34
Dakar	204	0.8774949	308	104
Apra Harbor	205	0.4193741	203	-2
Novorossiysk	206	0.3849053	159	-47
Rades	207	0.3390818	232	25
Mariel	208	0.3043624	219	11
Bilbao	209	0.2530552	201	-8
Matadi	210	0.2148891	176	-34
Caldera (Costa Rica)	211	0.1884466	264	53
La Guaira	212	0.1403443	263	51
Bordeaux	213	-0.168196	223	10
Trapani	214	-0.296926	209	-5
Shanghai	215	-0.402068	318	103
Belawan	216	-0.424559	238	22
Gdynia	217	-0.518666	225	8
Riga	218	-0.527474	207	-11
Lisbon	219	-0.59083	220	1
Marseille	220	-0.610633	297	77
Beira	221	-1.370338	268	47
Helsinki	222	-1.466602	169	-53
Point Lisas Ports	223	-1.478159	301	78
Kotka	224	-1.504547	231	7
Mogadiscio	225	-1.521115	254	29
Alicante	226	-1.684575	222	-4
Toamasina	227	-1.8707	280	53
Panjang	228	-2.111492	236	8

Port Name	2022 Rank	Index Points	2021 Rank	Change
Batumi	229	-2.145147	233	4
Miami	230	-2.662386	39	-191
Freetown	231	-2.765453	272	41
Nassau	232	-3.359467	208	-24
Tripoli (Lebanon)	233	-3.438159	89	-144
Teesport	234	-3.451123	250	16
Mobile	235	-3.60963	150	-85
Saint John	236	-3.8961	235	-1
Port Of Spain	237	-3.999666	252	15
Manaus	238	-4.190544	259	21
Hueneme	239	-4.777436	274	35
Itajai	240	-4.860375	#N/A	#N/A
Arica	241	-5.04979	295	54
Venice	242	-5.249944	230	-12
Bangkok	243	-5.307291	304	61
Varna	244	-5.32636	248	4
Maputo	245	-5.893511	323	78
San Antonio	246	-5.981112	320	74
Southampton	247	-6.017641	348	101
St Petersburg	248	-6.166687	#N/A	#N/A
Takoradi	249	-6.414522	290	41
Port Victoria	250	-6.470642	298	48
Gavle	251	-6.593461	256	5
Puerto Cabello	252	-7.384221	284	32
Agadir	253	-7.390557	260	7
Davao	254	-7.499438	279	25
Timaru	255	-7.522139	314	59
San Vicente	256	-7.880376	162	-94
Bejaia	257	-7.947162	289	32
Sokhna	258	-8.319628	352	94
Durres	259	-8.355378	319	60
Dublin	260	-8.49749	299	39
Lagos (Nigeria)	261	-8.503313	358	97
Aden	262	-8.547208	285	23
Corinto	263	-9.068531	283	20
Rotterdam	264	-9.558479	300	36
Kingston (Jamaica)	265	-10.03605	128	-137
Alexandria (Egypt)	266	-10.59644	266	0
Mayotte	267	-10.67549	293	26
Felixstowe	268	-10.97785	336	68
Seattle	269	-11.17249	322	53

Port Name	2022 Rank	Index Points	2021 Rank	Change
Naples	270	-12.15288	267	-3
Santo Tomas De Castilla	271	-12.40153	275	4
Iskenderun	272	-13.25392	72	-200
Melbourne	273	-13.25584	294	21
Mejillones	274	-13.26753	241	-33
Monrovia	275	-13.3903	#N/A	#N/A
Halifax	276	-13.76381	18	-258
Lae	277	-14.92325	306	29
Owendo	278	-15.07203	303	25
Otago Harbour	279	-15.55807	292	13
Adelaide	280	-16.17577	257	-23
Tanjung Priok	281	-16.48438	114	-167
Gdansk	282	-17.48768	199	-83
Brisbane	283	-17.58514	281	-2
Iquique	284	-17.89507	311	27
Ashdod	285	-18.07028	342	57
Guayaquil	286	-18.19975	302	16
Tarragona	287	-18.67975	157	-130
Antofagasta	288	-19.69405	273	-15
Montreal	289	-19.98314	313	24
Acajutla	290	-20.63371	269	-21
Port Elizabeth	291	-21.10723	317	26
Walvis Bay	292	-21.48845	332	40
Poti	293	-21.6105	213	-80
Constantza	294	-22.6387	261	-33
Port Botany	295	-24.63636	321	26
Manzanillo (Mexico)	296	-25.09643	52	-244
Port Reunion	297	-25.71414	#N/A	#N/A
Douala	298	-27.11337	340	42
Onne	299	-27.60095	343	44
San Pedro (Cote D'ivoire)	300	-27.883	315	15
Baltimore (USA)	301	-28.31127	#N/A	#N/A
Montevideo	302	-28.65839	265	-37
Valencia	303	-29.62095	180	-123
New York & New Jersey	304	-30.6021	#N/A	#N/A
Tin Can Island	305	-31.18211	334	29
Chattogram	306	-32.49516	347	41
Qasr Ahmed	307	-32.62911	288	-19
Cristobal	308	-34.88104	185	-123
Tacoma	309	-36.76471	341	32
Fremantle	310	-38.76647	328	18

