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TRANSPORT GLOBAL PRACTICE

The Container Port PERFORMANCE INDEX 2021

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A Comparable Assessment of Container Port Performance

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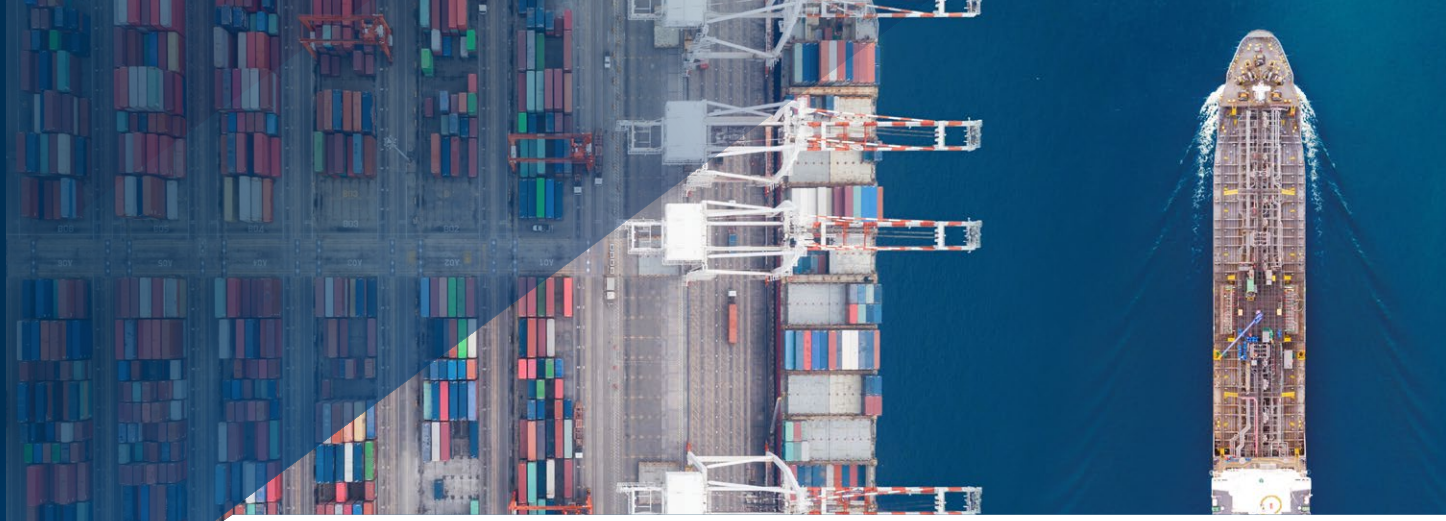
Table of contents

Tables

Figures



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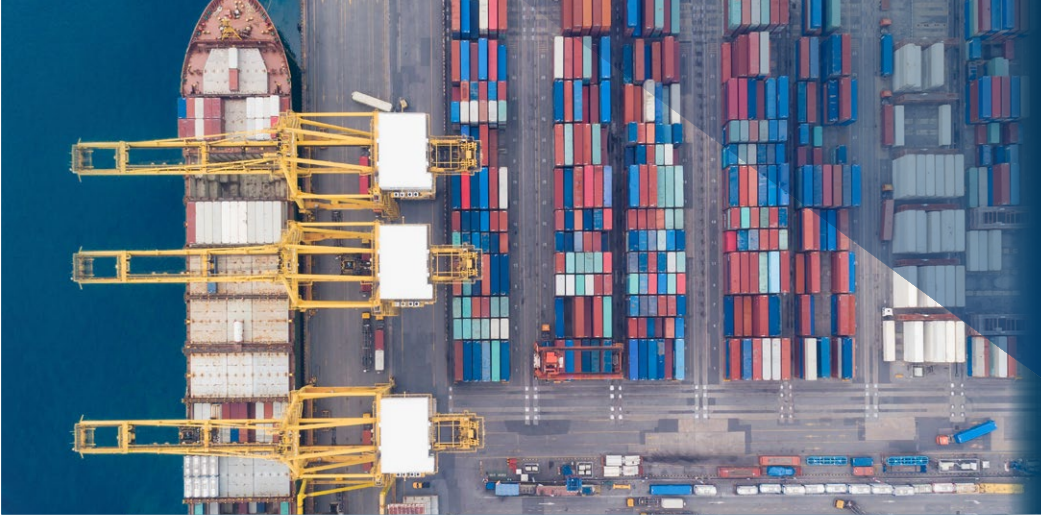

Acronyms

AIS	automatic identification system
CI	crane intensity
COVID-19	coronavirus disease 2019
CPPI 2020	Container Port Performance Index 2020
CPPI 2021	Container Port Performance Index 2021
EEZ	exclusive economic zone
FA	factor analysis
GCI	Global Competitiveness Index
GCMPH	Gross Crane Moves per Hour
GDP	gross domestic product
GRT	gross register 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 ship is fully secured at berth, and all mooring lines are fast.

Arrival: The total elapsed time between the Automatic Identification System (AIS) recorded arrival at the actual port limit (so excludes waiting time at anchorage) and the vessel all lines fast at the berth.

Berth Hours: The time elapsed from all lines fast to all lines released.

Call size: The number of container moves per call.

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 transshipment container activity.

Moves: Total container moves. Discharge + restowage moves + load. Excluding hatch covers, gearboxes, and so on.

Moves per Crane: Total Moves for a Call divided by the Crane Intensity.

Other Berth Hours: Activities between All-Fast and First Lift ("Start") plus the time taken to depart from the berth (All Lines Released) after the Last container Lift ("Finish").

Other Port Hours +"Arrival": The combination of idle/waiting time at anchorage plus the time required to steam-in from the Port Limits and until All-Fast alongside the berth.

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 to Berth Hours: The time from when a ship first arrived at the port limits or anchorage zone until it is all fast alongside the berth.

Ship size: Nominal capacity in Twenty Foot Equivalent Units or TEUs.

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 or TEUs.

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 COVID-19 pandemic, the March 2021 blocking of the Suez Canal by a container ship that had run aground, and the more recent shock engendered by Russia's invasion of Ukraine continue to impact the global economy. The most visible indications of stress in the system are the shortages of certain products, the ships waiting at anchorage outside the major maritime ports, and the impact on the cost of goods. These challenges also continue to underline the critical role that ports, and their associated logistical chains, play in the global economy.

A great variety of public and private stakeholders interact in a port to maintain the flows of vital medical and food supplies, critical agricultural products, energy streams, and other goods and services essential to facilitate the economic life of a country. These interactions comprise physical interactions, such as cargo-handling operations, vessel-related services, and transfers to/from land-based modes for imports and exports.

Maritime transport carries over 80 percent of global merchandise trade by volume, and any impediment or friction at the port will have tangible repercussions for their respective hinterlands and populations. In the short term, this is likely to take the form of shortages of essential goods and higher prices, as we saw early in the pandemic. But over the medium to longer term, an inefficient port will result in slower economic growth, less employment, and higher costs for importers and exporters.

Despite the centrality of the port to global value chains, one of the major challenges to stimulating improvement 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.

However, the introduction of new technologies, increased digitalization, and the willingness on the part of industry interests to work collectively toward systemwide improvements now provide the capacity and the opportunity to measure and compare container port performance in a robust and reliable manner. This technical report, which represents the second edition of the Container Port Performance Index (CPPI), has been produced by the Transport Global Practice of the World Bank in collaboration with the Maritime, Trade and Supply Chain division of S&P Global Market Intelligence.

The CPPI is intended, as in its earlier iteration, 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 CPPI is not intended to cover the entire performance of a port, but to illustrate opportunities for improvement and, hopefully, stimulate a dialogue among key stakeholders to move this essential agenda forward.

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Executive summary

Maritime transport is the backbone of globalized trade and the manufacturing supply chain. The maritime sector offers the most economical, energy efficient, and reliable mode of transportation over long distances. More than four-fifths of global merchandise trade (by volume) is carried by sea. A significant and growing portion of that volume, accounting for approximately 35 percent of total volumes and more than 60 percent of commercial value, is carried in containers. The growth of containerization has led to vast changes in the where and the how goods are manufactured and processed, a process that continues to evolve. Container ports, accordingly, are critical nodes in global supply chains and central to the growth strategies of many emerging economies. In many cases, the development of high-quality container port infrastructure, operated efficiently, has been a prerequisite to successful export-led growth strategies. It can facilitate investment in production and distribution systems, supporting the expansion of manufacturing and logistics, creating employment, and raising income levels.

Accordingly, how a maritime port performs is a crucial element in the cost of international trade for a country. Unfortunately, ports and terminals, particularly for containers, can often be sources of shipment delays, supply chain disruptions, additional costs, and reduced competitiveness. Poorly performing ports are characterized by limitations in spatial and operating efficiency, limitations in maritime and landside access, inadequate oversight, and poor coordination between the public agencies involved, resulting in a lack of predictability and reliability. Poor performance can also have an impact far beyond the hinterland of a port: Container shipping services are operated on fixed schedules with vessel turnaround at each of the ports of call on the route planned within the allocated time for port stay. Poor performance at one port on the route could disrupt the entire schedule. The result far too often is that instead of facilitating trade, the port increases the cost of imports and exports, reduces the competitiveness of its host country and its hinterland, and inhibits economic growth and poverty reduction. These impacts can be particularly pronounced for landlocked developing countries (LLDCs) and the small island developing states (SIDS).

Despite the centrality of the port to global value chains, one of the major challenges to stimulating improvement 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 comparable measure(s) to assess performance across ports and time. The introduction of new technologies, increased digitalization, and the willingness of industry interests to work collectively toward systemwide improvements has now provided the opportunity to measure and compare container port performance in a robust and reliable manner. This technical paper, which presents the second edition of the Container Port Performance Index (CPPI), has been produced by the World Bank's Transport Global Practice in collaboration with the Maritime, Trade and Supply Chain division of S&P Global Market Intelligence.

The CPPI is intended to identify gaps and opportunities for improvement that will ultimately benefit all stakeholders from shipping lines to national governments to consumers. The CPPI is intended to serve as a reference point 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, logistic, and supply chain services.

The development of the CPPI rests on total port time in the manner explained in subsequent sections of the report. This second iteration utilizes data for the full calendar year 2021. It includes ports that had a minimum of 20 valid port calls within the 12-month period of the study. Accordingly, the number of ports covered has increased from 351 in CPPI 2020 to 370 in this edition. The CPPI 2021 has again 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. The two approaches are explained later in the report, with further detail on the latter provided in appendix B.

Table E.1 presents the CPPI 2021 using the same two methodological approaches. The ranking and score in the right-hand columns result from the use of the statistical approach and the ranking and score in the left-hand columns result from the administrative approach. The index points used to construct the ranking in the administrative approach reflect the approach outlined in chapter 2 of the report, which is an aggregate of the performance of the port, weighted relative to the average, across call and vessel size. Accordingly, the score can be negative, where a port compares poorly to the average in one call size and vessel size category, particularly if it does not have an offsetting positive score(s) in other cell(s). Appendix A, table A.1, also provides the score for each port, by call size and vessel size, and hence potential areas of focus for interventions. Further iterations of the CPPI will explore the determinants of the ranking in more detail.

The use of FA also results in a statistic (a total score) that is the sum of a weighted average of indices for each of the same five vessel sizes: feeders (<1,500 TEUs), intra-regional (1,500–5,000 TEUs), intermediate (5,000–8,500 TEUs), neo-Panamax (8,500–13,500 TEUs), and ultra-large container carriers (>13,500 TEU). The indices for each vessel size are estimated based on the time expired in the port and a number of unknown factors, or latent variables (see appendix B for a more detailed explanation of the approach), which impact on performance, but cannot be seen. The resulting total scores are standardized, with a “negative” score indicating a performance that is better than the average. Overall, there is a marked improvement in consistency between the rankings that result from the two approaches, and a considerable reduction in divergences compared to CPPI 2020.

The two top-ranked container ports in the CPPI 2021 are King Abdullah Port (Saudi Arabia) 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. King Abdullah Port was ranked second in both approaches in CPPI 2020. The Port of Salalah ranked sixth and ninth in the statistical and administrative approaches, respectively, in CPPI 2020. Of the top 10 ranked ports, all have improved their position since CPPI 2020, with Jeddah and Hamad Port moving up 35 and 34 positions in the ranking, respectively. The exceptions are Yokohama, which has fallen from first place in both approaches in 2020, to 10th and 12th in CPPI 2021 in the administrative and statistical approaches, respectively, and Guangzhou, which dropped from sixth to ninth place in the administrative approach.

There are 37 new entrants to the CPPI 2021, and a number of significant movers in terms of their ranking since the CPPI 2020. One hundred and forty-nine ports improved their rankings in CPPI 2021, compared to CPPI 2020, with some of the largest improvers increasing their ranking by over 200 positions. By contrast, the ranking of 182 ports fell in the CPPI 2021, over the inaugural edition, with some of the largest movers falling nearly 300 positions, reflecting the challenges faced by ports during the period of the study.

TABLE E.1. • The CPPI 2021: Global Ranking of Container Ports

ADMINISTRATIVE APPROACH			STATISTICAL APPROACH		
Port Name	Rank	Total Points	Port Name	Rank	Index Value
KING ABDULLAH PORT	1	217.914	KING ABDULLAH PORT	1	93.387
SALALAH	2	197.675	SALALAH	2	87.372
HAMAD PORT	3	194.823	YANGSHAN	3	83.522
YANGSHAN	4	183.455	HAMAD PORT	4	82.146
KHALIFA PORT	5	182.649	KHALIFA PORT	5	81.052
TANGER-MEDITERRANEAN	6	178.096	TANGER-MEDITERRANEAN	6	80.411
NINGBO	7	170.696	NINGBO	7	76.077
JEDDAH	8	161.493	JEDDAH	8	73.527
GUANGZHOU	9	161.331	GUANGZHOU	9	72.749
YOKOHAMA	10	159.234	ALGECIRAS	10	70.323
ALGECIRAS	11	155.851	CAI MEP	11	67.529
CARTAGENA (COLOMBIA)	12	152.950	YOKOHAMA	12	66.451
CAI MEP	13	148.433	PORT SAID	13	63.390
DAMMAM	14	143.504	DAMMAM	14	62.454
PORT SAID	15	141.336	CARTAGENA (COLOMBIA)	15	61.901
SHEKOU	16	137.844	TANJUNG PELEPAS	16	59.830
CHIWAN	17	132.828	SHEKOU	17	58.312
TANJUNG PELEPAS	18	131.424	HALIFAX	18	56.910
DJIBOUTI	19	129.354	BARCELONA	19	55.311
BUENAVENTURA	20	124.415	CHIWAN	20	55.013
KAOHSIUNG	21	123.452	KAOHSIUNG	21	54.588
BARCELONA	22	119.332	COLOMBO	22	54.090
PORT OF VIRGINIA	23	118.295	BUENAVENTURA	23	53.033
COLOMBO	24	117.493	DJIBOUTI	24	52.476
BUSAN	25	114.739	BUSAN	25	52.307
PIPAVAV	26	109.823	TIANJIN	26	51.441
TIANJIN	27	109.448	PORT OF VIRGINIA	27	50.444
YARIMCA	28	106.663	MERSIN	28	49.791
MIAMI	29	105.762	YEOSU	29	48.823
SINES	30	105.359	YARIMCA	30	48.489
SINGAPORE	31	103.562	SINGAPORE	31	47.816
MAGDALLA	32	103.005	AQABA	32	45.327
YEOSU	33	102.674	QINGDAO	33	44.227
MERSIN	34	102.273	PIPAVAV	34	43.713
AQABA	35	101.250	SINES	35	42.930
OSAKA	36	100.987	AMBARLI	36	42.530
VUNG TAU	37	100.873	KOBE	37	41.998
JEBEL ALI	38	100.226	HONG KONG	38	41.377
CORONEL	39	100.170	MIAMI	39	40.559
KOBE	40	99.002	XIAMEN	40	39.737
SHIMIZU	41	96.454	MAGDALLA	41	37.582
QINGDAO	42	95.043	JEBEL ALI	42	37.549

ADMINISTRATIVE APPROACH			STATISTICAL APPROACH		
Port Name	Rank	Total Points	Port Name	Rank	Index Value
AMBARLI	43	93.586	NAGOYA	43	37.197
MAWAN	44	92.571	OSAKA	44	36.350
XIAMEN	45	92.212	SHIMIZU	45	35.895
HALIFAX	46	91.744	MUNDRA	46	35.568
SOHAR	47	89.717	SOHAR	47	35.096
MUNDRA	48	86.563	LAEM CHABANG	48	34.706
WILMINGTON (NORTH CAROLINA)	49	84.187	CORONEL	49	33.796
HONG KONG	50	83.775	JAWAHARLAL NEHRU PORT	50	33.142
IMBITUBA	51	82.974	TOKYO	51	32.543
INCHEON	52	82.106	MANZANILLO (MEXICO)	52	31.859
NAGOYA	53	81.608	INCHEON	53	31.820
JAWAHARLAL NEHRU PORT	54	79.672	BREMERHAVEN	54	29.896
PHILADELPHIA	55	74.759	BALBOA	55	29.611
TOKYO	56	74.453	DAMIETTA	56	29.427
LAEM CHABANG	57	74.024	WILMINGTON (NORTH CAROLINA)	57	29.111
DAMIETTA	58	72.703	PHILADELPHIA	58	28.729
BREMERHAVEN	59	67.922	PORT KLANG	59	28.629
BALBOA	60	67.846	ITAPOA	60	26.592
TAMPA	61	67.841	KHALIFA BIN SALMAN	61	26.488
KHALIFA BIN SALMAN	62	67.720	TAMPA	62	25.486
HAIPHONG	63	67.120	HAIPHONG	63	24.603
PORT TAMPA BAY	64	64.318	COLON	64	24.562
GIOIA TAURO	65	62.420	POSORJA	65	24.225
POSORJA	66	61.465	PORT TAMPA BAY	66	24.194
KEELUNG	67	59.776	AARHUS	67	24.076
HAZIRA	68	59.142	BALTIMORE (MARYLAND)	68	23.730
PORT KLANG	69	59.038	HAZIRA	69	23.585
ISKENDERUN	70	59.012	DILISKELESI	70	23.442
SANTA CRUZ DE TENERIFE	71	58.835	KAMARAJAR	71	22.441
ITAPOA	72	57.826	ISKENDERUN	72	21.916
COLON	73	57.339	LIANYUNGANG	73	21.818
MARSAXLOKK	74	54.994	MARSAXLOKK	74	21.723
PAITA	75	54.742	MUHAMMAD BIN QASIM	75	21.688
BALTIMORE (MARYLAND)	76	54.641	ALTAMIRA	76	21.645
DILISKELESI	77	54.305	KEELUNG	77	20.716
LIANYUNGANG	78	53.418	ANTWERP	78	20.671
CHENNAI	79	53.394	JOHOR	79	20.597
JOHOR	80	52.565	PUERTO LIMON	80	20.312
MUHAMMAD BIN QASIM	81	50.962	DALIAN	81	20.193
AARHUS	82	50.953	PIRAEUS	82	20.096

ADMINISTRATIVE APPROACH			STATISTICAL APPROACH		
Port Name	Rank	Total Points	Port Name	Rank	Index Value
DALIAN	83	50.940	RIO DE JANEIRO	83	20.056
KAMARAJAR	84	50.258	PAITA	84	20.015
ALTAMIRA	85	50.070	VERACRUZ	85	20.014
PUERTO LIMON	86	47.807	ENSENADA	86	20.013
TRIPOLI (LEBANON)	87	47.491	KRISHNAPATNAM	87	19.994
NOUMEA	88	46.920	SANTA CRUZ DE TENERIFE	88	19.591
MANZANILLO (MEXICO)	89	46.685	TRIPOLI (LEBANON)	89	19.531
KARACHI	90	46.399	KARACHI	90	19.459
YOKKAICHI	91	46.268	RIO GRANDE (BRAZIL)	91	19.297
LAZARO CARDENAS	92	46.050	CHENNAI	92	18.847
RIO DE JANEIRO	93	45.956	NOUMEA	93	18.277
SAVONA-VADO	94	45.900	JACKSONVILLE	94	17.677
KRISHNAPATNAM	95	45.824	KATTUPALLI	95	17.567
ANTWERP	96	45.146	FUZHOU	96	17.317
RIO GRANDE (BRAZIL)	97	44.636	VISAKHAPATNAM	97	17.160
VISAKHAPATNAM	98	44.483	COCHIN	98	17.057
COCHIN	99	44.280	CAUCEDO	99	16.868
JACKSONVILLE	100	44.256	SIAM SEAPORT	100	16.867
PIRAEUS	101	43.772	YOKKAICHI	101	16.864
ENSENADA	102	43.588	PORT EVERGLADES	102	16.769
SIAM SEAPORT	103	43.527	TANJUNG PERAK	103	16.338
VERACRUZ	104	43.117	NANTES SAINT-NAZAIRE	104	16.047
NANTES SAINT-NAZAIRE	105	41.619	GEMLIK	105	15.943
KATTUPALLI	106	41.494	IMBITUBA	106	15.827
TANJUNG PERAK	107	41.333	POINTE-À-PITRE	107	15.702
VALPARAISO	108	40.314	NEW ORLEANS	108	15.404
POINTE-À-PITRE	109	40.162	LAZARO CARDENAS	109	15.138
PUERTO QUETZAL	110	36.422	MAWAN	110	14.962
PENANG	111	36.340	SAVONA-VADO	111	14.739
SALVADOR	112	36.123	GIOIA TAURO	112	14.642
GEMLIK	113	36.099	VALPARAISO	113	14.494
CAUCEDO	114	34.291	TANJUNG PRIOK	114	13.605
NEW ORLEANS	115	34.153	BOSTON (USA)	115	13.428
PORT EVERGLADES	116	33.709	PENANG	116	13.331
BOSTON (USA)	117	33.384	HAKATA	117	12.580
GOTHENBURG	118	32.139	LIRQUEN	118	12.555
HOUSTON	119	32.044	SEPETIBA	119	11.902
NAHA	120	31.940	OMAEZAKI	120	11.448
PECEM	121	29.363	MOJI	121	10.971
FORT-DE-FRANCE	122	28.535	DA CHAN BAY TERMINAL ONE	122	10.951
SEPETIBA	123	28.257	HOUSTON	123	10.771
TANJUNG PRIOK	124	28.231	BUENOS AIRES	124	10.536

ADMINISTRATIVE APPROACH			STATISTICAL APPROACH		
Port Name	Rank	Total Points	Port Name	Rank	Index Value
TAICHUNG	125	27.616	SAIGON	125	10.436
LIRQUEN	126	26.883	NAHA	126	10.434
OMAEZAKI	127	26.855	FORT-DE-FRANCE	127	10.420
HAKATA	128	26.746	KINGSTON (JAMAICA)	128	10.158
KOPER	129	26.321	PECEM	129	10.037
CHARLESTON	130	26.183	SALVADOR	130	9.682
KINGSTON (JAMAICA)	131	25.432	PORT BRONKA	131	9.559
MOJI	132	24.923	CAT LAI	132	9.460
FUZHOU	133	24.656	EL DEKHEILA	133	9.355
CRISTOBAL	134	24.246	PUERTO QUETZAL	134	9.340
VALENCIA	135	23.809	TAICHUNG	135	9.315
ZHOUSHAN	136	22.522	UMM QASR	136	8.849
MALAGA	137	22.325	SANTA MARTA	137	8.715
PORT BRONKA	138	22.021	VIGO	138	8.620
EL DEKHEILA	139	21.701	PORT AKDENIZ	139	8.467
SAIGON	140	21.080	MALAGA	140	8.270
BUENOS AIRES	141	21.032	PUERTO CORTES	141	8.141
DA CHAN BAY TERMINAL ONE	142	20.563	OSLO	142	8.025
SANTA MARTA	143	20.317	SAN JUAN	143	8.022
PUERTO CORTES	144	20.098	TANJUNG EMAS	144	7.855
CAT LAI	145	19.813	ITAJAÍ	145	7.811
OSLO	146	18.877	QUY NHON	146	7.640
LIMASSOL	147	18.415	SANTOS	147	7.590
BORUSAN	148	18.332	SHARJAH	148	7.570
VIGO	149	18.234	BORUSAN	149	7.476
UMM QASR	150	17.973	MOBILE	150	7.384
WELLINGTON	151	17.761	SHANTOU	151	6.977
PORT AKDENIZ	152	17.753	GOTHENBURG	152	6.911
TANJUNG EMAS	153	17.284	PUERTO BOLIVAR (ECUADOR)	153	6.649
QUY NHON	154	17.144	CHORNOMORSK	154	6.638
SHARJAH	155	16.731	RIO HAINA	155	6.621
PUERTO BOLIVAR (ECUADOR)	156	16.720	DANANG	156	6.541
SAN JUAN	157	16.477	TARRAGONA	157	6.501
RIO HAINA	158	16.156	PAPEETE	158	6.438
BARRANQUILLA	159	16.034	NOVOROSSIYSK	159	6.273
TARRAGONA	160	15.948	MUUGA-PORT OF TALLINN	160	6.248
DANANG	161	15.780	CIVITAVECCHIA	161	6.047
CIVITAVECCHIA	162	15.620	SAN VICENTE	162	6.011
MOBILE	163	15.366	BARRANQUILLA	163	5.981
CEBU	164	14.903	ODESSA	164	5.755
SHANTOU	165	14.432	BERBERA	165	5.752
SAN VICENTE	166	14.418	PARANAGUA	166	5.744

ADMINISTRATIVE APPROACH			STATISTICAL APPROACH		
Port Name	Rank	Total Points	Port Name	Rank	Index Value
PAPEETE	167	14.229	HELSINGBORG	167	5.739
HELSINGBORG	168	14.121	ANCONA	168	5.537
CHORNOMORSK	169	13.895	HELSINKI	169	5.524
PUERTO BARRIOS	170	13.762	KLAIPEDA	170	5.482
MATADI	171	13.688	CEBU	171	5.364
NOVOROSSIYSK	172	13.554	LIMASSOL	172	5.203
PLOČE	173	13.197	LATAKIA	173	5.061
LATAKIA	174	13.064	PHILIPSBURG	174	5.027
MUUGA-PORT OF TALLINN	175	12.837	PORT-AU-PRINCE	175	4.921
FREDERICIA	176	12.830	MATADI	176	4.869
PHILIPSBURG	177	12.744	SHUAIBA	177	4.853
PORT-AU-PRINCE	178	12.047	SUBIC BAY	178	4.820
ANCONA	179	11.804	SHUWAIKH	179	4.729
HELSINKI	180	11.625	VALENCIA	180	4.685
SUBIC BAY	181	11.622	PLOČE	181	4.675
NORRKOPING	182	11.336	BAR	182	4.639
BAR	183	11.238	FREDERICIA	183	4.634
BERBERA	184	10.913	NORRKOPING	184	4.593
SHUAIBA	185	10.770	CRISTOBAL	185	4.443
KLAIPEDA	186	10.587	CALLAO	186	4.400
RAVENNA	187	10.047	CHARLESTON	187	4.399
SANTOS	188	9.866	RAVENNA	188	4.056
SHUWAIKH	189	9.587	NELSON	189	3.966
RIJEKA	190	9.469	GUSTAVIA	190	3.960
CATANIA	191	9.365	JUBAIL	191	3.870
SALERNO	192	9.315	WELLINGTON	192	3.722
BARI	193	9.166	CATANIA	193	3.579
NELSON	194	8.590	BARI	194	3.490
BURGAS	195	8.586	SALERNO	195	3.237
HAIFA	196	8.497	PUERTO BARRIOS	196	3.154
GUSTAVIA	197	8.136	BURGAS	197	3.072
PARANAGUA	198	8.119	PALERMO	198	2.735
APRA HARBOR	199	7.721	GDANSK	199	2.722
PUERTO PROGRESO	200	7.525	RIJEKA	200	2.632
RAUMA	201	7.474	BILBAO	201	2.558
BILBAO	202	7.192	LEIXÕES	202	2.509
GDANSK	203	6.155	APRA HARBOR	203	2.387
PALERMO	204	5.569	WILHELMSHAVEN	204	2.236
LEIXÕES	205	5.299	PUERTO PROGRESO	205	2.197
COPENHAGEN	206	4.970	LARVIK	206	2.153
ITAJAÍ	207	4.452	RIGA	207	2.089
CAGAYAN DE ORO	208	4.440	NASSAU	208	1.920

ADMINISTRATIVE APPROACH			STATISTICAL APPROACH		
Port Name	Rank	Total Points	Port Name	Rank	Index Value
ODESSA	209	4.411	TRAPANI	209	1.804
LARVIK	210	4.325	RAUMA	210	1.793
KAWASAKI	211	4.222	BELL BAY	211	1.682
NASSAU	212	4.013	HERAKLION	212	1.578
TRAPANI	213	3.980	POTI	213	1.537
RIGA	214	3.903	VITÓRIA	214	1.535
LISBON	215	3.589	TARTOUS	215	1.534
HERAKLION	216	3.267	CHU LAI	216	1.476
VITÓRIA	217	3.264	CADIZ	217	1.288
BELL BAY	218	3.146	KOPER	218	1.152
TARTOUS	219	2.818	MARIEL	219	1.047
CHU LAI	220	2.797	LISBON	220	0.836
CADIZ	221	2.588	KRISTIANSAND	221	0.831
MARIEL	222	1.973	ALICANTE	222	0.745
KRISTIANSAND	223	1.764	BORDEAUX	223	0.626
NEMRUT BAY	224	1.695	GIJON	224	0.596
VARNA	225	1.502	GDYNIA	225	0.530
POTI	226	1.404	CAGAYAN DE ORO	226	0.415
MAZATLAN	227	1.394	COPENHAGEN	227	0.266
BORDEAUX	228	1.158	ZHOUSHAN	228	0.225
ALICANTE	229	1.007	GEORGETOWN (GUYANA)	229	0.210
KOMPONG SOM	230	0.902	VENICE	230	0.147
MEJILLONES	231	0.860	KOTKA	231	-0.149
HAMBURG	232	0.185	RADES	232	-0.164
WILHELMSHAVEN	233	-0.020	BATUMI	233	-0.183
ANTOFAGASTA	234	-0.322	BLUFF	234	-0.308
VENICE	235	-0.390	SAINT JOHN	235	-0.325
GIJON	236	-0.544	PANJANG	236	-0.399
RADES	237	-0.821	TOMAKOMAI	237	-0.448
GEORGETOWN (GUYANA)	238	-0.963	BELAWAN	238	-0.480
TOMAKOMAI	239	-1.381	CONAKRY	239	-0.481
SAINT JOHN	240	-1.730	MAZATLAN	240	-0.524
BLUFF	241	-1.784	MEJILLONES	241	-0.564
CONAKRY	242	-1.833	NEMRUT BAY	242	-0.745
KOTKA	243	-2.040	KOMPONG SOM	243	-0.874
VILA DO CONDE	244	-2.095	QINZHOU	244	-0.929
BATUMI	245	-2.241	VILA DO CONDE	245	-0.934
PANJANG	246	-2.779	IZMIR	246	-1.093
QINZHOU	247	-3.362	HAIFA	247	-1.267
SAMSUN	248	-3.711	VARNA	248	-1.584
JUBAIL	249	-3.792	KAWASAKI	249	-1.752
BELAWAN	250	-3.890	TEESPORT	250	-2.064
NEW YORK AND NEW JERSEY	251	-4.321	NEW YORK AND NEW JERSEY	251	-2.159

ADMINISTRATIVE APPROACH			STATISTICAL APPROACH		
Port Name	Rank	Total Points	Port Name	Rank	Index Value
GAVLE	252	-4.762	PORT OF SPAIN	252	-2.258
IZMIR	253	-4.805	SAMSUN	253	-2.272
PORT OF SPAIN	254	-5.624	MOGADISCIO	254	-2.435
GDYNIA	255	-6.058	ST. PETERSBURG	255	-2.789
ST. PETERSBURG	256	-6.294	GAVLE	256	-3.180
TEESPORT	257	-6.418	ADELAIDE	257	-3.425
CALLAO	258	-6.638	HAMBURG	258	-3.518
MOGADISCIO	259	-7.613	MANAUS	259	-3.644
CALDERA (COSTA RICA)	260	-8.156	AGADIR	260	-3.714
AGADIR	261	-8.711	CONSTANTZA	261	-3.719
CASABLANCA	262	-9.239	CASABLANCA	262	-4.073
MANAUS	263	-9.337	LA GUAIRA	263	-4.392
ADELAIDE	264	-9.863	CALDERA (COSTA RICA)	264	-4.755
LA GUAIRA	265	-10.037	MONTEVIDEO	265	-4.983
YANTIAN	266	-10.230	ALEXANDRIA (EGYPT)	266	-5.001
TURBO	267	-11.329	NAPLES	267	-5.039
FREETOWN	268	-11.843	BEIRA	268	-5.257
HUENEME	269	-12.006	ACAJUTLA	269	-5.390
BEIRA	270	-12.045	YANTIAN	270	-5.466
ACAJUTLA	271	-12.182	VUNG TAU	271	-5.658
CONSTANTZA	272	-12.712	FREETOWN	272	-5.691
SANTO TOMAS DE CASTILLA	273	-13.292	ANTOFAGASTA	273	-5.760
DAVAO	274	-13.669	HUENEME	274	-6.110
FORTALEZA	275	-14.807	SANTO TOMAS DE CASTILLA	275	-6.427
KALININGRAD	276	-14.877	KALININGRAD	276	-6.574
ALEXANDRIA (EGYPT)	277	-15.305	TURBO	277	-6.623
ZEEBRUGGE	278	-15.389	FORTALEZA	278	-6.668
TOAMASINA	279	-16.113	DAVAO	279	-6.968
SUAPE	280	-17.478	TOAMASINA	280	-7.109
TAKORADI	281	-18.202	BRISBANE	281	-8.469
QASR AHMED	282	-18.283	NAPIER	282	-8.561
NAPLES	283	-19.737	CORINTO	283	-8.686
MONTEVIDEO	284	-20.895	PUERTO CABELLO	284	-9.380
BEJAIA	285	-21.270	ADEN	285	-9.507
CORINTO	286	-21.337	LE HAVRE	286	-9.533
PUERTO CABELLO	287	-23.284	SUAPE	287	-9.607
BRISBANE	288	-24.619	QASR AHMED	288	-9.944
PORT VICTORIA	289	-25.449	BEJAIA	289	-10.471
NAPIER	290	-25.742	TAKORADI	290	-11.023
ROTTERDAM	291	-26.820	ZEEBRUGGE	291	-11.150
LE HAVRE	292	-26.886	OTAGO HARBOUR	292	-11.396
MOMBASA	293	-27.174	MAYOTTE	293	-11.873

ADMINISTRATIVE APPROACH			STATISTICAL APPROACH		
Port Name	Rank	Total Points	Port Name	Rank	Index Value
MAYOTTE	294	-27.444	MELBOURNE	294	-11.938
POINT LISAS PORTS	295	-28.104	ARICA	295	-12.157
GUAYAQUIL	296	-29.497	MOMBASA	296	-12.177
ARICA	297	-30.042	MARSEILLE	297	-12.209
OTAGO HARBOUR	298	-30.113	PORT VICTORIA	298	-12.337
BANGKOK	299	-30.452	DUBLIN	299	-12.365
DUBLIN	300	-30.607	ROTTERDAM	300	-13.017
LAE	301	-31.730	POINT LISAS PORTS	301	-13.433
OWENDO	302	-32.614	GUAYAQUIL	302	-13.513
DAKAR	303	-32.840	OWENDO	303	-13.583
YANGON	304	-34.103	BANGKOK	304	-14.923
ADEN	305	-34.779	ALGIERS	305	-15.275
ALGIERS	306	-36.205	LAE	306	-16.182
GRANGEMOUTH	307	-36.219	YANGON	307	-16.590
MELBOURNE	308	-37.421	DAKAR	308	-17.575
DURRES	309	-37.626	LA SPEZIA	309	-18.987
TIMARU	310	-37.693	YUZHNY	310	-19.100
MONTREAL	311	-39.809	IQUIQUE	311	-19.234
PORT ELIZABETH	312	-46.416	LYTTELTON	312	-19.801
LA SPEZIA	313	-47.346	MONTREAL	313	-20.272
LYTTELTON	314	-47.720	TIMARU	314	-21.135
MARSEILLE	315	-49.482	SAN PEDRO (COTE D'IVOIRE)	315	-21.804
SHANGHAI	316	-51.827	GRANGEMOUTH	316	-22.520
YUZHNY	317	-52.207	PORT ELIZABETH	317	-23.885
SAN PEDRO (COTE D'IVOIRE)	318	-53.819	SHANGHAI	318	-24.039
IQUIQUE	319	-53.887	DURRES	319	-24.525
SAN ANTONIO	320	-55.808	SAN ANTONIO	320	-25.395
MAPUTO	321	-58.683	PORT BOTANY	321	-25.565
LIVERPOOL (UNITED KINGDOM)	322	-58.778	SEATTLE	322	-25.648
PORT LOUIS	323	-61.778	MAPUTO	323	-26.003
PORT BOTANY	324	-63.908	MANILA	324	-28.809
TAURANGA	325	-64.477	LIVERPOOL (UNITED KINGDOM)	325	-29.027
TRIESTE	326	-64.659	VLADIVOSTOK	326	-29.594
MANILA	327	-67.096	THESSALONIKI	327	-29.655
WALVIS BAY	328	-68.372	FREMANTLE	328	-29.997
ASHDOD	329	-69.310	PORT LOUIS	329	-30.575
VLADIVOSTOK	330	-69.773	TAURANGA	330	-31.494
THESSALONIKI	331	-71.418	PORT RÉUNION	331	-33.187
DUTCH HARBOR	332	-74.601	WALVIS BAY	332	-34.889
PORT RÉUNION	333	-85.474	LIVORNO	333	-37.620
FELIXSTOWE	334	-86.502	TIN CAN ISLAND	334	-38.451
FREMANTLE	335	-90.529	GENOA	335	-39.902

ADMINISTRATIVE APPROACH			STATISTICAL APPROACH		
Port Name	Rank	Total Points	Port Name	Rank	Index Value
SEATTLE	336	-92.888	FELIXSTOWE	336	-40.078
GENOA	337	-93.568	DUTCH HARBOR	337	-40.159
LIVORNO	338	-96.571	TRIESTE	338	-40.420
TIN CAN ISLAND	339	-98.354	PRINCE RUPERT	339	-44.345
DOUALA	340	-106.203	DOUALA	340	-44.552
CHATTOGRAM	341	-109.249	TACOMA	341	-45.529
ONNE	342	-111.104	ASHDOD	342	-46.157
BRISTOL	343	-111.703	ONNE	343	-49.702
PRINCE RUPERT	344	-114.287	BRISTOL	344	-52.914
TACOMA	345	-119.152	DUNKIRK	345	-53.157
SOUTHAMPTON	346	-120.369	COTONOU	346	-54.931
LONDON	347	-124.535	CHATTOGRAM	347	-54.949
COTONOU	348	-130.819	SOUTHAMPTON	348	-55.490
LOMÉ	349	-133.170	LOMÉ	349	-56.728
DUNKIRK	350	-142.600	AUCKLAND	350	-62.159
AUCKLAND	351	-142.913	FREEPORT (BAHAMAS)	351	-64.071
FREEPORT (BAHAMAS)	352	-157.072	SOKHNA	352	-66.771
SOKHNA	353	-158.457	TEMA	353	-67.093
TEMA	354	-160.565	NOUAKCHOTT	354	-70.175
KRIBI DEEP SEA PORT	355	-174.476	LONDON	355	-73.209
NOUAKCHOTT	356	-175.532	BEIRUT	356	-73.234
BEIRUT	357	-183.442	KRIBI DEEP SEA PORT	357	-74.427
LAGOS (NIGERIA)	358	-188.317	LAGOS (NIGERIA)	358	-80.295
OAKLAND	359	-207.413	ABIDJAN	359	-93.807
ABIDJAN	360	-216.138	OAKLAND	360	-95.795
DAR ES SALAAM	361	-248.798	DAR ES SALAAM	361	-105.753
POINTE-NOIRE	362	-320.281	POINTE-NOIRE	362	-110.337
NGQURA	363	-359.179	DURBAN	363	-155.820
DURBAN	364	-386.098	CAPE TOWN	364	-159.253
CAPE TOWN	365	-410.746	NGQURA	365	-170.593
LUANDA	366	-442.446	LUANDA	366	-174.675
SAVANNAH	367	-464.721	SAVANNAH	367	-217.103
VANCOUVER (CANADA)	368	-573.524	VANCOUVER (CANADA)	368	-245.879
LONG BEACH	369	-952.470	LOS ANGELES	369	-281.841
LOS ANGELES	370	-954.086	LONG BEACH	370	-348.928

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

The CPPI 2021 also sees a marked reduction in discrepancies between the findings of the administrative and statistical approaches compared to CPPI 2020. 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. 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). Approximately 40 percent (137 ports) were ranked within 10 places or less of themselves in the CPPI 2020. CPPI 2021 registered 267 ports (72 percent) which were ranked within 10 places or less of themselves, a 32 percent improvement on CPPI 2020 rankings. In CPPI 2021, the first 20 ports and final 20 ports are within an average of one place from themselves in the dual rankings.