Port Name	2022 Rank	Index Points	2021 Rank	Change
Livorno	311	-39.35032	333	22
Dar Es Salaam	312	-42.56314	361	49
Genoa	313	-43.08853	335	22
Le Havre	314	-45.59272	286	-28
Lyttelton	315	-45.61401	312	-3
Lome	316	-45.74376	#N/A	#N/A
Pointe-Noire	317	-46.03578	362	45
Freeport (Bahamas)	318	-47.5856	351	33
Port Louis	319	-48.51084	329	10
Dunkirk	320	-51.82757	345	25
Thessaloniki	321	-53.02881	327	6
Napier	322	-54.03063	282	-40
Beirut	323	-54.84456	356	33
Kribi Deep Sea Port	324	-55.07653	357	33
Hamburg	325	-55.9153	258	-67
Auckland	326	-56.08951	350	24
Tauranga	327	-56.9159	330	3
Mombasa	328	-56.93792	296	-32
Manila	329	-64.58673	324	-5
Cotonou	330	-68.15778	346	16
Nouakchott	331	-70.48896	354	23
Abidjan	332	-84.62539	359	27
La Spezia	333	-88.35868	309	-24
Houston	334	-91.60496	123	-211
Rijeka	335	-95.62783	200	-135
Los Angeles	336	-98.4873	369	33
Luanda	337	-107.5817	366	29
Ngqura	338	-118.686	365	27
Durban	339	-123.8653	363	24
Trieste	340	-130.9884	338	-2
Charleston	341	-138.3375	187	-154
Prince Rupert	342	-145.9609	339	-3
Oakland	343	-154.6855	360	17
Cape Town	344	-164.2052	364	20
Koper	345	-196.1089	218	-127
Long Beach	346	-209.2063	370	24
Vancouver (Canada)	347	-224.4264	368	21
Savannah	348	-396.8871	367	19

Source: Original table produced for this publication, based on CPPI 2022 data

Appendix B: Constructing the CPPI

The administrative and statistical approaches are explained in detail in this section.

The Structure of the Data

Before discussing the methodology employed in constructing the CPPI with matrix factorization, it is helpful to first summarize the structure of available data. The data set is segmented by the following five categories of ship sizes:

- Feeders: <1,500 TEUs
- Intra-regional: 1,500 TEUs –5,000 TEUs
- Intermediate: 5,000 TEUs –8,500 TEUs
- Neo-Panamax: 8,500 TEUs –13,500 TEUs
- Ultra-large container carriers: >13,500 TEUs

For each category, there are 10 different bands for call size. The port productivity is captured by average idle hour, which consists of two parts: port-to-berth (PB) and on-berth (B). In the previous CPPI iteration, total variables used = 5 x 10 x 2. Of course, many of them have missing values. The objective is to build a model to summarize these variables and then construct a port productivity index for all ports under consideration. The average waiting time and average berth time is calculated for each call size. The resulting data is a table/matrix whose rows represent ports and whose columns contain the average waiting and berth times of each call size.

Imputation of Missing Values

A major practical problem is that most idle hour variables have a significant number of missing values. For instance, in the port performance data set, the two smaller ship sizes contain little data for the larger call sizes. Consequently, as in the administrative approach, the call size groups with more than 2,000 moves were removed from the <1,500 TEU ship category, and the call size groups with more than 4,000 moves were removed from the 1,501 TEU–5,000 TEU ship category.