Looking to the future, the intention is that the CPPI will evolve and be enhanced in subsequent editions, reflecting refinement, stakeholder feedback, and improvement in data scope and quality. The World Bank-S&P Global Market Intelligence team will continue to refine the methodologies; the scope, where possible increasing the number of ports; and the data. The overall objective remains the identification of potential improvement to ultimately benefit all public and private stakeholders, including ports, shipping lines, governments, line agencies, businesses, and consumers.

1. Introduction

Maritime transport is the backbone of globalized trade and the manufacturing supply chain, with more than four-fifths of global merchandise trade (by volume) carried by sea. The maritime sector offers the most economical and reliable mode of transportation over long distances. Over the past two decades, compound annual growth in maritime trade has been 2.9 percent. In 2020, maritime trade volumes were impacted by the COVID-19 pandemic, but fell less dramatically than expected, and rebounded by the end of the year, but still ended the year down by 3.8 percent or 10.65 billion tons (UNCTAD 2021). Container trade, accounting for approximately 35 percent of total volume and more than 60 percent by value, fell by 1.2 percent from 2019 levels. Both overall maritime and container trade reflected the 3.5 percent fall in global economic output.

Maritime ports have been central to economic and social development since the dawn of maritime trade. This is as true today as it has been for thousands of years. The growth of containerization, since Malcom McLean's innovation in 1958 (Levinson 2006), has led to vast changes in where and how goods are manufactured, a dynamic process that has not yet stopped evolving. Container ports, as a result, have become critical nodes in global supply chains and are central to the growth stories and strategies of many emerging economies. In many cases, the development of high-quality port infrastructure, operated efficiently, has been a prerequisite to successful, often export-led, growth strategies. Done well, it provides the necessary confidence to facilitate investment in production and distribution systems, supporting the expansion of manufacturing and logistics, creating employment, and raising income levels.

More specifically, how a maritime port performs is a crucial element in the cost of trading for a country. Poorly performing ports constrain trade growth, an impact particularly pronounced for LLDCs and SIDS. The port, together with the access infrastructure (whether inland waterway, rail, or road) to the hinterland, constitutes a crucial link to the global marketplace and needs to operate efficiently. Efficient performance encompasses a myriad factors, including the efficiency of the port itself; the availability of sufficient draught, quay, and dock facilities; the quality of the connections to road and rail services; the competitiveness of those services; and the efficacy of the procedures employed by the public agencies involved in container clearance. Inefficiencies or nontariff barriers in any of these actors will result in higher costs, reduced competitiveness, and lower trade (Kathuria 2018).

The efficiency of port infrastructure has also been identified as a key contributor to 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, resulted 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.

Unfortunately, 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 limitations in spatial and operating efficiency, limitations in maritime and landside access, inadequate oversight, and poor coordination between the public agencies involved, resulting in a lack of predictability and reliability. The result far too often 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 fixed port turnaround times. 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 in order 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 realize improvement 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 challenge of both managing and overseeing the sector historically. While modern ports collect data for performance purposes, it is difficult to compare the outcomes with competitors or with ports in similar circumstances, due to the lack of available comparative date. Managers may know that performance is improving year on year, but they may not know whether performance is up to the standards of leading ports with similar profiles.

Perhaps not surprisingly, 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, to illustrate the broad approaches identified in the literature and comment 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 the willingness on the part of industry interests to work collectively toward systemwide improvements now provides the capacity and opportunity to measure and compare container port performance in a robust and reliable manner. The data used to compile the CPPI 2021 is from S&P Global's Port Performance Program. The Port Performance Program was started in 2009 with the goal of driving efficiency improvements in container port operations and supporting programs to optimize port calls. The program includes 11 of the world's largest liner shipping companies, which collectively operate close to 80 percent of global 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 subsidiary shipping companies. In 2021, performance time stamp data were captured for 164,500 port calls involving 257.4 million container moves at 826 container terminals in 443 ports worldwide. The nature, source, and scope of the data are discussed in the subsequent chapter.

The rationale behind the CPPI was to use available empirical data to create an objective measure to compare container port performance across ports, and eventually over time. Container port performance is most relevant from the perspective of customer experience and the speed and efficiency with which customer assets are handled. In this second edition of the CPPI, the focus remains purely on quayside performance reflecting the experience of a ship operator, the port's main customer. The operational efficiency with which ports receive and turn around container ships is of critical importance

to the carrier's decision to call a port in view of other options. The two methodologies employed in this study, and the justification for their use, are presented in summary in chapter 2, with further detail provided in appendices A and B. The results in terms of the CPPI 2022 are presented in chapter 3, with further detail provided in appendix A.

The CPPI has been developed to contribute to the identification of opportunities for improvement that will ultimately benefit all public and private stakeholders. The CPPI is intended to serve as a reference point 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 engaged in trade, logistic, and supply chain services. The intention of the joint team is that the methodology, scope, and data will be enhanced in subsequent annual iterations, reflecting refinement, stakeholder feedback, and data scope and quality improvements.

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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 included 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, higher levels of reliability and predictability can be achieved, which is advantageous for more effective supply chain operations and planning as containerships will spend around 15 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 will 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, can cause delays to shipments and disruption to supply chains. A service recovery can involve significantly higher sailing speeds, increasing fuel consumption, emissions, and costs, or the omission of a port or ports from the standard rotation, disrupting supply chains and often resulting in additional contingency costs.

Time is valuable for stakeholders, and so it is logical to measure port performance based upon the total amount of time ships are required to spend in port. The CPPI 2021 has been developed based on total port time in the manner explained in subsequent sections. This second iteration utilizes data from the full calendar year of 2021. The construction of the CPPI 2021 has employed the same two approaches as the earlier edition, an administrative approach and a statistical approach, to ensure that the resulting ranking of container port performance reflects as closely as possible actual port performance, whilst also being statistically robust. The approaches are discussed in this chapter, with further detail on the statistical methodology provided in appendix B. The results are presented in chapter 3.

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) to when it departs from the berth having completed its cargo exchange. The time expended from berth departure (all lines up) to the departure from the port limits is deliberately excluded. The justification for the exclusion is that any performance loss that pertains to departure delays, such as pilot or tug availability, readiness of the mooring gang, channel access and water depths, ship readiness, and so on, will be incurred while the ship is still alongside. Additional time resulting from these causes will, therefore, be captured when the clock stops at berth departure.

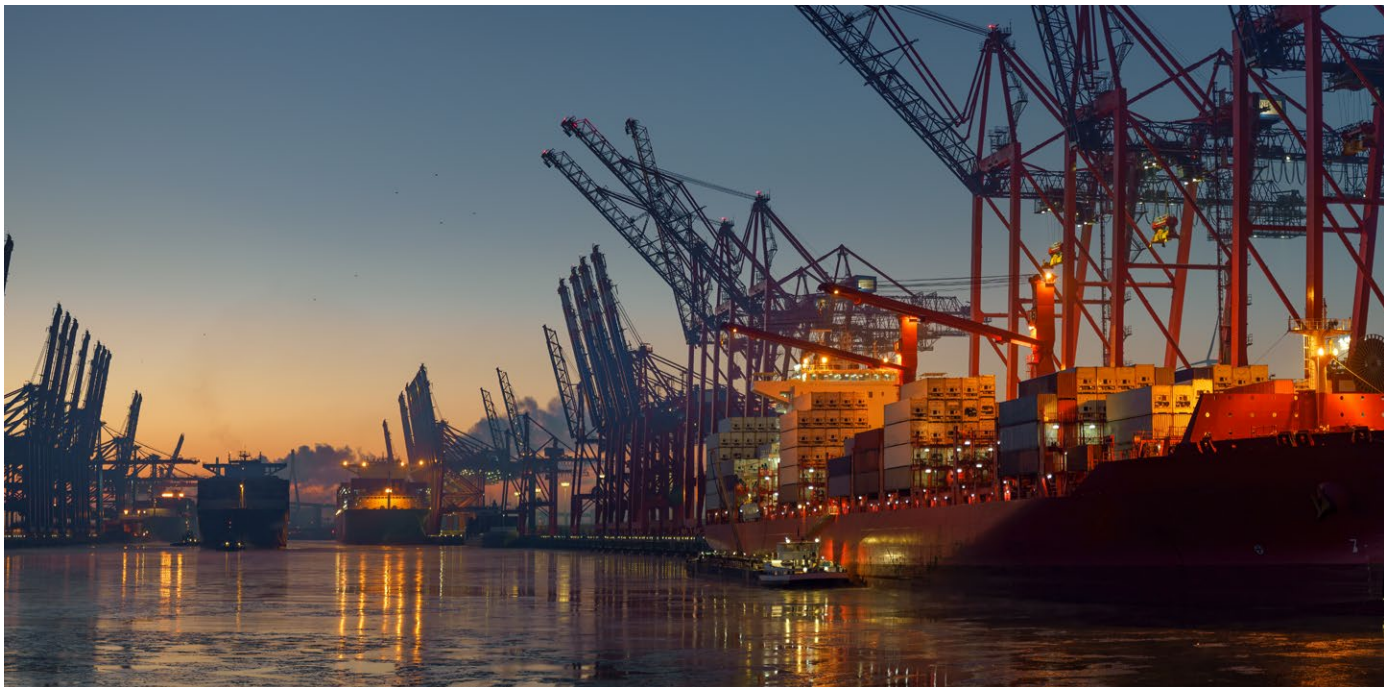
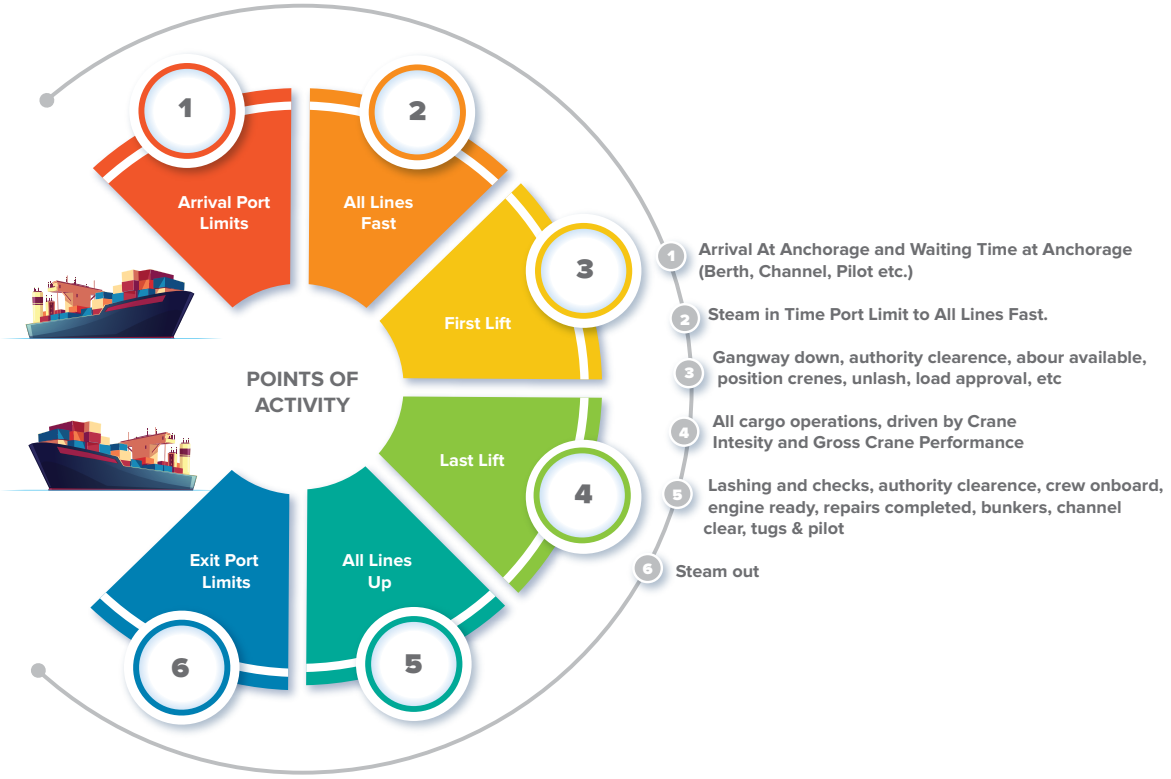


FIGURE 2.1. • The Anatomy of a Port Call



Source: Original figure produced for this publication.

Ships may spend additional time in a port after the departure from a berth, but the time associated with these additional activities is excluded from the CPPI. Ships may dwell within a port's limits for reasons that include bunkering, repairs, or simply waiting in safe areas if unable to berth on earliest arrival at the next port. Except for bunkering not being performed simultaneously with cargo operations, these causes of additional port time are not necessarily reflective of efficiency or poor performance of the port and hence are excluded from the CPPI.

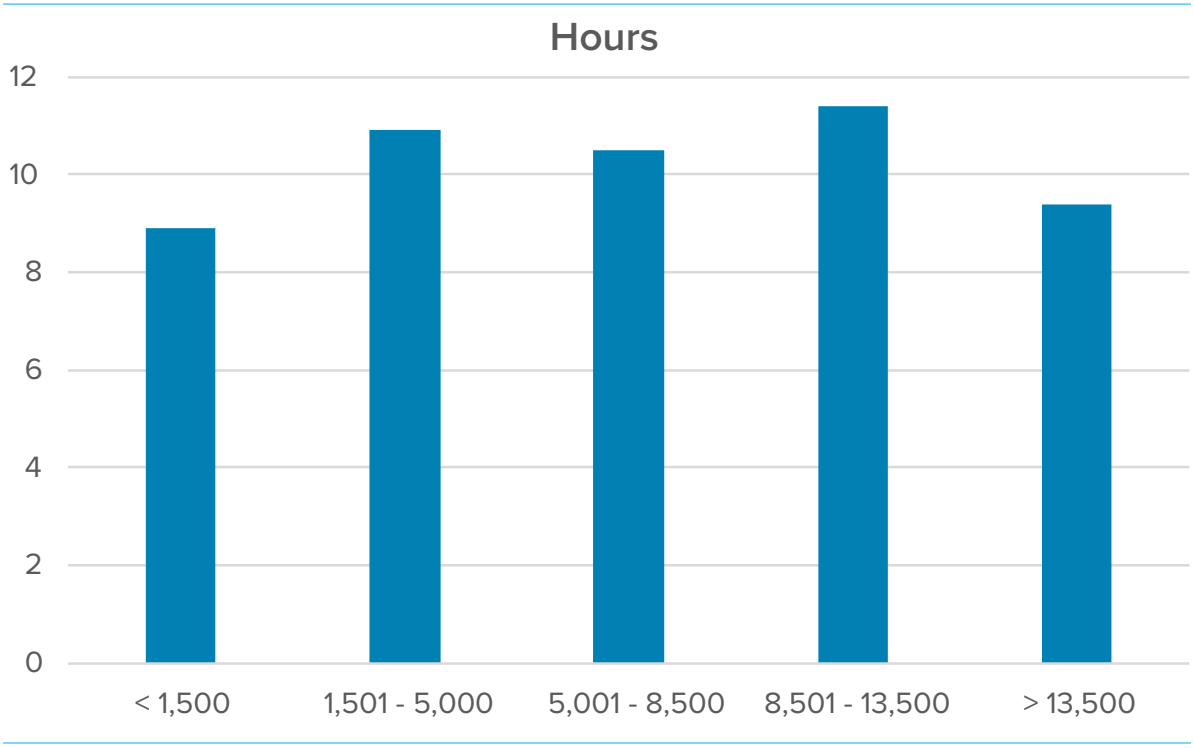
None of these causes of additional port time are reflective of port inefficiency per se but delay on the part of the clearance authorities can lead to a delay in first lift and idle time after cargo operations have been completed. However, the available data are insufficiently granular to see the root causes of delays. The presumption is that the percentage of ships that idle alongside the berth after completion of cargo operations for reasons unrelated to port performance is modest, and their continued inclusion will not have any significant effect on the CPPI result.

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 Anchorage, Arrival Port Limits' and 'All Lines Fast' (steps one to two in Figure 2, the Anatomy of a Port Call); the second comprises time elapsed between 'All Lines Fast' and 'All Lines Up' (steps two to five, also commonly referred to as 'on-berth time' or 'berth hours'). The logic behind this division is that while there will always need to be time consumed between steps two and five, the bulk of time between steps one and two, excluding actual sailing time, is waiting time that could be completely eliminated.

The issue of waiting time in the measurement of port performance. Waiting time, defined as the period between 'Arrival Port Limits' or when the ship enters an anchorage zone, and 'All Lines Fast' is generally regarded as pure waste. As such, in the construction of the CPPI, one possibility was to apply a penalty to waiting time. The decision was taken not to, as the introduction of a penalty of this type was seen as a normative judgement which is inconsistent with the overarching objective of producing an objective quantitative index. The 2021 data set has been enhanced since the initial CPPI 2020 was published. Great effort has been undertaken to critically review all anchorage geo-fencing, with a host of enhancements being made to the AIS data collection and processing. As a result, there is a significant increase in global average in-port hours, across all ports. For ports with high anchorage times, this will result in a lower ranking in 2021 as all 'port time' is being captured.

There was a related deliberation on whether to apply a "discount" to waiting time for the smallest segment of ships. This arises because ships with less than 1,500 twenty-foot equivalent units (TEUs) of nominal capacity spend notably more time waiting at some hub ports than all other ship size segments (see figure 2.2). The disparity could exist because larger ships generally enjoy a higher priority for berthing. It could also be partly explained as being a consequence of the practice of feeder ships waiting for cargo to become available, close to where they expect that demand to materialize. Neither circumstance is linked to port performance. This disparity is not as prevalent in the CPPI 2021 data but remains a small issue at some hubs (see table 2.1).

FIGURE 2.2. • Average Arrival Times at Hub Ports per Ship Size Range



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

TABLE 2.1. • Disparity in Arrival Times at Selected Hub Ports

PORT	LESS THAN 1,500 TEU CAPACITY – ARRIVAL HOURS	AVERAGE ARRIVAL HOURS FOR ALL SHIPS	AVERAGE LONGER WAITING TIME FOR FEEDERS
Jebel Ali	32.1	11.8	171.1%
Colon	18.8	9.3	102.6%
Gioia Tauro	9.3	4.7	99.1%
Salalah	6.4	3.3	92.6%
Marsaxlokk	21.6	12.3	75.8%
Busan	6.8	4.1	64.9%
Rotterdam	30.3	19.2	58.4%
Tanjung Pelepas	14.8	10.0	47.8%
Algeciras	6.9	4.8	45.3%
Port Said	4.1	3.1	32.5%
Kingston	10.1	7.8	28.9%

Source: Original table produced for this publication, based on CPPI 2021 data.
Note: TEU = twenty-foot equivalent unit.

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. Since port calls of ships with less than 1,500 TEUs of capacity comprise just 10 percent of total calls in the CPPI, any impact to the overall CPPI of the disparity in waiting times between ships with less than 1,500 TEUs of nominal capacity and other segments is expected to be very slight. The same issue with respect to this being a normative judgment inconsistent with an objective quantitative index also applied.

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 11 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 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 subsidiary shipping companies. In 2021, performance time stamp data were captured for 164,500 port calls involving 257.4 million container moves at 826 container terminals in 443 ports worldwide.

Following receipt from the shipping lines, the port call data undergo an automated validation and quality checking process before mapping to AIS vessel movements data. This 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 productivity metrics tracked in the program.

Most of the port performance metrics are constructed from the combined AIS and liner shipping data. The metrics consist primarily of time components cross-referenced with workload achieved, 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 have been 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 in the first place considered secondary. The primary function of AIS is as a navigational safety aid, to ensure 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 to 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 that is 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 other 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.

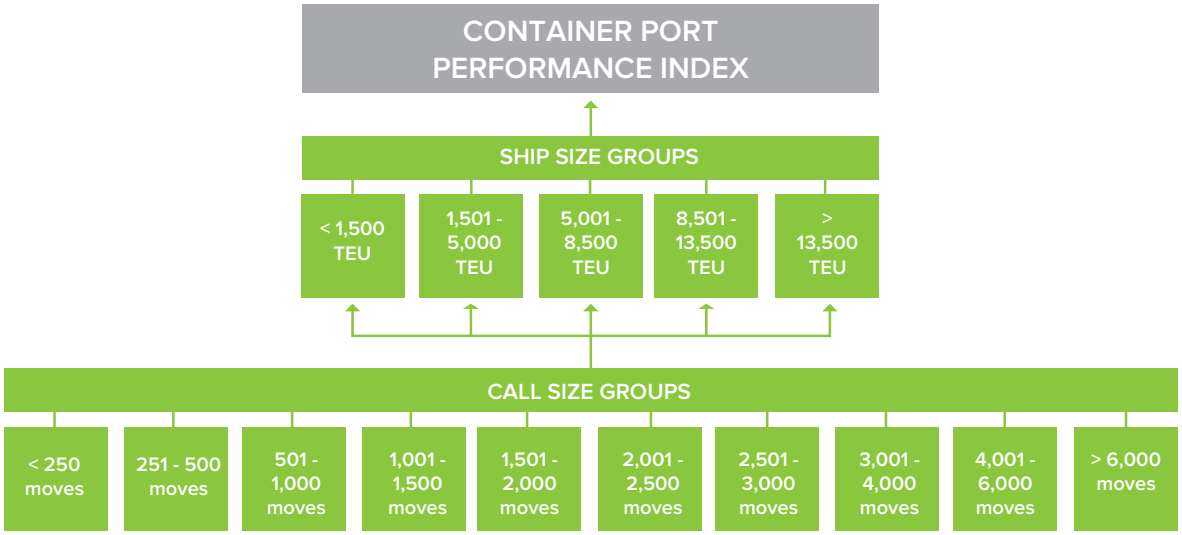
Zones also cover anchorages recording vessels having arrived around a port but awaiting authority to enter, or vessels laid up awaiting orders. Additional zones cover the arrival of vessels at repair yards or those navigating locks. Anchorage zones may be created on an ad hoc basis. Not all ports have anchorage areas and of 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 a reliable tool of high standards, but it also has its flaws which can have an impact on transmission and quality of data being captured. Some of the issues that may affect the signal could be either due to the AIS transponder being deliberately turned off, problematic reception, high traffic density areas, weather conditions, or anomalous positions.

The Construction of the CPPI

For a port to qualify for inclusion in the CPPI it must have registered at least 20 valid port calls where port hours can be calculated within the full calendar year. Of the 444 ports from which IHS Markit received port call information, 370 are included in the main index of CPPI 2021. There were 163,852 distinct port calls recorded in the data over this time period.

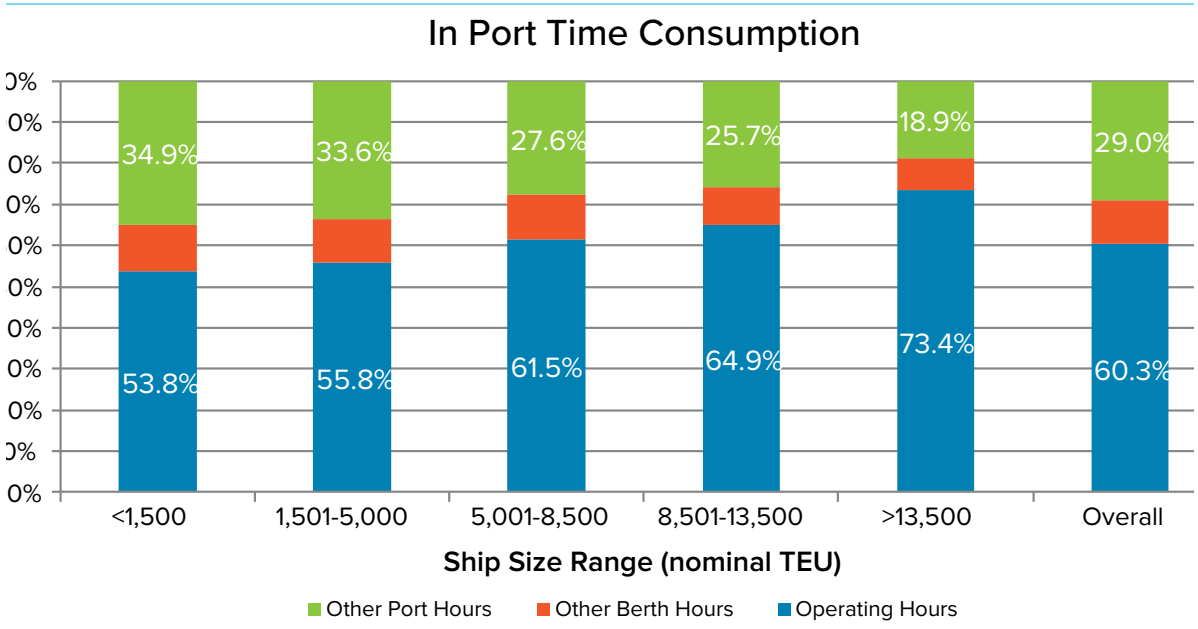
FIGURE 2.3. • The Structure of the CPPI



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

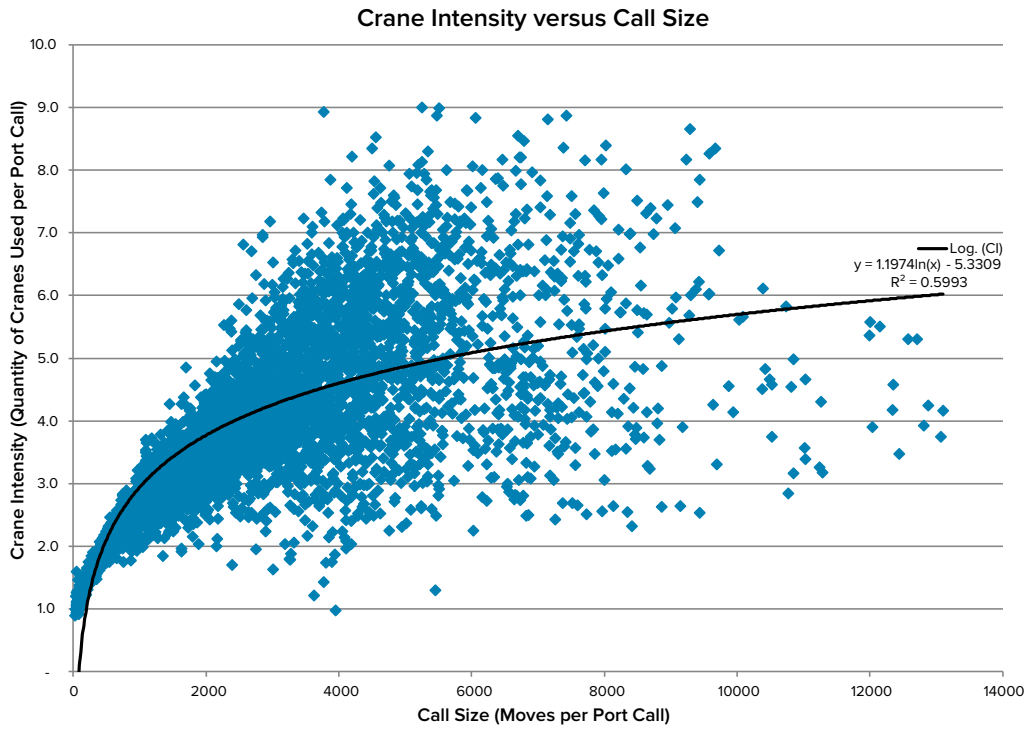
Port hours per ship call is the overarching metric on which the CPPI is based. However, to account for significant differences in ship calls determined by: (1) greater or lesser workloads; and (2) smaller or larger capacity ships, calls are analyzed in 10 narrow call size groups and five ship size groups that generally reflect the types of ships deployed on specific trades and services (see figure 2.3).

FIGURE 2.4. • Port Time per Port Stay Step or Process



Source: Original figure produced for this publication, based on CPPI 2021 data.
Note: Other port hours ("arrival") are a combination of idle/waiting time at anchorage plus the time required to steam in from the port limits and until all fast alongside the berth.
Other berth hours are activities between all fast and first lift ("start") plus the time taken to depart from the berth (all lines released) after the last container lift ("finish").
Operating hours is defined as the time required for container operations between the first and last container lifts.

FIGURE 2.5. • Regression Analysis: Crane Intensity versus Call Size

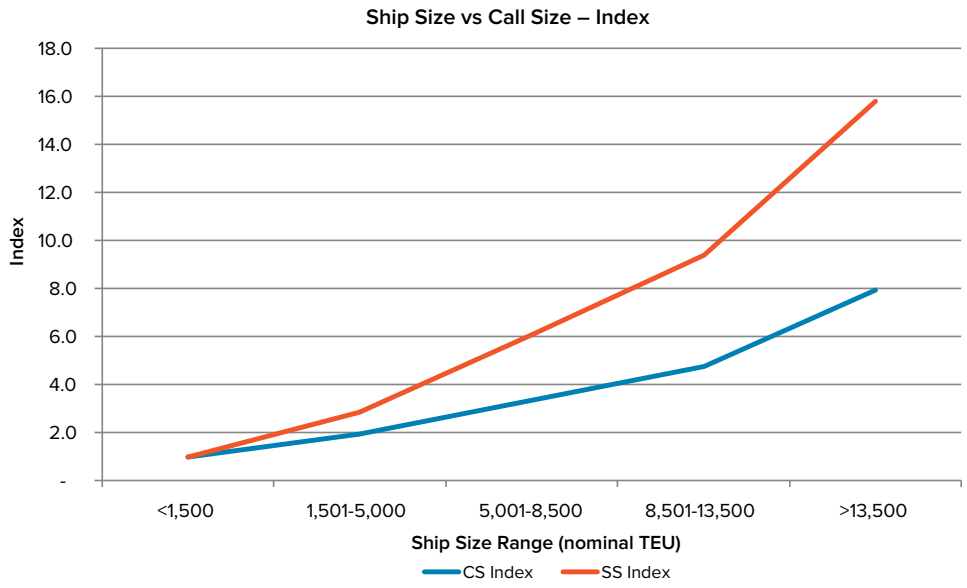


Source: Original figure produced for this publication, based on CPPI 2021 data.

An average of around 60 percent of total port time is consumed by container-handling operations. As figure 2.4 shows, the ratio of time spent on handling operations increases as ship size increases, driven by larger call sizes. Call size does not affect the amount of time spent on arrival, start, and finish processes. These processes are, however, influenced by ship size. Mooring operations and lashing completion generally take longer on larger ships, although this is somewhat offset by larger ships potentially enjoying a slightly higher priority and assignment of resources.

A correlation of close to 60 percent is observed between call size and crane intensity (CI) using a logarithmic trend line. As figure 2.5 shows, CI increases rapidly through smaller call sizes and starts to peak and flatten when call sizes reach 4,000 to 6,000 moves per call. With a maximum observed CI of around nine cranes per ship, it is interesting to note that for calls exceeding 11,000 moves, CI is always below 6.0. This is a global representation, and most of the call sizes in excess of 11,000 moves occur on North America's west coast, where ports have multiple terminals, each with a limited quantity of cranes (crane density), and where the deployment of additional cranes is generally considered to be cost prohibitive. Above and beyond crane density will be factors relating to how close together adjacent cranes can operate. There can also be some constraints from the stowage plan if an excessively intense area of work is concentrated in one part of the ship.

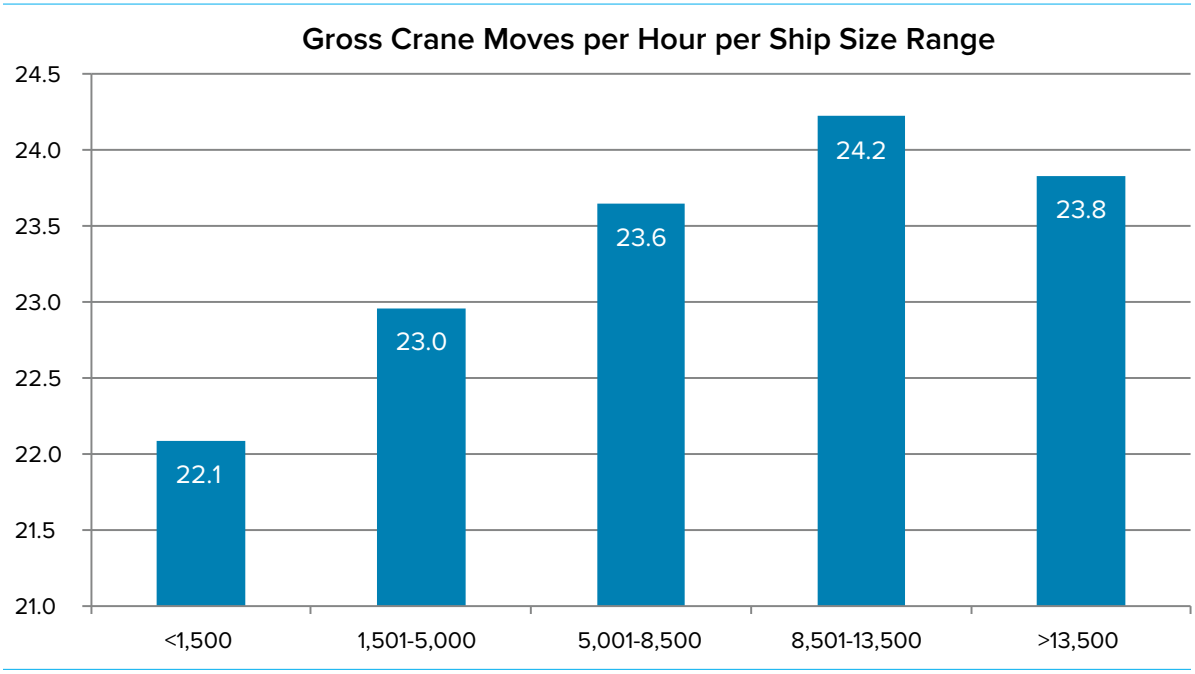
FIGURE 2.6. • Relationship between Global Ship Size and Call Size



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

Average call size increases as ship size increases, but not proportionately with ship size (see figure 2.6). This result is partially influenced by the deployment trends and dynamics of the liner shipping networks, and the capacity and volume of a particular port. For example, a ship of 20,000 TEU capacity will likely be deployed on the Asia-North Europe trade lane and make more than 12 port calls per rotation. On the other hand, a ship of 14,000 TEUs deployed on the transpacific route would likely serve just eight ports in a full rotation. If all rotations had an equal quantity of port calls, then call size and ship size would trend proportionately, assuming that (1) a port can physically handle larger vessels; and (2) there are a sufficient number of containers to be loaded and unloaded to justify a stop by a vessel of that size.

FIGURE 2.7. • Gross Crane Productivity



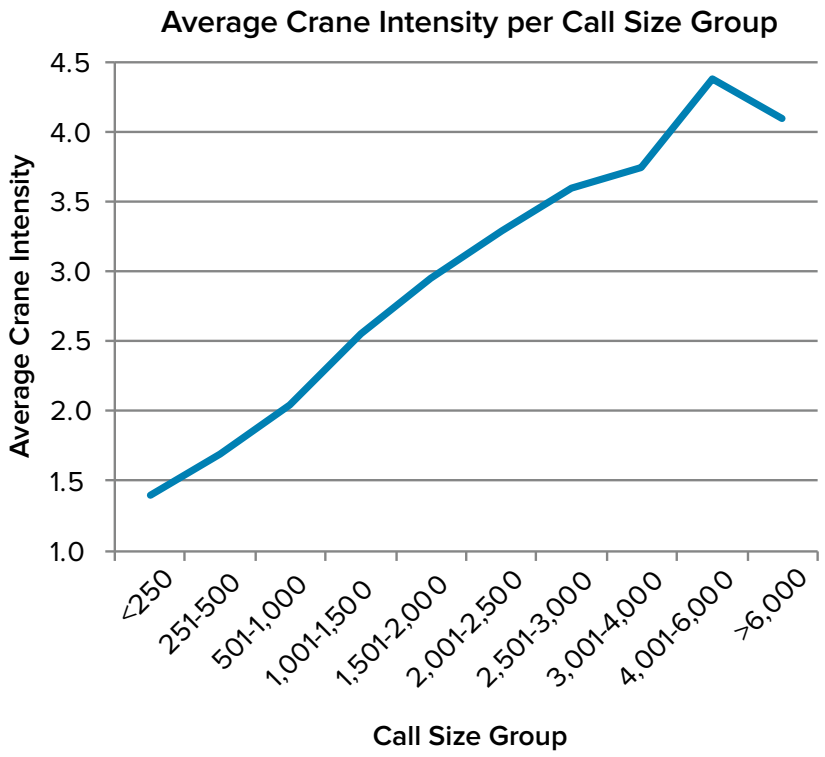
Source: Original figure produced for this publication, based on CPPI 2021 data.

The gross crane productivity by ship size group displayed in figure 2.7 is a global average across all ports. There is limited variation in average gross crane productivity performance for ship size groups including and larger than 1,501 to 5,000 TEUs of capacity. Average gross crane productivity is lower for the smallest ship size group, albeit by around only 6 percent versus the average of all. A different result might have been expected because height and out-trolley distances are greater on larger ships. However, the additional cycle time necessitated by the greater distances is likely compensated for by a larger quantity of moves per bay and more moves per hatch-cover move and gantry position.

Smaller ships also tend to suffer more from trim and list in port and generally deploy poorer lashing systems. This would further account for the slightly lower performance that is observed. Analysis of CI and productivity shows that CI has a major impact on operating time and by extension 60 percent of total port time. It is evident, therefore, that both ship and call size segments need to be reflected in the construction of the CPPI for it to be realistic.

When comparing port performance and efficiency, it is necessary to take note of and account for the extent of this impact. This can be done in two ways: by applying a weighting by call size, or by examining performance within call size groups that are narrow enough to effectively neutralize the influence of call size and CI. After extensively testing both methods, we find the former can generate some volatile results when applied across a broad range of ports and ship sizes, and, therefore, chose the latter as being the more reliable for the CPPI methodology.

FIGURE 2.8. • Average Crane Intensity per Defined Call Size Group



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

There is also a progressive increasing trend in CI as we move through the call size groups (see figure 2.8). This trend peaks and flattens once we pass the 6,000 moves per call range, leading to the presumption that CI does not have a major influence when call size exceeds 6,000 moves per call.

TABLE 2.2. • 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	178	380	735	1,234	1,733	2,236	2,734	3,449	4,778	7,863
Median	187	383	731	1,224	1,728	2,224	2,728	3,420	4,630	6,914
Lower Range	159	325	621	1,040	1,469	1,890	2,319	2,907	3,936	5,877
Upper Range	215	440	840	1,407	1,987	2,557	3,138	3,932	5,325	7,951
Total Ports	308	357	352	309	251	218	180	165	120	81
Within Range	231	320	311	300	250	218	180	165	117	68
Percentage in Range	75.0%	89.6%	88.4%	97.1%	99.6%	100.0%	100.0%	100.0%	97.5%	84.0%

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

In order to assess the sensitivity within each call size group across all 370 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 2.2). In the six call size groups from the 1,001–1,500 to 4,001–6,000 moves groups, more than 97 percent of ports have an average call size well within this tolerance range. When one goes beyond the threshold of 6,000 moves per call, call size has much less of an impact on CI (see figure 2.8). 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 those ports with an average call size above the tolerance range, it would ordinarily be possible to increase CI to match the slightly higher call sizes, and, therefore, the conclusion is that they are not being penalized unfairly.