A more sophisticated approach is to use likelihood-based methods to impute those missing values. For the current data set, expectation–maximization (EM) algorithm can be utilized to provide a maximum-likelihood estimator for each missing value. It relies on two critical assumptions. The first assumption is that gaps are random, or more specifically, the gaps are not caused by sample selection bias. The second assumption is that all variables under consideration follow a normal distribution. Given the data set, these two assumptions are plausible. EM computes the maximum likelihood estimator for the mean and variance of the normal distribution given the observed data. Knowing the distribution that generates the missing data, we can then sample from it to impute the missing values. Matrix factorization can then be performed on the resulting data set, instead of the original one filled with missing values.

Missing values in the resulting table/matrix are reconstructed using the EM algorithm (Dempster, Laird, and Rubin 1977). A non-negativity constraint is added to make sure the reconstructed times are non-negative. Assuming the data has a multivariate Gaussian distribution with mean vector μ and covariance matrix Σ, the EM algorithm provides an estimate of the two parameters μ and Σ via maximum likelihood.

Missing values are imputed using their conditional expectation. In this approach, given a row with available values x_a and missing values x_m, the missing values are imputed by their conditional expectation E(x_m 1_(x_m)²|x_a) given the available data, where the expected value is computed only over the non-negative values of x_m to ensure the imputed values are non-negative.

In this iteration, arrival and berth hours are aggregated into total port hours, just like in the administrative approach. The data structure after this aggregation for a particular category k (k = 1, 2, 3, 4, 5) can be summarized as shown in Table B.1.

Table B.1 • Sample Port Productivity Data Structure by Ship Size

SHIP SIZE (K)	CALL SIZE BAND (NUMBER OF MOVES)									
	<250			251–500			.....	>6,000		
Ports	Port-to-Berth	Berth	Total Port Hours	Port-to-Berth	Berth	Total Port Hours		Port-to-Berth	Berth	Total Port Hours
1										
2										
3										
. . .										

Source: Original table produced for this publication

Why Is Matrix Factorization Useful?

Essentially, for each port, quite a few variables contain information about its efficiency. These include average time cost under various categories: (1) different call size bands, and (2) berth/port-to-berth. The reason matrix factorization can be helpful is that these variables are in fact determined by a small number of unobserved factors, which might include quality of infrastructure, expertise of staff, and so on. Depending on the data, very few of such factors can summarize almost all useful information. The challenge lies in the inability to observe those latent factors; however, a simple example could be helpful: Imagine three ports, each with four different types of time cost, as shown in table B.2.

Table B.2 • Sample Illustration of Latent Factors

PORT	COST 1	COST 2	COST 3	COST 4
A	1	2	3	4
B	2	4	6	8
C	3	6	9	12

Source: Original table produced for this publication

As one can observe, costs 2 to 4 are just some multiples of cost 1. Although we have four variables, to rank the efficiency of these three ports, just one variable is enough (A>B>C). This is an extreme case, but the idea can be generalized if these variables are somehow correlated, but to a less extreme extent. In that case, the factors are computed as some linear combination of costs 1 to 4. Of course, if costs 1 to 4 are completely independent of each other, then this method makes no sense. Fortunately, this is not the case for our data set. Thus, for each port, we can compute its score on all factors and then combine those scores together to reach a final efficiency score.

Note that in the statistical approach using matrix factorization, the scores are not calculated for each call size range. On the contrary, the whole data set, including the smaller ports, is used simultaneously to obtain latent factors. This is in sharp contrast to the administrative approach. The statistical approach factors in all the correlations among hours for various call size bands, which purely from a statistical perspective is more efficient.

There is no right or wrong methodology, but the two different approaches that are considered complementary. Hence, the decision in this iteration of the CPPI to maintain both approaches, to try and ensure that the resulting ranking(s) of container port performance reflects as closely as possible actual port performance, whilst also being statistically robust.

The Statistical Methodology

The data are scaled and weighted as in the administrative approach.

- Let p_ij denote average port time of port i in call size j.
- Let p_(avg,j) denote the average of the average port time of all ports in the given call size.
- Let w_j denote the ratio of port calls that are in the call size group j
- The data are scaled by replacing p_ij by.

$$p_{ij} = (p_{\text{avg},j} - p_{ij}) \cdot w_j.$$

A positive value of x_(ij) means the port is doing better than average, whereas a negative value means it is doing worse than average.