There is a practical consideration and that is the desire to keep to a workable number of call size groups. A workable number of call size groups ensure that the data are not overly diluted, and so additional call size groups for below 1,000 moves per call have not been created. After examining multiple options, an efficiency comparison based on these 10 defined call size groups was found to be both objective and relevant, whilst neutralizing the influence of call size and CI.

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

Therefore, we introduce five different ship size groups into the CPPI methodology. Five ship size groups (see table 2.3) are considered to be the optimum number of ship size groups to account for the fact that larger ships use more fuel, without overly diluting the data. The groups are defined based upon clustering similar classes of container ships together and to the greatest extent possible the trade lanes where they would generally be deployed. The typology is based on nominal TEU capacity, but it would be equally effective to categorize based on GRT or length overall.

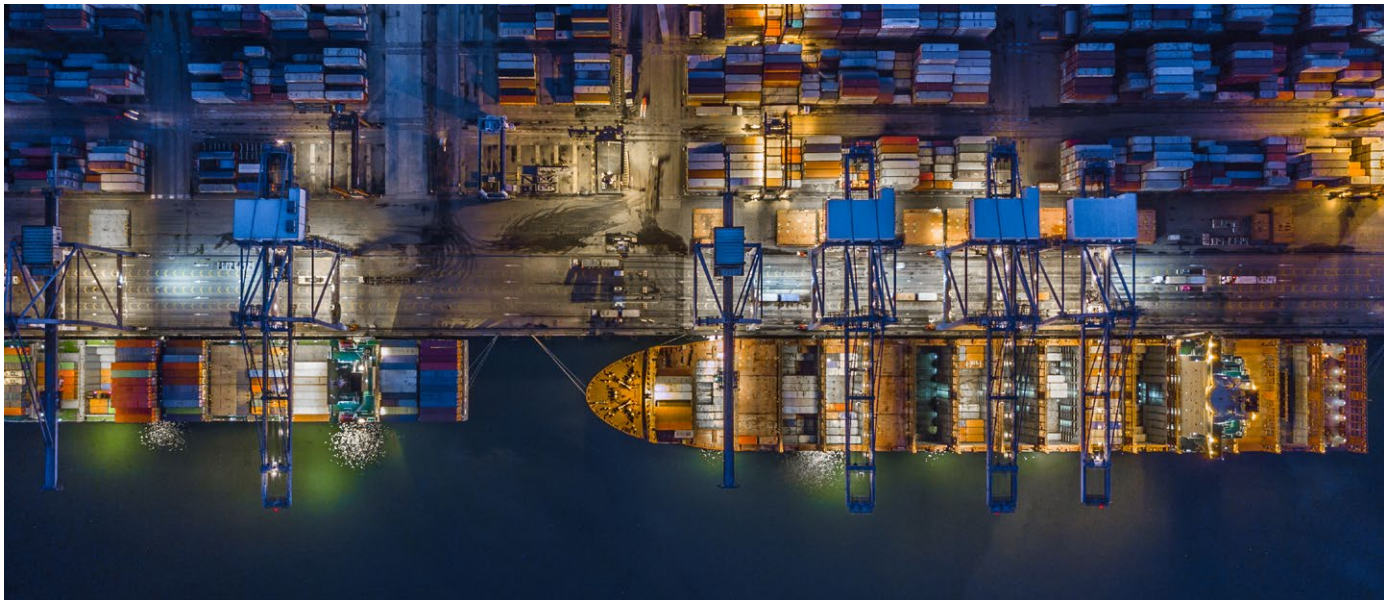
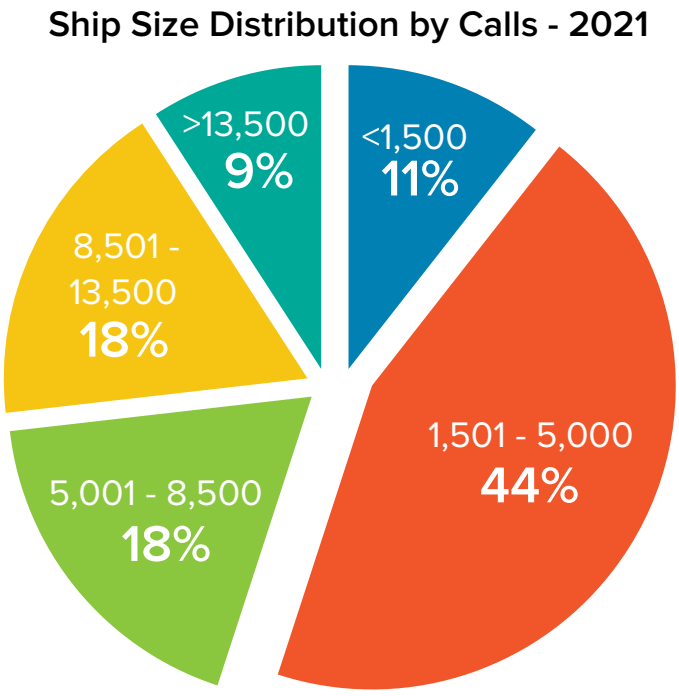


TABLE 2.3. • Ship Size Groups

NOMINAL TEU CAPACITY RANGE	DESCRIPTION
Less than 1,500 TEUs	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 TEUs	A vast quantity of these classic Panamax ships are deployed on intra-regional trades. They are found on Intra-Asian trades and north-south trades to and from Africa, Latin America, and Oceania, as well as Transatlantic services.
5,000 to 8,500 TEUs	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 and Latin America, as well as Oceania, trades. There is some presence on transatlantic and Asia–Middle East trades as well.
8,500 to 13,500 TEUs	These Neo-Panamax vessels are largely deployed on east-west trades, particularly transpacific, 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 TEUs	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 transpacific services calling at North America's west coast ports.

Source: Original table produced for this publication.

FIGURE 2.9. • Ship Size Distribution by Calls in 2021



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

Some 44 percent of all calls in the database were made by ships with a capacity of between 1,500 and 5,000 TEUs. The other two mid-range ship size bands are also well represented. As expected, there is a lower concentration of calls in the smallest and largest ship size bands. Nevertheless, there is still a sufficiently high quantity of data for representative benchmarking in the smallest and largest ship size bands (see figure 2.9).

TABLE 2.4. • Call Size and Ship Size Combinations: Percentage of Calls

SHIP SIZE GROUP	CALL SIZE GROUP									
	<250	251-500	501-1000	1001-1500	1501-2000	2001-2500	2501-3000	3001-4000	4001-6000	>6000
1 <1,500	23.0%	36.2%	33.9%	6.0%	0.5%	0.2%	0.1%	0.1%	0.0%	0.0%
2 1,501-5,000	6.3%	20.1%	35.4%	20.2%	10.1%	4.5%	1.8%	1.4%	0.2%	0.0%
3 5,001-8,500	1.3%	5.5%	22.0%	23.7%	18.0%	11.9%	7.4%	6.9%	2.7%	0.6%
4 8,501-13,500	0.6%	3.7%	13.4%	16.0%	14.7%	13.7%	11.1%	14.7%	9.2%	3.1%
5 >13,500	0.2%	0.4%	3.0%	5.7%	8.3%	9.9%	9.8%	20.0%	28.3%	14.4%

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

Of the potential 50 (5 x 10) ship and call size categories, there is insufficient data for meaningful analysis in seven of them (as indicated in table 2.4 gray cells) and they are, therefore, omitted from the CPPI. Some of the other call size bands within ship size ranges contain limited data but they are considered sufficient for inclusion and analysis. Data for each ship size group is extracted from the full data set, and then broken down into average hours consumed within each call size group at each port. Total port hours are broken down into arrival hours (defined as elapsed time from arrival port limits to all lines fast) and berth hours (defined as all lines fast to all lines released). With 43 potential ship and call size combinations per qualifying port, there will naturally be many combinations where no actual data exist.

The objective of preparing the index and the ranking is that it should reflect as closely as possible actual port performance, whilst also being statistically robust. With respect to the largest ports—the top 100 ports by annual move count—there is real empirical data present in each of the 43 distinct ship size and call size categories. However, for smaller ports there are many categories with no data, particularly those with only a few hundred calls in total. If these unpopulated categories are ignored, the appraisal of performance would be undertaken on different quantities of categories, which is likely to unduly disadvantage smaller ports that might well be quite efficient despite their modest size and throughput.

Imputing missing values: the administrative approach

Addressing this undeserved handicap is approached in two different ways: an administrative approach and a statistical approach. In the case of the former, the approach involved assigning values to empty categories based upon data that are available when a port has registered a data point within a specific ship size range.

TABLE 2.5. • Quantity of Ports Included per Ship Size Group

SHIP SIZE RANGE	QUANTITY OF PORTS INCLUDED	BASE CALL SIZE
Less than 1,500 TEUs	292	251–500
1,500–5,000 TEUs	349	501–1,000
5,000–8,500 TEUs	227	1,001–1,500
8,500–13,500 TEUs	183	1,501–2,000
More than 13,500 TEUs	103	3,001–4,000

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

For each ship size group, the call size group that has the largest quantity of data representation is selected (see table 2.5). Ideally, this is a mid-range call size group because the lowest and highest groups 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 present for the base call size group.

Imputing vessel arrival values. Where any call size group does not have an arrival hours value, it is populated by 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 less of a 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 had either higher or lower berth hours than the average, it is most probable that would be the case in the adjacent call size group as well.

Table 2.6 contains an illustrative 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 2.6. • An 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 2021 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's ability to add cranes to larger call size groups exists, which might not be true in all cases. On the other hand, it would be illogical to blindly assume that any port would simply achieve the average of the entire group or, possibly worse, to assume that a port performing below average in one call size group would miraculously perform much better than average in others where it did not record any actual calls.

Imputing missing values: the statistical approach

A more sophisticated approach is using 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 index: 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 2021.

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 2.7 provides an illustration as to how it is done.[7]

TABLE 2.7. • 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.

However, the imputation method might unfairly appraise some ports that only recorded data within a few call size groups. If, for example, the performance in a few call size groups was worse than the average for all ports within the ship size group, this would be prorated to all call size groups. This required a judgment, as the alternative of ignoring call size groups without actual data, effectively resulting in a zero score for those groups, would not necessarily result in a better outcome. In the latter case, ports with limited call size diversity would not be credited with positive scores in each and every call size group which they are likely to have achieved if they had a greater diversity of call sizes.

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 quantity of ports being included per ship size group was presented earlier in table 2.5. 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 2.8). 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.

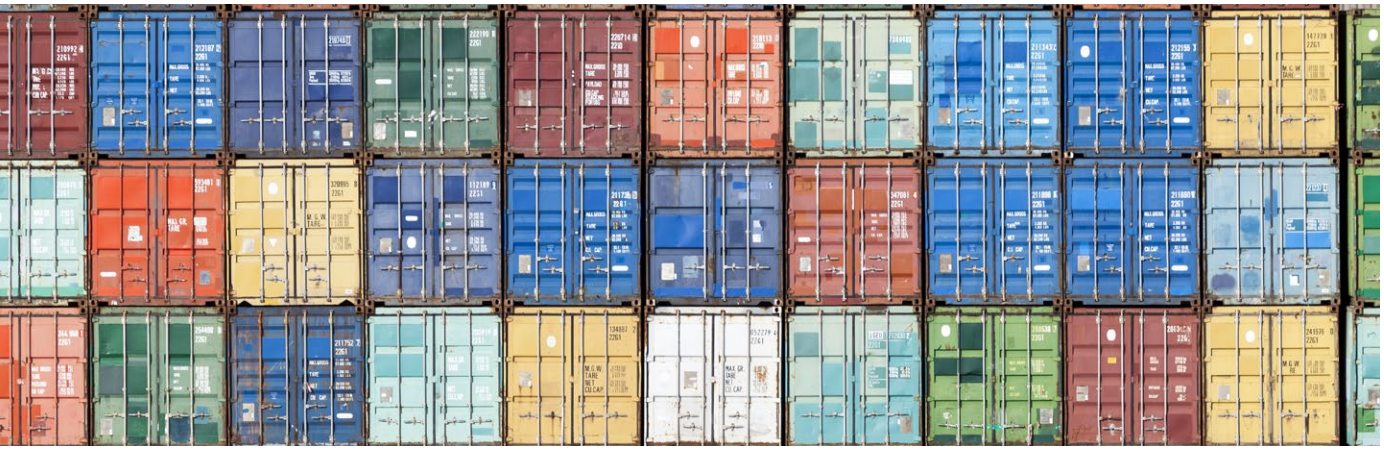


TABLE 2.8. • Assumptions to Determine a Fuel Consumption Index

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

Source: Original table produced for this publication, based on CPPI 2021 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 capacity in excess of 13,500 TEUs than it would be for a ship in the 1,500–5,000 TEU capacity range. The total aggregated index points per port within each ship size group are then weighted by this "cost" 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 upon 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. To achieve a final CPPI score and ranking in the administrative approach, accumulated results within each ship size group are multiplied by the index values per ship size group and then summed. The ranking is then based in descending order on final summed totals across all ship size groups. The resulting index for main and secondary ports using the administrative approach is presented in chapter 3 and appendix A.

Constructing the index: the statistical approach

An alternative approach to construct an index of container port performance is to use a statistical technique such as factor analysis (FA). The advantage of FA is that it can be used to examine a large data set and ascertain the impact of a series of measured variables on an unseen latent variable (for example, in this case of efficiency), which cannot be measured directly with a single variable. Instead, it is seen via the relationships it has with a series of visible and measurable variables, each of which contains information about the "efficiency" of the port. The latent variable, efficiency, is a function of each of the measured variables, and an error term for each. FA then determines the relative weight to be attached to each of the measured variables vis-à-vis the efficiency of the port, together with some uncertainty, which is captured by the error terms.

At the level of the individual port, the measured variables include the average time expended for the different stages, under various categories—(1) different call size bands; and (2) berth/port-to-berth. The actual values of these variables are determined by a small number of unobserved factors, such as the availability and quality of the infrastructure, the layout of the port, the expertise of the employees, the available depth in the channel and at the berth, and so on. The challenge is that we cannot observe these latent factors and how they contribute to the impact on the measured variable, and ultimately on the latent variable. A simple example may be illustrative: Suppose we have three ports and for each port we have four different types of time cost, as shown in table 2.9.

TABLE 2.9. • Simple 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 from table 2.9, 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 FA, 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. Although one downside of this approach is that FA does not consider that some observations might be more reliable than others as they are based on more calls. This implies the results, and potentially the ranking, for some of the ports could be distorted in the presence of large outliers.

There is no right or wrong methodology, but the two different approaches that are considered complementary. Hence, the decision in the inaugural edition of the CPPI to use 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. Chapter 3 presents the CPPI 2021 from both approaches, explaining divergences, where possible.

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 h**ttps://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

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**.

3. The Container Port Performance Index 2021

Introduction

The CPPI 2021 has been developed based on total port time in the manner explained in the previous sections. The rationale of using two methodologies, as explained earlier, is to ensure that the ranking reflects as closely as possible actual port performance, whilst also being statistically robust. This second edition utilizes data up to the end of 2021.

The resulting rankings of container port performance, based on the two different approaches, 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 alphabetically in appendix A. The subsequent sections present a summary by region and by throughput, so ports in the same region, or with the same throughput, within broad categories can be compared.

The CPPI 2021

Table 3.1 presents the rankings of container port performance in the CPPI 2021, which resulted from using both the statistical and administrative approaches. The ranking and score in the left-hand columns are results from the administrative approach; the ranking and score in the right-hand columns show results from the statistical approach. The index points used to construct the ranking in the administrative approach reflect the approach as outlined in the chapter explaining the methodology, which is an aggregate of the performance

of the port, weighted relative to the average, across call and vessel size (see table A.1 in appendix A for the detailed rankings produced by the administrative approach). Accordingly, the scores can be negative, where a port compares poorly to the average in one call size and vessel size category, particularly if it does not have an offsetting positive score or scores in other cells.

The use of matrix factorization also results in a statistic (a total score/index value) that is the sum of a weighted average of indices for each of the same five vessel sizes.[1] The indices for each vessel size are estimated based on the time expired in the port, and a number of unknown factors, or latent variables (see appendix B for a more detailed explanation of the approach), which have an impact on performance, but cannot be seen. The resulting index values have both positive and negative values. Intuitively, the highest positive index value is allocated to the best performing port, while the most negative value is assigned to the port with the worst performance.

The two top-ranked container ports in the CPPI 2021 are King Abdullah Port (Saudi Arabia) 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. King Abdullah Port was ranked second in both approaches in CPPI 2020. The Port of Salalah ranked sixth and ninth in the statistical and administrative approaches, respectively, for CPPI 2020. Of the top 10 ranked ports, all have improved their position since CPPI 2020, with Jeddah and Hamad Port moving 35 and 34 positions in the ranking, respectively. The exceptions are Yokohama, which has fallen from first place in both in 2020, to 10th and 12th in CPPI 2021, and Guangzhou, which dropped from sixth to ninth place.

There are 37 new entrants to the CPPI 2021, and a number of significant movers in terms of their ranking since the CPPI 2020. One hundred and forty-nine ports improved their rankings in CPPI 2021, compared to CPPI 2020, with some of the largest improvers increasing their ranking by more than 200 positions. By contrast, the ranking of 182 ports fell in the CPPI 2021, over the inaugural edition, with some of the largest movers falling nearly 300 positions, reflecting the challenges faced by ports during the period of interest.