Let X = (x_(ij)) denote the resulting matrix of scaled port time. Assume X has n rows (n ports) and p columns (p call size bands). Instead of using factor analysis as in the previous iteration, the matrix X is decomposed as X ≈ WH where W is a n×k matrix and H is an entrywise non-negative k ×p matrix. The integer k (the number of columns of W) is chosen to be a small number to compress the data. The matrix W represents factors and the matrix H factor loadings that are used to explain the data X. A number of k = 3 factors was found to be adequate to approximate the data matrix X.

Note: In the previous iteration, a factor analysis (FA) approach was used. The FA produces a matrix factorization X ≈ WH as above, except that the matrix H does not need to be non-negative. This is a problem since a large positive factor does not necessarily represent a small port time if the corresponding loading is negative. The new approach fixes that problem by enforcing non-negativity in the loadings matrix H. This approach produces results that are consistent with the administrative approach.

The CPPI for each ship size is obtained by adding the three columns of W.

The CPPI index is a weighted sum of these indices: Let CPPIi denote the CPPI index for ship size i (i = 1, . . . ,5).

$$CPPI = \sum_{i=1}^{5} CPPI_i \cdot \alpha_i,$$

where $(\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5) = (0.46, 1.00, 1.54, 1.97, 2.57)$

The Administrative Approach

Aggregating arrival and berth hours into total port hours. This report indicated earlier that a case could be made for penalizing waiting time which is regarded as pure waste. However, as expressed earlier, this would be a normative judgment, accordingly both arrival and berth hours are weighted as 1.0 and the two time segments are summed to form total port hours in CPPI 2022.

Appraising port hours performance. Average port hours are naturally higher in the larger than smaller call size groups. This can magnify the difference in hours between a subject port and the average port hours of the overall group. So, appraising on the difference between a port's average hours and average hours of the group may skew the scoring unduly toward the larger call size calls. There are also far fewer calls within the larger than smaller call size groups, and this also needs to be reflected in the construction of the CPPI to retain maximum objectivity.

The method applied to each call size group individually is that the port's average port hours is compared with the group's average port hours as a negative or positive quantity of hours. The result of that comparison is weighted by the ratio of port calls in each call size group for the entire group of ports Table B.3 provides an illustration as to how it is done.

Table B.3 • Port Hours Performance Appraisal

PORT	PORT HOURS	HOURS DIFFERENCE	CALL SIZE GROUP WEIGHT	RESULT
Example Port	22.56	12.09	0.160	1.9344
Group Average	34.65			

Source: Original table produced for this publication, based on CPPI 2021 data

In this illustrative example, the subject port used 12.09 fewer hours than the average of the entire group (22.56 versus 34.65). Since 16.0 percent of all port calls in this ship size group were in the subject call size group, the difference in hours (12.09) is multiplied by ratio 0.160 for an overall index points result of 1.9344. Where a port uses more port time than the average for all ports, the index points become negative.

Aggregation to a score and rank per ship size group. The "results" achieved per port within each of the 10 call size groups are then summed together to calculate a score within the overall ship size group (it is five and eight groups rather than 10 groups in the case of the two smaller ship size groups, respectively). Based upon these scores, there is a sub-ranking performed within each ship size group that can be reviewed in the final CPPI rankings.

Aggregating all Ship Size Groups

No allowance was made for ports that did not handle ships within specific ship size groups during the period under consideration. The primary reason is many of the smaller ports are not capable of handling some of the larger ship sizes and so would in effect be awarded positive (or negative) results for scenarios that are physically impossible. The omission of scores within some ship size groups would only be an issue if an attempt was made to compare the performance of major mainline ports with those of far smaller ports. But this is a comparison that is neither fair nor valuable.

For the comparison between similarly sized ports, this factor will not contribute, or at least not significantly. In aggregating the scores from the various ship size groups into the overall CPPI in the administrative approach, a factor was built in to differentiate the importance and significance of better performance of larger ships over smaller ones. This was constructed based on the relative fuel consumption (and, therefore, emissions and cost) of different ship sizes in the form of an index (see table B.4). For each ship size group, a typical mid-range example ship was selected. Based upon the expected deployment of such ships, a range of sea legs were defined (and weighted), at a typical pro forma service speed, and the impact on fuel consumption that one hour longer (or shorter) in port would be likely to yield.