TABLE 3.1. • The CPPI 2021

ADMINISTRATIVE APPROACH			STATISTICAL APPROACH		
Port Name	Rank	Total Points	Port Name	Rank	Index Value
KING ABDULLAH PORT	1	217.914	KING ABDULLAH PORT	1	93.387
SALALAH	2	197.675	SALALAH	2	87.372
HAMAD PORT	3	194.823	YANGSHAN	3	83.522
YANGSHAN	4	183.455	HAMAD PORT	4	82.146
KHALIFA PORT	5	182.649	KHALIFA PORT	5	81.052
TANGER-MEDITERRANEAN	6	178.096	TANGER-MEDITERRANEAN	6	80.411
NINGBO	7	170.696	NINGBO	7	76.077
JEDDAH	8	161.493	JEDDAH	8	73.527
GUANGZHOU	9	161.331	GUANGZHOU	9	72.749
YOKOHAMA	10	159.234	ALGECIRAS	10	70.323
ALGECIRAS	11	155.851	CAI MEP	11	67.529
CARTAGENA (COLOMBIA)	12	152.950	YOKOHAMA	12	66.451
CAI MEP	13	148.433	PORT SAID	13	63.390
DAMMAM	14	143.504	DAMMAM	14	62.454

ADMINISTRATIVE APPROACH			STATISTICAL APPROACH		
Port Name	Rank	Total Points	Port Name	Rank	Index Value
PORT SAID	15	141.336	CARTAGENA (COLOMBIA)	15	61.901
SHEKOU	16	137.844	TANJUNG PELEPAS	16	59.830
CHIWAN	17	132.828	SHEKOU	17	58.312
TANJUNG PELEPAS	18	131.424	HALIFAX	18	56.910
DJIBOUTI	19	129.354	BARCELONA	19	55.311
BUENAVENTURA	20	124.415	CHIWAN	20	55.013
KAOHSIUNG	21	123.452	KAOHSIUNG	21	54.588
BARCELONA	22	119.332	COLOMBO	22	54.090
PORT OF VIRGINIA	23	118.295	BUENAVENTURA	23	53.033
COLOMBO	24	117.493	DJIBOUTI	24	52.476
BUSAN	25	114.739	BUSAN	25	52.307
PIPAVAV	26	109.823	TIANJIN	26	51.441
TIANJIN	27	109.448	PORT OF VIRGINIA	27	50.444
YARIMCA	28	106.663	MERSIN	28	49.791
MIAMI	29	105.762	YEOSU	29	48.823
SINES	30	105.359	YARIMCA	30	48.489
SINGAPORE	31	103.562	SINGAPORE	31	47.816
MAGDALLA	32	103.005	AQABA	32	45.327
YEOSU	33	102.674	QINGDAO	33	44.227
MERSIN	34	102.273	PIPAVAV	34	43.713
AQABA	35	101.250	SINES	35	42.930
OSAKA	36	100.987	AMBARLI	36	42.530
VUNG TAU	37	100.873	KOBE	37	41.998
JEBEL ALI	38	100.226	HONG KONG	38	41.377
CORONEL	39	100.170	MIAMI	39	40.559
KOBE	40	99.002	XIAMEN	40	39.737
SHIMIZU	41	96.454	MAGDALLA	41	37.582
QINGDAO	42	95.043	JEBEL ALI	42	37.549
AMBARLI	43	93.586	NAGOYA	43	37.197
MAWAN	44	92.571	OSAKA	44	36.350
XIAMEN	45	92.212	SHIMIZU	45	35.895
HALIFAX	46	91.744	MUNDRA	46	35.568
SOHAR	47	89.717	SOHAR	47	35.096
MUNDRA	48	86.563	LAEM CHABANG	48	34.706
WILMINGTON (NORTH CAROLINA)	49	84.187	CORONEL	49	33.796
HONG KONG	50	83.775	JAWAHARLAL NEHRU PORT	50	33.142
IMBITUBA	51	82.974	TOKYO	51	32.543
INCHEON	52	82.106	MANZANILLO (MEXICO)	52	31.859
NAGOYA	53	81.608	INCHEON	53	31.820
JAWAHARLAL NEHRU PORT	54	79.672	BREMERHAVEN	54	29.896
PHILADELPHIA	55	74.759	BALBOA	55	29.611

ADMINISTRATIVE APPROACH			STATISTICAL APPROACH		
Port Name	Rank	Total Points	Port Name	Rank	Index Value
TOKYO	56	74.453	DAMIETTA	56	29.427
LAEM CHABANG	57	74.024	WILMINGTON (NORTH CAROLINA)	57	29.111
DAMIETTA	58	72.703	PHILADELPHIA	58	28.729
BREMERHAVEN	59	67.922	PORT KLANG	59	28.629
BALBOA	60	67.846	ITAPOA	60	26.592
TAMPA	61	67.841	KHALIFA BIN SALMAN	61	26.488
KHALIFA BIN SALMAN	62	67.720	TAMPA	62	25.486
HAIPHONG	63	67.120	HAIPHONG	63	24.603
PORT TAMPA BAY	64	64.318	COLON	64	24.562
GIOIA TAURO	65	62.420	POSORJA	65	24.225
POSORJA	66	61.465	PORT TAMPA BAY	66	24.194
KEELUNG	67	59.776	AARHUS	67	24.076
HAZIRA	68	59.142	BALTIMORE (MARYLAND)	68	23.730
PORT KLANG	69	59.038	HAZIRA	69	23.585
ISKENDERUN	70	59.012	DILISKELESI	70	23.442
SANTA CRUZ DE TENERIFE	71	58.835	KAMARAJAR	71	22.441
ITAPOA	72	57.826	ISKENDERUN	72	21.916
COLON	73	57.339	LIANYUNGANG	73	21.818
MARSAXLOKK	74	54.994	MARSAXLOKK	74	21.723
PAITA	75	54.742	MUHAMMAD BIN QASIM	75	21.688
BALTIMORE (MARYLAND)	76	54.641	ALTAMIRA	76	21.645
DILISKELESI	77	54.305	KEELUNG	77	20.716
LIANYUNGANG	78	53.418	ANTWERP	78	20.671
CHENNAI	79	53.394	JOHOR	79	20.597
JOHOR	80	52.565	PUERTO LIMON	80	20.312
MUHAMMAD BIN QASIM	81	50.962	DALIAN	81	20.193
AARHUS	82	50.953	PIRAEUS	82	20.096
DALIAN	83	50.940	RIO DE JANEIRO	83	20.056
KAMARAJAR	84	50.258	PAITA	84	20.015
ALTAMIRA	85	50.070	VERACRUZ	85	20.014
PUERTO LIMON	86	47.807	ENSENADA	86	20.013
TRIPOLI (LEBANON)	87	47.491	KRISHNAPATNAM	87	19.994
NOUMEA	88	46.920	SANTA CRUZ DE TENERIFE	88	19.591
MANZANILLO (MEXICO)	89	46.685	TRIPOLI (LEBANON)	89	19.531
KARACHI	90	46.399	KARACHI	90	19.459
YOKKAICHI	91	46.268	RIO GRANDE (BRAZIL)	91	19.297
LAZARO CARDENAS	92	46.050	CHENNAI	92	18.847
RIO DE JANEIRO	93	45.956	NOUMEA	93	18.277
SAVONA-VADO	94	45.900	JACKSONVILLE	94	17.677
KRISHNAPATNAM	95	45.824	KATTUPALLI	95	17.567
ANTWERP	96	45.146	FUZHOU	96	17.317

ADMINISTRATIVE APPROACH			STATISTICAL APPROACH		
Port Name	Rank	Total Points	Port Name	Rank	Index Value
RIO GRANDE (BRAZIL)	97	44.636	VISAKHAPATNAM	97	17.160
VISAKHAPATNAM	98	44.483	COCHIN	98	17.057
COCHIN	99	44.280	CAUCEDO	99	16.868
JACKSONVILLE	100	44.256	SIAM SEAPORT	100	16.867
PIRAEUS	101	43.772	YOKKAICHI	101	16.864
ENSENADA	102	43.588	PORT EVERGLADES	102	16.769
SIAM SEAPORT	103	43.527	TANJUNG PERAK	103	16.338
VERACRUZ	104	43.117	NANTES SAINT-NAZAIRE	104	16.047
NANTES SAINT-NAZAIRE	105	41.619	GEMLIK	105	15.943
KATTUPALLI	106	41.494	IMBITUBA	106	15.827
TANJUNG PERAK	107	41.333	POINTE-À-PITRE	107	15.702
VALPARAISO	108	40.314	NEW ORLEANS	108	15.404
POINTE-À-PITRE	109	40.162	LAZARO CARDENAS	109	15.138
PUERTO QUETZAL	110	36.422	MAWAN	110	14.962
PENANG	111	36.340	SAVONA-VADO	111	14.739
SALVADOR	112	36.123	GIOIA TAURO	112	14.642
GEMLIK	113	36.099	VALPARAISO	113	14.494
CAUCEDO	114	34.291	TANJUNG PRIOK	114	13.605
NEW ORLEANS	115	34.153	BOSTON (USA)	115	13.428
PORT EVERGLADES	116	33.709	PENANG	116	13.331
BOSTON (USA)	117	33.384	HAKATA	117	12.580
GOTHENBURG	118	32.139	LIRQUEN	118	12.555
HOUSTON	119	32.044	SEPETIBA	119	11.902
NAHA	120	31.940	OMAEZAKI	120	11.448
PECEM	121	29.363	MOJI	121	10.971
FORT-DE-FRANCE	122	28.535	DA CHAN BAY TERMINAL ONE	122	10.951
SEPETIBA	123	28.257	HOUSTON	123	10.771
TANJUNG PRIOK	124	28.231	BUENOS AIRES	124	10.536
TAICHUNG	125	27.616	SAIGON	125	10.436
LIRQUEN	126	26.883	NAHA	126	10.434
OMAEZAKI	127	26.855	FORT-DE-FRANCE	127	10.420
HAKATA	128	26.746	KINGSTON (JAMAICA)	128	10.158
KOPER	129	26.321	PECEM	129	10.037
CHARLESTON	130	26.183	SALVADOR	130	9.682
KINGSTON (JAMAICA)	131	25.432	PORT BRONKA	131	9.559
MOJI	132	24.923	CAT LAI	132	9.460
FUZHOU	133	24.656	EL DEKHEILA	133	9.355
CRISTOBAL	134	24.246	PUERTO QUETZAL	134	9.340
VALENCIA	135	23.809	TAICHUNG	135	9.315
ZHOUSHAN	136	22.522	UMM QASR	136	8.849
MALAGA	137	22.325	SANTA MARTA	137	8.715
PORT BRONKA	138	22.021	VIGO	138	8.620

ADMINISTRATIVE APPROACH			STATISTICAL APPROACH		
Port Name	Rank	Total Points	Port Name	Rank	Index Value
EL DEKHEILA	139	21.701	PORT AKDENIZ	139	8.467
SAIGON	140	21.080	MALAGA	140	8.270
BUENOS AIRES	141	21.032	PUERTO CORTES	141	8.141
DA CHAN BAY TERMINAL ONE	142	20.563	OSLO	142	8.025
SANTA MARTA	143	20.317	SAN JUAN	143	8.022
PUERTO CORTES	144	20.098	TANJUNG EMAS	144	7.855
CAT LAI	145	19.813	ITAJAÍ	145	7.811
OSLO	146	18.877	QUY NHON	146	7.640
LIMASSOL	147	18.415	SANTOS	147	7.590
BORUSAN	148	18.332	SHARJAH	148	7.570
VIGO	149	18.234	BORUSAN	149	7.476
UMM QASR	150	17.973	MOBILE	150	7.384
WELLINGTON	151	17.761	SHANTOU	151	6.977
PORT AKDENIZ	152	17.753	GOTHENBURG	152	6.911
TANJUNG EMAS	153	17.284	PUERTO BOLIVAR (ECUADOR)	153	6.649
QUY NHON	154	17.144	CHORNOMORSK	154	6.638
SHARJAH	155	16.731	RIO HAINA	155	6.621
PUERTO BOLIVAR (ECUADOR)	156	16.720	DANANG	156	6.541
SAN JUAN	157	16.477	TARRAGONA	157	6.501
RIO HAINA	158	16.156	PAPEETE	158	6.438
BARRANQUILLA	159	16.034	NOVOROSSIYSK	159	6.273
TARRAGONA	160	15.948	MUUGA-PORT OF TALLINN	160	6.248
DANANG	161	15.780	CIVITAVECCHIA	161	6.047
CIVITAVECCHIA	162	15.620	SAN VICENTE	162	6.011
MOBILE	163	15.366	BARRANQUILLA	163	5.981
CEBU	164	14.903	ODESSA	164	5.755
SHANTOU	165	14.432	BERBERA	165	5.752
SAN VICENTE	166	14.418	PARANAGUA	166	5.744
PAPEETE	167	14.229	HELSINGBORG	167	5.739
HELSINGBORG	168	14.121	ANCONA	168	5.537
CHORNOMORSK	169	13.895	HELSINKI	169	5.524
PUERTO BARRIOS	170	13.762	KLAIPEDA	170	5.482
MATADI	171	13.688	CEBU	171	5.364
NOVOROSSIYSK	172	13.554	LIMASSOL	172	5.203
PLOČE	173	13.197	LATAKIA	173	5.061
LATAKIA	174	13.064	PHILIPSBURG	174	5.027
MUUGA-PORT OF TALLINN	175	12.837	PORT-AU-PRINCE	175	4.921
FREDERICIA	176	12.830	MATADI	176	4.869
PHILIPSBURG	177	12.744	SHUAIBA	177	4.853
PORT-AU-PRINCE	178	12.047	SUBIC BAY	178	4.820
ANCONA	179	11.804	SHUWAIKH	179	4.729
HELSINKI	180	11.625	VALENCIA	180	4.685

ADMINISTRATIVE APPROACH			STATISTICAL APPROACH		
Port Name	Rank	Total Points	Port Name	Rank	Index Value
SUBIC BAY	181	11.622	PLOČE	181	4.675
NORRKOPING	182	11.336	BAR	182	4.639
BAR	183	11.238	FREDERICIA	183	4.634
BERBERA	184	10.913	NORRKOPING	184	4.593
SHUAIBA	185	10.770	CRISTOBAL	185	4.443
KLAIPEDA	186	10.587	CALLAO	186	4.400
RAVENNA	187	10.047	CHARLESTON	187	4.399
SANTOS	188	9.866	RAVENNA	188	4.056
SHUWAIKH	189	9.587	NELSON	189	3.966
RIJEKA	190	9.469	GUSTAVIA	190	3.960
CATANIA	191	9.365	JUBAIL	191	3.870
SALERNO	192	9.315	WELLINGTON	192	3.722
BARI	193	9.166	CATANIA	193	3.579
NELSON	194	8.590	BARI	194	3.490
BURGAS	195	8.586	SALERNO	195	3.237
HAIFA	196	8.497	PUERTO BARRIOS	196	3.154
GUSTAVIA	197	8.136	BURGAS	197	3.072
PARANAGUA	198	8.119	PALERMO	198	2.735
APRA HARBOR	199	7.721	GDANSK	199	2.722
PUERTO PROGRESO	200	7.525	RIJEKA	200	2.632
RAUMA	201	7.474	BILBAO	201	2.558
BILBAO	202	7.192	LEIXÕES	202	2.509
GDANSK	203	6.155	APRA HARBOR	203	2.387
PALERMO	204	5.569	WILHELMSHAVEN	204	2.236
LEIXÕES	205	5.299	PUERTO PROGRESO	205	2.197
COPENHAGEN	206	4.970	LARVIK	206	2.153
ITAJAÍ	207	4.452	RIGA	207	2.089
CAGAYAN DE ORO	208	4.440	NASSAU	208	1.920
ODESSA	209	4.411	TRAPANI	209	1.804
LARVIK	210	4.325	RAUMA	210	1.793
KAWASAKI	211	4.222	BELL BAY	211	1.682
NASSAU	212	4.013	HERAKLION	212	1.578
TRAPANI	213	3.980	POTI	213	1.537
RIGA	214	3.903	VITÓRIA	214	1.535
LISBON	215	3.589	TARTOUS	215	1.534
HERAKLION	216	3.267	CHU LAI	216	1.476
VITÓRIA	217	3.264	CADIZ	217	1.288
BELL BAY	218	3.146	KOPER	218	1.152
TARTOUS	219	2.818	MARIEL	219	1.047
CHU LAI	220	2.797	LISBON	220	0.836
CADIZ	221	2.588	KRISTIANSAND	221	0.831
MARIEL	222	1.973	ALICANTE	222	0.745

ADMINISTRATIVE APPROACH			STATISTICAL APPROACH		
Port Name	Rank	Total Points	Port Name	Rank	Index Value
KRISTIANSAND	223	1.764	BORDEAUX	223	0.626
NEMRUT BAY	224	1.695	GIJON	224	0.596
VARNA	225	1.502	GDYNIA	225	0.530
POTI	226	1.404	CAGAYAN DE ORO	226	0.415
MAZATLAN	227	1.394	COPENHAGEN	227	0.266
BORDEAUX	228	1.158	ZHOUSHAN	228	0.225
ALICANTE	229	1.007	GEORGETOWN (GUYANA)	229	0.210
KOMPONG SOM	230	0.902	VENICE	230	0.147
MEJILLONES	231	0.860	KOTKA	231	-0.149
HAMBURG	232	0.185	RADES	232	-0.164
WILHELMSHAVEN	233	-0.020	BATUMI	233	-0.183
ANTOFAGASTA	234	-0.322	BLUFF	234	-0.308
VENICE	235	-0.390	SAINT JOHN	235	-0.325
GIJON	236	-0.544	PANJANG	236	-0.399
RADES	237	-0.821	TOMAKOMAI	237	-0.448
GEORGETOWN (GUYANA)	238	-0.963	BELAWAN	238	-0.480
TOMAKOMAI	239	-1.381	CONAKRY	239	-0.481
SAINT JOHN	240	-1.730	MAZATLAN	240	-0.524
BLUFF	241	-1.784	MEJILLONES	241	-0.564
CONAKRY	242	-1.833	NEMRUT BAY	242	-0.745
KOTKA	243	-2.040	KOMPONG SOM	243	-0.874
VILA DO CONDE	244	-2.095	QINZHOU	244	-0.929
BATUMI	245	-2.241	VILA DO CONDE	245	-0.934
PANJANG	246	-2.779	IZMIR	246	-1.093
QINZHOU	247	-3.362	HAIFA	247	-1.267
SAMSUN	248	-3.711	VARNA	248	-1.584
JUBAIL	249	-3.792	KAWASAKI	249	-1.752
BELAWAN	250	-3.890	TEESPORT	250	-2.064
NEW YORK AND NEW JERSEY	251	-4.321	NEW YORK AND NEW JERSEY	251	-2.159
GAVLE	252	-4.762	PORT OF SPAIN	252	-2.258
IZMIR	253	-4.805	SAMSUN	253	-2.272
PORT OF SPAIN	254	-5.624	MOGADISCIO	254	-2.435
GDYNIA	255	-6.058	ST. PETERSBURG	255	-2.789
ST. PETERSBURG	256	-6.294	GAVLE	256	-3.180
TEESPORT	257	-6.418	ADELAIDE	257	-3.425
CALLAO	258	-6.638	HAMBURG	258	-3.518
MOGADISCIO	259	-7.613	MANAUS	259	-3.644
CALDERA (COSTA RICA)	260	-8.156	AGADIR	260	-3.714
AGADIR	261	-8.711	CONSTANTZA	261	-3.719
CASABLANCA	262	-9.239	CASABLANCA	262	-4.073
MANAUS	263	-9.337	LA GUAIRA	263	-4.392
ADELAIDE	264	-9.863	CALDERA (COSTA RICA)	264	-4.755

ADMINISTRATIVE APPROACH			STATISTICAL APPROACH		
Port Name	Rank	Total Points	Port Name	Rank	Index Value
LA GUAIRA	265	-10.037	MONTEVIDEO	265	-4.983
YANTIAN	266	-10.230	ALEXANDRIA (EGYPT)	266	-5.001
TURBO	267	-11.329	NAPLES	267	-5.039
FREETOWN	268	-11.843	BEIRA	268	-5.257
HUENEME	269	-12.006	ACAJUTLA	269	-5.390
BEIRA	270	-12.045	YANTIAN	270	-5.466
ACAJUTLA	271	-12.182	VUNG TAU	271	-5.658
CONSTANTZA	272	-12.712	FREETOWN	272	-5.691
SANTO TOMAS DE CASTILLA	273	-13.292	ANTOFAGASTA	273	-5.760
DAVAO	274	-13.669	HUENEME	274	-6.110
FORTALEZA	275	-14.807	SANTO TOMAS DE CASTILLA	275	-6.427
KALININGRAD	276	-14.877	KALININGRAD	276	-6.574
ALEXANDRIA (EGYPT)	277	-15.305	TURBO	277	-6.623
ZEEBRUGGE	278	-15.389	FORTALEZA	278	-6.668
TOAMASINA	279	-16.113	DAVAO	279	-6.968
SUAPE	280	-17.478	TOAMASINA	280	-7.109
TAKORADI	281	-18.202	BRISBANE	281	-8.469
QASR AHMED	282	-18.283	NAPIER	282	-8.561
NAPLES	283	-19.737	CORINTO	283	-8.686
MONTEVIDEO	284	-20.895	PUERTO CABELLO	284	-9.380
BEJAIA	285	-21.270	ADEN	285	-9.507
CORINTO	286	-21.337	LE HAVRE	286	-9.533
PUERTO CABELLO	287	-23.284	SUAPE	287	-9.607
BRISBANE	288	-24.619	QASR AHMED	288	-9.944
PORT VICTORIA	289	-25.449	BEJAIA	289	-10.471
NAPIER	290	-25.742	TAKORADI	290	-11.023
ROTTERDAM	291	-26.820	ZEEBRUGGE	291	-11.150
LE HAVRE	292	-26.886	OTAGO HARBOUR	292	-11.396
MOMBASA	293	-27.174	MAYOTTE	293	-11.873
MAYOTTE	294	-27.444	MELBOURNE	294	-11.938
POINT LISAS PORTS	295	-28.104	ARICA	295	-12.157
GUAYAQUIL	296	-29.497	MOMBASA	296	-12.177
ARICA	297	-30.042	MARSEILLE	297	-12.209
OTAGO HARBOUR	298	-30.113	PORT VICTORIA	298	-12.337
BANGKOK	299	-30.452	DUBLIN	299	-12.365
DUBLIN	300	-30.607	ROTTERDAM	300	-13.017
LAE	301	-31.730	POINT LISAS PORTS	301	-13.433
OWENDO	302	-32.614	GUAYAQUIL	302	-13.513
DAKAR	303	-32.840	OWENDO	303	-13.583
YANGON	304	-34.103	BANGKOK	304	-14.923
ADEN	305	-34.779	ALGIERS	305	-15.275
ALGIERS	306	-36.205	LAE	306	-16.182