Table B.4 • Assumptions to Determine a Fuel Consumption Index

NOMINAL TEU CAPACITY RANGE	EXPECTED DEPLOYMENT	SEA LEG	WEIGHT (PERCENT)	INDEX WEIGHT
Less than 1,500 TEUs	Feeders Intra-regional	Singapore–Surabaya Rotterdam–Dublin Kingston–Port-au-Prince Busan–Qingdao	25 25 25 25	0.46
1,500 to 5,000 TEUs	Intra-regional Africa Latin America Oceania Transatlantic	Shanghai¬–Manila Rotterdam–Genoa Algeciras–Tema Charleston–Santos Xiamen–Brisbane Felixstowe–New York	30 30 10 10 10 10	1.00
5,000 to 8,500 TEUs	Africa Latin America Oceania Transatlantic Asia–Middle East	Hong Kong–Tema Charleston–Santos Xiamen–Brisbane Felixstowe–New York Shanghai–Dubai	20 20 20 20 20	1.54
8,500 to 13,500 TEUs	Transpacific Asia–Middle East Asia–Mediterranean	Busan–Charleston (via Panama) Hong Kong–Los Angeles Shanghai–Dubai Singapore–Piraeus	25 25 25 25	1.97
Greater than 13,500 TEUs	Asia–Mediterranean Asia–North Europe Transpacific	Singapore–Piraeus Singapore–Rotterdam Hong Kong–Los Angeles	40 40 20	2.57

Source: Original table produced for this publication, based on CPPI 2022 data

The index weight then suggests that it is 2.57 times more costly to recover an additional hour of port time at sea for a ship with a capacity of more than 13,500 TEUs than it would be for a ship in the 1,500 TEU–5,000 TEU capacity range. The total aggregated index points per port within each ship size group are then weighted by this cost/environmental factor. The sum of the weighted index points for each port across all five ship size groups are then summed and the final CPPI ranking is based on those weighted values.

The primary focus was micro-delays and it was assumed that these would be recovered on long-haul ocean legs, and not between coastal ports, which would be more costly. Through simulation, if the index values are tweaked up or down by up to 10 percent, the overall ranking is unaffected. If they are adjusted so that larger ship size groups have lower indices than smaller ones, it results in radical changes to the overall ranking. The resulting index for main and secondary ports using the administrative approach is presented in chapter 3 and appendix A.

Notes

[1]International Maritime Organization (IMO) Resolution MSC.74(69) Annex 3.

[2]See the International Maritime Organization's website on "International Convention for the Safety of Life at Sea (SOLAS), 1974," (accessed March 2022), at https://www.imo.org/en/About/Conventions/ Pages/International-Convention-for-the-Safety-of-Life-at-Sea-(SOLAS),-1974.aspx.

[3]International Convention for the Safety of Life at Sea (SOLAS), under the revised SOLAS 1974 Chapter V (as amended)—Safety of Navigation, section 19.2.415, carriage requirements for shipborne navigational systems and equipment.

[4]See ITU's website on "Technical Characteristics for an Automatic Identification System Using Time Division Multiple Access in the VHF Maritime Mobile Frequency Band," (accessed November 2021), at https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.1371-5-201402-I!!PDF-E.pdf.

[5]It may be a conventional land-based port or a stretch of water designated as an area for transferring cargo or passengers from ship to ship.

[6]The precise approach to produce a robust data set is detailed in appendix B.

[7]The actual equation is: (Group Average Port Hours/Example Port Hours) x Call Size Group Weight.

References

- Dempster, A. P., N. M. Laird, and D. B. Rubin. 1977. "Maximum Likelihood from Incomplete Data via the EM Algorithm." Journal of the Royal Statistical Society: Series B (Methodological), 39 (1): 1–22. https://doi.org/10.1111/j.2517-6161.1977.tb01600.x.
- IALA (International Association of Marine Aids to Navigation and Lighthouse Authorities). 2005. IALA Guideline 1050: The Management and Monitoring of AIS information. Edition 1.0. Saint Germain: IALA. https://www.iala-aism.org/product/management-and-monitoring-of-ais-information-1050/?download=true.
- IALA (International Association of Marine Aids to Navigation and Lighthouse Authorities). 2016. IALA Guideline 1082: An Overview of AIS. Edition 2.0. Saint Germain: IALA. 19. https://www.iala-aism.org/product/an-overview-of-ais-1082/?download=true.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