ADMINISTRATIVE APPROACH			STATISTICAL APPROACH		
Port Name	Rank	Total Points	Port Name	Rank	Index Value
GRANGEMOUTH	307	-36.219	YANGON	307	-16.590
MELBOURNE	308	-37.421	DAKAR	308	-17.575
DURRES	309	-37.626	LA SPEZIA	309	-18.987
TIMARU	310	-37.693	YUZHNY	310	-19.100
MONTREAL	311	-39.809	IQUIQUE	311	-19.234
PORT ELIZABETH	312	-46.416	LYTTELTON	312	-19.801
LA SPEZIA	313	-47.346	MONTREAL	313	-20.272
LYTTELTON	314	-47.720	TIMARU	314	-21.135
MARSEILLE	315	-49.482	SAN PEDRO (COTE D'IVOIRE)	315	-21.804
SHANGHAI	316	-51.827	GRANGEMOUTH	316	-22.520
YUZHNY	317	-52.207	PORT ELIZABETH	317	-23.885
SAN PEDRO (COTE D'IVOIRE)	318	-53.819	SHANGHAI	318	-24.039
IQUIQUE	319	-53.887	DURRES	319	-24.525
SAN ANTONIO	320	-55.808	SAN ANTONIO	320	-25.395
MAPUTO	321	-58.683	PORT BOTANY	321	-25.565
LIVERPOOL (UNITED KINGDOM)	322	-58.778	SEATTLE	322	-25.648
PORT LOUIS	323	-61.778	MAPUTO	323	-26.003
PORT BOTANY	324	-63.908	MANILA	324	-28.809
TAURANGA	325	-64.477	LIVERPOOL (UNITED KINGDOM)	325	-29.027
TRIESTE	326	-64.659	VLADIVOSTOK	326	-29.594
MANILA	327	-67.096	THESSALONIKI	327	-29.655
WALVIS BAY	328	-68.372	FREMANTLE	328	-29.997
ASHDOD	329	-69.310	PORT LOUIS	329	-30.575
VLADIVOSTOK	330	-69.773	TAURANGA	330	-31.494
THESSALONIKI	331	-71.418	PORT RÉUNION	331	-33.187
DUTCH HARBOR	332	-74.601	WALVIS BAY	332	-34.889
PORT RÉUNION	333	-85.474	LIVORNO	333	-37.620
FELIXSTOWE	334	-86.502	TIN CAN ISLAND	334	-38.451
FREMANTLE	335	-90.529	GENOA	335	-39.902
SEATTLE	336	-92.888	FELIXSTOWE	336	-40.078
GENOA	337	-93.568	DUTCH HARBOR	337	-40.159
LIVORNO	338	-96.571	TRIESTE	338	-40.420
TIN CAN ISLAND	339	-98.354	PRINCE RUPERT	339	-44.345
DOUALA	340	-106.203	DOUALA	340	-44.552
CHATTOGRAM	341	-109.249	TACOMA	341	-45.529
ONNE	342	-111.104	ASHDOD	342	-46.157
BRISTOL	343	-111.703	ONNE	343	-49.702
PRINCE RUPERT	344	-114.287	BRISTOL	344	-52.914
TACOMA	345	-119.152	DUNKIRK	345	-53.157
SOUTHAMPTON	346	-120.369	COTONOU	346	-54.931
LONDON	347	-124.535	CHATTOGRAM	347	-54.949
COTONOU	348	-130.819	SOUTHAMPTON	348	-55.490

ADMINISTRATIVE APPROACH			STATISTICAL APPROACH		
Port Name	Rank	Total Points	Port Name	Rank	Index Value
LOMÉ	349	-133.170	LOMÉ	349	-56.728
DUNKIRK	350	-142.600	AUCKLAND	350	-62.159
AUCKLAND	351	-142.913	FREEPORT (BAHAMAS)	351	-64.071
FREEPORT (BAHAMAS)	352	-157.072	SOKHNA	352	-66.771
SOKHNA	353	-158.457	TEMA	353	-67.093
TEMA	354	-160.565	NOUAKCHOTT	354	-70.175
KRIBI DEEP SEA PORT	355	-174.476	LONDON	355	-73.209
NOUAKCHOTT	356	-175.532	BEIRUT	356	-73.234
BEIRUT	357	-183.442	KRIBI DEEP SEA PORT	357	-74.427
LAGOS (NIGERIA)	358	-188.317	LAGOS (NIGERIA)	358	-80.295
OAKLAND	359	-207.413	ABIDJAN	359	-93.807
ABIDJAN	360	-216.138	OAKLAND	360	-95.795
DAR ES SALAAM	361	-248.798	DAR ES SALAAM	361	-105.753
POINTE-NOIRE	362	-320.281	POINTE-NOIRE	362	-110.337
NGQURA	363	-359.179	DURBAN	363	-155.820
DURBAN	364	-386.098	CAPE TOWN	364	-159.253
CAPE TOWN	365	-410.746	NGQURA	365	-170.593
LUANDA	366	-442.446	LUANDA	366	-174.675
SAVANNAH	367	-464.721	SAVANNAH	367	-217.103
VANCOUVER (CANADA)	368	-573.524	VANCOUVER (CANADA)	368	-245.879
LONG BEACH	369	-952.470	LOS ANGELES	369	-281.841
LOS ANGELES	370	-954.086	LONG BEACH	370	-348.928

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

The CPPI 2021 also displays a marked reduction in the discrepancies between the two approaches compared to CPPI 2020. 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. 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). Approximately 40 percent (137 ports) were ranked within 10 places or less of themselves in the CPPI 2020. CPPI 2021 registered 267 ports (72 percent) that were ranked within 10 places or less of themselves, a 32 percent improvement on CPPI 2020 rankings. In CPPI 2021, the first 20 ports and final 20 ports are within an average of one place from themselves in the dual rankings.

Ranking by Region

This section presents the results of the 370 ports in the CPPI 2021 by region. One of the requested amendments to CPPI 2020 was to tabulate the results and rankings by region and by throughput, to allow easier comparison with ports in the region, but also with ports with a similar throughput. This section offers a summary tabulation of the results and ranking (see table 3.2 onward) by the following defined 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	Rank	Index Points
PORT OF VIRGINIA	23	118.3
MIAMI	29	105.8
HALIFAX	46	91.7
WILMINGTON (NORTH CAROLINA)	49	84.2
PHILADELPHIA	55	74.8
TAMPA	61	67.8
PORT TAMPA BAY	64	64.3
BALTIMORE	76	54.6
JACKSONVILLE	100	44.3
NEW ORLEANS	115	34.2
PORT EVERGLADES	116	33.7
BOSTON (UNITED STATES)	117	33.4
HOUSTON	119	32.0
CHARLESTON	130	26.2
MOBILE	163	15.4
APRA HARBOR	199	7.7
SAINT JOHN	240	(1.7)
NEW YORK AND NEW JERSEY	251	(4.3)
HUENEME	269	(12.0)
MONTREAL	311	(39.8)
DUTCH HARBOR	332	(74.6)
SEATTLE	336	(92.9)
PRINCE RUPERT	344	(114.3)
TACOMA	345	(119.2)
OAKLAND	359	(207.4)
SAVANNAH	367	(464.7)
VANCOUVER (CANADA)	368	(573.5)
LONG BEACH	369	(952.5)
LOS ANGELES	370	(954.1)

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

Port Name	Rank	Index Points
CARTAGENA (COLOMBIA)	12	152.9
BUENAVENTURA	20	124.4
CORONEL	39	100.2
IMBITUBA	51	83.0
BALBOA	60	67.8
POSORJA	66	61.5
ITAPOA	72	57.8
COLON	73	57.3
PAITA	75	54.7
ALTAMIRA	85	50.1
PUERTO LIMON	86	47.8
MANZANILLO (MEXICO)	89	46.7
LAZARO CARDENAS	92	46.0
RIO DE JANEIRO	93	46.0
RIO GRANDE (BRAZIL)	97	44.6
ENSENADA	102	43.6
VERACRUZ	104	43.1
VALPARAISO	108	40.3
POINTE-À-PITRE	109	40.2
PUERTO QUETZAL	110	36.4
SALVADOR	112	36.1
CAUCEDO	114	34.3
PECEM	121	29.4
FORT-DE-FRANCE	122	28.5
SEPETIBA	123	28.3
LIRQUEN	126	26.9
KINGSTON (JAMAICA)	131	25.4
CRISTOBAL	134	24.2
BUENOS AIRES	141	21.0
SANTA MARTA	143	20.3
PUERTO CORTES	144	20.1
PUERTO BOLIVAR (ECUADOR)	156	16.7
SAN JUAN	157	16.5
RIO HAINA	158	16.2
BARRANQUILLA	159	16.0
SAN VICENTE	166	14.4
PUERTO BARRIOS	170	13.8
PHILIPSBURG	177	12.7
PORT-AU-PRINCE	178	12.0
SANTOS	188	9.9
GUSTAVIA	197	8.1
PARANAGUA	198	8.1
PUERTO PROGRESO	200	7.5

Port Name	Rank	Index Points
ITAJAÍ	207	4.5
NASSAU	212	4.0
VITÓRIA	217	3.3
MARIEL	222	2.0
MAZATLAN	227	1.4
MEJILLONES	231	0.9
ANTOFAGASTA	234	(0.3)
GEORGETOWN (GUYANA)	238	(1.0)
VILA DO CONDE	244	(2.1)
PORT OF SPAIN	254	(5.6)
CALLAO	258	(6.6)
CALDERA (COSTA RICA)	260	(8.2)
MANAUS	263	(9.3)
LA GUAIRA	265	(10.0)
TURBO	267	(11.3)
ACAJUTLA	271	(12.2)
SANTO TOMAS DE CASTILLA	273	(13.3)
FORTALEZA	275	(14.8)
SUAPE	280	(17.5)
MONTEVIDEO	284	(20.9)
CORINTO	286	(21.3)
PUERTO CABELLO	287	(23.3)
POINT LISAS PORTS	295	(28.1)
GUAYAQUIL	296	(29.5)
ARICA	297	(30.0)
IQUIQUE	319	(53.9)
SAN ANTONIO	320	(55.8)
FREEPORT (BAHAMAS)	352	(157.1)

TABLE 3.4. • The CPPI by Region: Europe and North Africa

Port Name	Rank	Index Points
TANGER-MEDITERRANEAN	6	178.1
ALGECIRAS	11	155.9
PORT SAID	15	141.3
BARCELONA	22	119.3
YARIMCA	28	106.7
SINES	30	105.4
MERSIN	34	102.3
AMBARLI	43	93.6
DAMIETTA	58	72.7
BREMERHAVEN	59	67.9
GIOIA TAURO	65	62.4

Port Name	Rank	Index Points
ISKENDERUN	70	59.0
SANTA CRUZ DE TENERIFE	71	58.8
MARSAXLOKK	74	55.0
DILISKELESI	77	54.3
AARHUS	82	51.0
TRIPOLI (LEBANON)	87	47.5
SAVONA-VADO	94	45.9
ANTWERP	96	45.1
PIRAEUS	101	43.8
NANTES SAINT-NAZAIRE	105	41.6
GEMLIK	113	36.1
GOTHENBURG	118	32.1
KOPER	129	26.3
VALENCIA	135	23.8
MALAGA	137	22.3
PORT BRONKA	138	22.0
EL DEKHEILA	139	21.7
OSLO	146	18.9
LIMASSOL	147	18.4
BORUSAN	148	18.3
VIGO	149	18.2
PORT AKDENIZ	152	17.8
TARRAGONA	160	15.9
CIVITAVECCHIA	162	15.6
HELSINGBORG	168	14.1
CHORNOMORSK	169	13.9
NOVOROSSIYSK	172	13.6
PLOČE	173	13.2
LATAKIA	174	13.1
MUUGA-PORT OF TALLINN	175	12.8
FREDERICIA	176	12.8
ANCONA	179	11.8
HELSINKI	180	11.6
NORRKOPING	182	11.3
BAR	183	11.2
KLAIPEDA	186	10.6
RAVENNA	187	10.0
RIJEKA	190	9.5
CATANIA	191	9.4
SALERNO	192	9.3
BARI	193	9.2
BURGAS	195	8.6
HAIFA	196	8.5
RAUMA	201	7.5

Port Name	Rank	Index Points
BILBAO	202	7.2
GDANSK	203	6.2
PALERMO	204	5.6
LEIXÕES	205	5.3
COPENHAGEN	206	5.0
ODESSA	209	4.4
LARVIK	210	4.3
TRAPANI	213	4.0
RIGA	214	3.9
LISBON	215	3.6
HERAKLION	216	3.3
TARTOUS	219	2.8
CADIZ	221	2.6
KRISTIANSAND	223	1.8
NEMRUT BAY	224	1.7
VARNA	225	1.5
POTI	226	1.4
BORDEAUX	228	1.2
ALICANTE	229	1.0
HAMBURG	232	0.2
WILHELMSHAVEN	233	(0.0)
VENICE	235	(0.4)
GIJON	236	(0.5)
RADES	237	(0.8)
KOTKA	243	(2.0)
BATUMI	245	(2.2)
SAMSUN	248	(3.7)
GAVLE	252	(4.8)
IZMIR	253	(4.8)
GDYNIA	255	(6.1)
ST. PETERSBURG	256	(6.3)
TEESPORT	257	(6.4)
AGADIR	261	(8.7)
CASABLANCA	262	(9.2)
CONSTANTZA	272	(12.7)
KALININGRAD	276	(14.9)
ALEXANDRIA (EGYPT)	277	(15.3)
ZEEBRUGGE	278	(15.4)
QASR AHMED	282	(18.3)
NAPLES	283	(19.7)
BEJAIA	285	(21.3)
ROTTERDAM	291	(26.8)
LE HAVRE	292	(26.9)
DUBLIN	300	(30.6)

Port Name	Rank	Index Points
ALGIERS	306	(36.2)
GRANGEMOUTH	307	(36.2)
DURRES	309	(37.6)
LA SPEZIA	313	(47.3)
MARSEILLE	315	(49.5)
YUZHNY	317	(52.2)
LIVERPOOL (UNITED KINGDOM)	322	(58.8)
TRIESTE	326	(64.7)
ASHDOD	329	(69.3)
VLADIVOSTOK	330	(69.8)
THESSALONIKI	331	(71.4)
FELIXSTOWE	334	(86.5)
GENOA	337	(93.6)
LIVORNO	338	(96.6)
BRISTOL	343	(111.7)
SOUTHAMPTON	346	(120.4)
LONDON	347	(124.5)
DUNKIRK	350	(142.6)
SOKHNA	353	(158.5)
BEIRUT	357	(183.4)

TABLE 3.5. • The CPPI by Region: West, Central, and South Asia

Port Name	Rank	Index Points
KING ABDULLAH PORT	1	217.9
SALALAH	2	197.7
HAMAD PORT	3	194.8
KHALIFA PORT	5	182.6
JEDDAH	8	161.5
DAMMAM	14	143.5
DJIBOUTI	19	129.4
COLOMBO	24	117.5
PIPAVAV	26	109.8
MAGDALLA	32	103.0
AQABA	35	101.2
JEBEL ALI	38	100.2
SOHAR	47	89.7
MUNDRA	48	86.6
JAWAHARLAL NEHRU PORT	54	79.7
KHALIFA BIN SALMAN	62	67.7
HAZIRA	68	59.1
CHENNAI	79	53.4
MUHAMMAD BIN QASIM	81	51.0

Port Name	Rank	Index Points
KAMARAJAR	84	50.3
KARACHI	90	46.4
KRISHNAPATNAM	95	45.8
VISAKHAPATNAM	98	44.5
COCHIN	99	44.3
KATTUPALLI	106	41.5
UMM QASR	150	18.0
SHARJAH	155	16.7
SHUAIBA	185	10.8
SHUWAIKH	189	9.6
JUBAIL	249	(3.8)
ADEN	305	(34.8)
CHATTOGRAM	341	(109.2)

TABLE 3.6. • The CPPI by Region: East Asia

Port Name	Rank	Index Points
YANGSHAN	4	183.5
NINGBO	7	170.7
GUANGZHOU	9	161.3
YOKOHAMA	10	159.2
CAI MEP	13	148.4
SHEKOU	16	137.8
CHIWAN	17	132.8
TANJUNG PELEPAS	18	131.4
KAOHSIUNG	21	123.5
BUSAN	25	114.7
TIANJIN	27	109.4
SINGAPORE	31	103.6
YEOSU	33	102.7
OSAKA	36	101.0
VUNG TAU	37	100.9
KOBE	40	99.0
SHIMIZU	41	96.5
QINGDAO	42	95.0
MAWAN	44	92.6
XIAMEN	45	92.2
HONG KONG	50	83.8
INCHEON	52	82.1
NAGOYA	53	81.6
TOKYO	56	74.5
LAEM CHABANG	57	74.0
HAIPHONG	63	67.1

Port Name	Rank	Index Points
KEELUNG	67	59.8
PORT KLANG	69	59.0
LIANYUNGANG	78	53.4
JOHOR	80	52.6
DALIAN	83	50.9
YOKKAICHI	91	46.3
SIAM SEAPORT	103	43.5
TANJUNG PERAK	107	41.3
PENANG	111	36.3
NAHA	120	31.9
TANJUNG PRIOK	124	28.2
TAICHUNG	125	27.6
OMAEZAKI	127	26.9
HAKATA	128	26.7
MOJI	132	24.9
FUZHOU	133	24.7
ZHOUSHAN	136	22.5
SAIGON	140	21.1
DA CHAN BAY TERMINAL ONE	142	20.6
CAT LAI	145	19.8
TANJUNG EMAS	153	17.3
QUY NHON	154	17.1
DANANG	161	15.8
CEBU	164	14.9
SHANTOU	165	14.4
SUBIC BAY	181	11.6
CAGAYAN DE ORO	208	4.4
KAWASAKI	211	4.2
CHU LAI	220	2.8
KOMPONG SOM	230	0.9
TOMAKOMAI	239	(1.4)
PANJANG	246	(2.8)
QINZHOU	247	(3.4)
BELAWAN	250	(3.9)
YANTIAN	266	(10.2)
DAVAO	274	(13.7)
BANGKOK	299	(30.5)
YANGON	304	(34.1)
SHANGHAI	316	(51.8)
MANILA	327	(67.1)

TABLE 3.7. • The CPPI by Region: Oceania

Port Name	Rank	Index Points
NOUMEA	88	46.9
WELLINGTON	151	17.8
PAPEETE	167	14.2
NELSON	194	8.6
BELL BAY	218	3.1
BLUFF	241	(1.8)
ADELAIDE	264	(9.9)
BRISBANE	288	(24.6)
NAPIER	290	(25.7)
OTAGO HARBOUR	298	(30.1)
LAE	301	(31.7)
MELBOURNE	308	(37.4)
TIMARU	310	(37.7)
LYTTELTON	314	(47.7)
PORT BOTANY	324	(63.9)
TAURANGA	325	(64.5)
FREMANTLE	335	(90.5)
AUCKLAND	351	(142.9)

TABLE 3.8. • The CPPI by Region: Sub-Saharan Africa

Port Name	Rank	Index Points
MATADI	171	13.7
BERBERA	184	10.9
CONAKRY	242	(1.8)
MOGADISCIO	259	(7.6)
FREETOWN	268	(11.8)
BEIRA	270	(12.0)
TOAMASINA	279	(16.1)
TAKORADI	281	(18.2)
PORT VICTORIA	289	(25.4)
MOMBASA	293	(27.2)
MAYOTTE	294	(27.4)
OWENDO	302	(32.6)
DAKAR	303	(32.8)
PORT ELIZABETH	312	(46.4)
SAN PEDRO (COTE D'IVOIRE)	318	(53.8)
MAPUTO	321	(58.7)
PORT LOUIS	323	(61.8)
WALVIS BAY	328	(68.4)
PORT RÉUNION	333	(85.5)
TIN CAN ISLAND	339	(98.4)

Port Name	Rank	Index Points
DOUALA	340	(106.2)
ONNE	342	(111.1)
COTONOU	348	(130.8)
LOMÉ	349	(133.2)
TEMA	354	(160.6)
KRIBI DEEP SEA PORT	355	(174.5)
NOUAKCHOTT	356	(175.5)
LAGOS (NIGERIA)	358	(188.3)
ABIDJAN	360	(216.1)
DAR ES SALAAM	361	(248.8)
POINTE-NOIRE	362	(320.3)
NGQURA	363	(359.2)
DURBAN	364	(386.1)
CAPE TOWN	365	(410.7)
LUANDA	366	(442.4)

Ranking by Throughput

This section presents the CPPI 2021 by throughput. This section offers a summary tabulation (see table 3.9 and onward) by throughput using the following defined ranges:

- Large: more than 4 million TEUs per year
- Medium: between 0.5 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	Size	Rank	IndexPoints
SALALAH	Large	2	197.7
YANGSHAN	Large	4	183.5
TANGER-MEDITERRANEAN	Large	6	178.1
NINGBO	Large	7	170.7
JEDDAH	Large	8	161.5
GUANGZHOU	Large	9	161.3
ALGECIRAS	Large	11	155.9
CAI MEP	Large	13	148.4
SHEKOU	Large	16	137.8
CHIWAN	Large	17	132.8
TANJUNG PELEPAS	Large	18	131.4
KAOHSIUNG	Large	21	123.5
COLOMBO	Large	24	117.5
BUSAN	Large	25	114.7

Port Name	Size	Rank	IndexPoints
TIANJIN	Large	27	109.4
SINGAPORE	Large	31	103.6
JEBEL ALI	Large	38	100.2
QINGDAO	Large	42	95.0
XIAMEN	Large	45	92.2
MUNDRA	Large	48	86.6
HONG KONG	Large	50	83.8
JAWAHARLAL NEHRU PORT	Large	54	79.7
TOKYO	Large	56	74.5
LAEM CHABANG	Large	57	74.0
BREMERHAVEN	Large	59	67.9
PORT KLANG	Large	69	59.0
COLON	Large	73	57.3
LIANYUNGANG	Large	78	53.4
DALIAN	Large	83	50.9
ANTWERP	Large	96	45.1
PIRAEUS	Large	101	43.8
TANJUNG PERAK	Large	107	41.3
TANJUNG PRIOK	Large	124	28.2
KINGSTON (JAMAICA)	Large	131	25.4
VALENCIA	Large	135	23.8
ZHOUSHAN	Large	136	22.5
SAIGON	Large	140	21.1
CAT LAI	Large	145	19.8
SANTOS	Large	188	9.9
HAMBURG	Large	232	0.2
QINZHOU	Large	247	(3.4)
NEW YORK AND NEW JERSEY	Large	251	(4.3)
YANTIAN	Large	266	(10.2)
ROTTERDAM	Large	291	(26.8)
SHANGHAI	Large	316	(51.8)
MANILA	Large	327	(67.1)
SAVANNAH	Large	367	(464.7)
LONG BEACH	Large	369	(952.5)
LOS ANGELES	Large	370	(954.1)

TABLE 3.10. • The CPPI by Region: Medium Ports (0.5 to 4 million TEUs per year)

Port Name	Size	Rank	Index Points
KING ABDULLAH PORT	Medium	1	217.9
HAMAD PORT	Medium	3	194.8
KHALIFA PORT	Medium	5	182.6

Port Name	Size	Rank	Index Points
YOKOHAMA	Medium	10	159.2
CARTAGENA (COLOMBIA)	Medium	12	152.9
DAMMAM	Medium	14	143.5
PORT SAID	Medium	15	141.3
DJIBOUTI	Medium	19	129.4
BUENAVENTURA	Medium	20	124.4
BARCELONA	Medium	22	119.3
PORT OF VIRGINIA	Medium	23	118.3
PIPAVAV	Medium	26	109.8
MIAMI	Medium	29	105.8
YEOSU	Medium	33	102.7
MERSIN	Medium	34	102.3
AQABA	Medium	35	101.2
OSAKA	Medium	36	101.0
KOBE	Medium	40	99.0
SHIMIZU	Medium	41	96.5
AMBARLI	Medium	43	93.6
MAWAN	Medium	44	92.6
HALIFAX	Medium	46	91.7
SOHAR	Medium	47	89.7
INCHEON	Medium	52	82.1
NAGOYA	Medium	53	81.6
DAMIETTA	Medium	58	72.7
BALBOA	Medium	60	67.8
TAMPA	Medium	61	67.8
HAIPHONG	Medium	63	67.1
GIOIA TAURO	Medium	65	62.4
KEELUNG	Medium	67	59.8
HAZIRA	Medium	68	59.1
MARSAXLOKK	Medium	74	55.0
BALTIMORE (MARYLAND)	Medium	76	54.6
CHENNAI	Medium	79	53.4
JOHOR	Medium	80	52.6
MUHAMMAD BIN QASIM	Medium	81	51.0
ALTAMIRA	Medium	85	50.1
MANZANILLO (MEXICO)	Medium	89	46.7
KARACHI	Medium	90	46.4
LAZARO CARDENAS	Medium	92	46.0
RIO DE JANEIRO	Medium	93	46.0
SAVONA-VADO	Medium	94	45.9
KRISHNAPATNAM	Medium	95	45.8
RIO GRANDE (BRAZIL)	Medium	97	44.6
COCHIN	Medium	99	44.3
JACKSONVILLE	Medium	100	44.3

Port Name	Size	Rank	Index Points
KATTUPALLI	Medium	106	41.5
VALPARAISO	Medium	108	40.3
PENANG	Medium	111	36.3
GEMLIK	Medium	113	36.1
CAUCEDO	Medium	114	34.3
NEW ORLEANS	Medium	115	34.2
PORT EVERGLADES	Medium	116	33.7
BOSTON (UNITED STATES)	Medium	117	33.4
GOTHENBURG	Medium	118	32.1
HOUSTON	Medium	119	32.0
NAHA	Medium	120	31.9
PECEM	Medium	121	29.4
TAICHUNG	Medium	125	27.6
HAKATA	Medium	128	26.7
KOPER	Medium	129	26.3
CHARLESTON	Medium	130	26.2
FUZHOU	Medium	133	24.7
CRISTOBAL	Medium	134	24.2
EL DEKHEILA	Medium	139	21.7
BUENOS AIRES	Medium	141	21.0
DA CHAN BAY TERMINAL ONE	Medium	142	20.6
SANTA MARTA	Medium	143	20.3
TANJUNG EMAS	Medium	153	17.3
MOBILE	Medium	163	15.4
CEBU	Medium	164	14.9
SHANTOU	Medium	165	14.4
PAPEETE	Medium	167	14.2
MATADI	Medium	171	13.7
HELSINKI	Medium	180	11.6
KLAIPEDA	Medium	186	10.6
PARANAGUA	Medium	198	8.1
BILBAO	Medium	202	7.2
GDANSK	Medium	203	6.2
LEIXÕES	Medium	205	5.3
ITAJAÍ	Medium	207	4.5
KOMPONG SOM	Medium	230	0.9
WILHELMSHAVEN	Medium	233	(0.0)
CONAKRY	Medium	242	(1.8)
KOTKA	Medium	243	(2.0)
JUBAIL	Medium	249	(3.8)
BELAWAN	Medium	250	(3.9)
IZMIR	Medium	253	(4.8)
GDYNIA	Medium	255	(6.1)
ST. PETERSBURG	Medium	256	(6.3)

Port Name	Size	Rank	Index Points
CALLAO	Medium	258	(6.6)
MANAUS	Medium	263	(9.3)
ADELAIDE	Medium	264	(9.9)
FREETOWN	Medium	268	(11.8)
CONSTANTZA	Medium	272	(12.7)
KALININGRAD	Medium	276	(14.9)
ALEXANDRIA (EGYPT)	Medium	277	(15.3)
ZEEBRUGGE	Medium	278	(15.4)
TAKORADI	Medium	281	(18.2)
NAPLES	Medium	283	(19.7)
MONTEVIDEO	Medium	284	(20.9)
BRISBANE	Medium	288	(24.6)
LE HAVRE	Medium	292	(26.9)
MOMBASA	Medium	293	(27.2)
GUAYAQUIL	Medium	296	(29.5)
OTAGO HARBOUR	Medium	298	(30.1)
BANGKOK	Medium	299	(30.5)
DUBLIN	Medium	300	(30.6)
DAKAR	Medium	303	(32.8)
YANGON	Medium	304	(34.1)
MELBOURNE	Medium	308	(37.4)
MONTREAL	Medium	311	(39.8)
LA SPEZIA	Medium	313	(47.3)
MARSEILLE	Medium	315	(49.5)
SAN ANTONIO	Medium	320	(55.8)
LIVERPOOL (UNITED KINGDOM)	Medium	322	(58.8)
PORT LOUIS	Medium	323	(61.8)
PORT BOTANY	Medium	324	(63.9)
TAURANGA	Medium	325	(64.5)
TRIESTE	Medium	326	(64.7)
FELIXSTOWE	Medium	334	(86.5)
FREMANTLE	Medium	335	(90.5)
SEATTLE	Medium	336	(92.9)
GENOA	Medium	337	(93.6)
LIVORNO	Medium	338	(96.6)
TIN CAN ISLAND	Medium	339	(98.4)
DOUALA	Medium	340	(106.2)
CHATTOGRAM	Medium	341	(109.2)
PRINCE RUPERT	Medium	344	(114.3)
TACOMA	Medium	345	(119.2)
SOUTHAMPTON	Medium	346	(120.4)
LONDON	Medium	347	(124.5)
COTONOU	Medium	348	(130.8)
LOMÉ	Medium	349	(133.2)

Port Name	Size	Rank	Index Points
AUCKLAND	Medium	351	(142.9)
FREEPORT (BAHAMAS)	Medium	352	(157.1)
TEMA	Medium	354	(160.6)
BEIRUT	Medium	357	(183.4)
LAGOS (NIGERIA)	Medium	358	(188.3)
OAKLAND	Medium	359	(207.4)
ABIDJAN	Medium	360	(216.1)
DAR ES SALAAM	Medium	361	(248.8)
NGQURA	Medium	363	(359.2)
DURBAN	Medium	364	(386.1)
CAPE TOWN	Medium	365	(410.7)
LUANDA	Medium	366	(442.4)
VANCOUVER (CANADA)	Medium	368	(573.5)

TABLE 3.11. • The CPPI by Region: Small Ports (less than 0.5 million TEUs per year)

Port Name	Size	Rank	Index Points
YARIMCA	Small	28	106.7
SINES	Small	30	105.4
MAGDALLA	Small	32	103.0
VUNG TAU	Small	37	100.9
CORONEL	Small	39	100.2
WILMINGTON (NORTH CAROLINA)	Small	49	84.2
IMBITUBA	Small	51	83.0
PHILADELPHIA	Small	55	74.8
KHALIFA BIN SALMAN	Small	62	67.7
PORT TAMPA BAY	Small	64	64.3
POSORJA	Small	66	61.5
ISKENDERUN	Small	70	59.0
SANTA CRUZ DE TENERIFE	Small	71	58.8
ITAPOA	Small	72	57.8
PAITA	Small	75	54.7
DILISKELESI	Small	77	54.3
AARHUS	Small	82	51.0
KAMARAJAR	Small	84	50.3
PUERTO LIMON	Small	86	47.8
TRIPOLI (LEBANON)	Small	87	47.5
NOUMEA	Small	88	46.9
YOKKAICHI	Small	91	46.3
VISAKHAPATNAM	Small	98	44.5
ENSENADA	Small	102	43.6
SIAM SEAPORT	Small	103	43.5

Port Name	Size	Rank	Index Points
VERACRUZ	Small	104	43.1
NANTES SAINT-NAZAIRE	Small	105	41.6
POINTE-À-PITRE	Small	109	40.2
PUERTO QUETZAL	Small	110	36.4
SALVADOR	Small	112	36.1
FORT-DE-FRANCE	Small	122	28.5
SEPETIBA	Small	123	28.3
LIRQUEN	Small	126	26.9
OMAEZAKI	Small	127	26.9
MOJI	Small	132	24.9
MALAGA	Small	137	22.3
PORT BRONKA	Small	138	22.0
PUERTO CORTES	Small	144	20.1
OSLO	Small	146	18.9
LIMASSOL	Small	147	18.4
BORUSAN	Small	148	18.3
VIGO	Small	149	18.2
UMM QASR	Small	150	18.0
WELLINGTON	Small	151	17.8
PORT AKDENIZ	Small	152	17.8
QUY NHON	Small	154	17.1
SHARJAH	Small	155	16.7
PUERTO BOLIVAR (ECUADOR)	Small	156	16.7
SAN JUAN	Small	157	16.5
RIO HAINA	Small	158	16.2
BARRANQUILLA	Small	159	16.0
TARRAGONA	Small	160	15.9
DANANG	Small	161	15.8
CIVITAVECCHIA	Small	162	15.6
SAN VICENTE	Small	166	14.4
HELSINGBORG	Small	168	14.1
CHORNOMORSK	Small	169	13.9
PUERTO BARRIOS	Small	170	13.8
NOVOROSSIYSK	Small	172	13.6
PLOČE	Small	173	13.2
LATAKIA	Small	174	13.1
MUUGA-PORT OF TALLINN	Small	175	12.8
FREDERICIA	Small	176	12.8
PHILIPSBURG	Small	177	12.7
PORT-AU-PRINCE	Small	178	12.0
ANCONA	Small	179	11.8
SUBIC BAY	Small	181	11.6
NORRKOPING	Small	182	11.3
BAR	Small	183	11.2

Port Name	Size	Rank	Index Points
BERBERA	Small	184	10.9
SHUAIBA	Small	185	10.8
RAVENNA	Small	187	10.0
SHUWAIKH	Small	189	9.6
RIJEKA	Small	190	9.5
CATANIA	Small	191	9.4
SALERNO	Small	192	9.3
BARI	Small	193	9.2
NELSON	Small	194	8.6
BURGAS	Small	195	8.6
HAIFA	Small	196	8.5
GUSTAVIA	Small	197	8.1
APRA HARBOR	Small	199	7.7
PUERTO PROGRESO	Small	200	7.5
RAUMA	Small	201	7.5
PALERMO	Small	204	5.6
COPENHAGEN	Small	206	5.0
CAGAYAN DE ORO	Small	208	4.4
ODESSA	Small	209	4.4
LARVIK	Small	210	4.3
KAWASAKI	Small	211	4.2
NASSAU	Small	212	4.0
TRAPANI	Small	213	4.0
RIGA	Small	214	3.9
LISBON	Small	215	3.6
HERAKLION	Small	216	3.3
VITÓRIA	Small	217	3.3
BELL BAY	Small	218	3.1
TARTOUS	Small	219	2.8
CHU LAI	Small	220	2.8
CADIZ	Small	221	2.6
MARIEL	Small	222	2.0
KRISTIANSAND	Small	223	1.8
NEMRUT BAY	Small	224	1.7
VARNA	Small	225	1.5
POTI	Small	226	1.4
MAZATLAN	Small	227	1.4
BORDEAUX	Small	228	1.2
ALICANTE	Small	229	1.0
MEJILLONES	Small	231	0.9
ANTOFAGASTA	Small	234	(0.3)
VENICE	Small	235	(0.4)
GIJON	Small	236	(0.5)
RADES	Small	237	(0.8)

Port Name	Size	Rank	Index Points
GEORGETOWN (GUYANA)	Small	238	(1.0)
TOMAKOMAI	Small	239	(1.4)
SAINT JOHN	Small	240	(1.7)
BLUFF	Small	241	(1.8)
VILA DO CONDE	Small	244	(2.1)
BATUMI	Small	245	(2.2)
PANJANG	Small	246	(2.8)
SAMSUN	Small	248	(3.7)
GAVLE	Small	252	(4.8)
PORT OF SPAIN	Small	254	(5.6)
TEESPORT	Small	257	(6.4)
MOGADISCIO	Small	259	(7.6)
CALDERA (COSTA RICA)	Small	260	(8.2)
AGADIR	Small	261	(8.7)
CASABLANCA	Small	262	(9.2)
LA GUAIRA	Small	265	(10.0)
TURBO	Small	267	(11.3)
HUENEME	Small	269	(12.0)
BEIRA	Small	270	(12.0)
ACAJUTLA	Small	271	(12.2)
SANTO TOMAS DE CASTILLA	Small	273	(13.3)
DAVAO	Small	274	(13.7)
FORTALEZA	Small	275	(14.8)
TOAMASINA	Small	279	(16.1)
SUAPE	Small	280	(17.5)
QASR AHMED	Small	282	(18.3)
BEJAIA	Small	285	(21.3)
CORINTO	Small	286	(21.3)
PUERTO CABELLO	Small	287	(23.3)
PORT VICTORIA	Small	289	(25.4)
NAPIER	Small	290	(25.7)
MAYOTTE	Small	294	(27.4)
POINT LISAS PORTS	Small	295	(28.1)
ARICA	Small	297	(30.0)
LAE	Small	301	(31.7)
OWENDO	Small	302	(32.6)
ADEN	Small	305	(34.8)
ALGIERS	Small	306	(36.2)
GRANGEMOUTH	Small	307	(36.2)
DURRES	Small	309	(37.6)
TIMARU	Small	310	(37.7)
PORT ELIZABETH	Small	312	(46.4)
LYTTELTON	Small	314	(47.7)
YUZHNY	Small	317	(52.2)

Port Name	Size	Rank	Index Points
SAN PEDRO (COTE D'IVOIRE)	Small	318	(53.8)
IQUIQUE	Small	319	(53.9)
MAPUTO	Small	321	(58.7)
WALVIS BAY	Small	328	(68.4)
ASHDOD	Small	329	(69.3)
VLADIVOSTOK	Small	330	(69.8)
THESSALONIKI	Small	331	(71.4)
DUTCH HARBOR	Small	332	(74.6)
PORT RÉUNION	Small	333	(85.5)
ONNE	Small	342	(111.1)
BRISTOL	Small	343	(111.7)
DUNKIRK	Small	350	(142.6)
SOKHNA	Small	353	(158.5)
KRIBI DEEP SEA PORT	Small	355	(174.5)
NOUAKCHOTT	Small	356	(175.5)
POINTE-NOIRE	Small	362	(320.3)

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

Conclusions and Next Steps

The rationale behind the CPPI was to use available empirical data to create an objective measure to compare container port performance across ports, and eventually over time. The intention was to, in a comparable manner, identify gaps and opportunities for improvement that will ultimately benefit all stakeholders, from shipping lines to national governments to consumers. The CPPI is intended to serve as a key reference point for 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, logistic, and supply chain services.

Looking to the future, the intention is that the CPPI will continue to be refined in subsequent editions, reflecting stakeholder feedback, improvement in data scope and quality, and additional analysis of trends. The World Bank-S&P Global Market Intelligence team will continue to refine the methodologies; the scope, where possible increasing the number of ports; and the data. The next iteration (CPPI 2022) will be comparable, facilitating analysis of trends in container port performance, both overall and potentially by disaggregation by ship or call size. The CPPI 2022 will also seek to remove the divergences between the two approaches, whilst gaining a further understanding of key determinants or influences on container port performance. The overall objective remains the identification of opportunities for improvement to ultimately benefit all public and private stakeholders, including ports, shipping lines, governments, line agencies, businesses, and consumers.

Note

1 Feeders (<1,500 TEUs), intra-regional (1,500–5,000 TEUs), intermediate (5,000–8,500 TEUs), neo-Panamax (8,500–13,500 TEUs), and ultra-large container carriers (>13,500 TEUs).

Appendix A: The CPPI 2021

TABLE A.1. • The CPPI 2021 (the Administrative Approach)

			# PORTS	292	349	227	183	103		
				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	2020H1	Change
KING ABDULLAH PORT	1	217.9	131		3	1	2	1	2	1
SALALAH	2	197.7	1,388	46	6	2	4	5	9	7
HAMAD PORT	3	194.8	274		4	4	11	2	38	35
YANGSHAN	4	183.5	3,542	16	15	8	10	6	10	6
KHALIFA PORT	5	182.6	859	63	53	11	8	3	22	17
TANGER-MEDITERRANEAN	6	178.1	2,923	67	56	9	16	4	15	9
NINGBO	7	170.7	4,163	43	26	15	13	9	13	6
JEDDAH	8	161.5	1,313	158	99	12	7	12	42	34
GUANGZHOU	9	161.3	1,535	24	29	32	14	15	6	-3
YOKOHAMA	10	159.2	1,238	20	8	35	18	19	1	-9
ALGECIRAS	11	155.9	2,248	149	63	26	24	8	32	21

			# PORTS	292	349	227	183	103		
				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	2020H1	Change
CARTAGENA (COLOMBIA)	12	152.9	1,485	89	23	19	12	27	34	22
CAI MEP	13	148.4	875	50	39	45	26	14	18	5
DAMMAM	14	143.5	296		43	25	22	22	92	78
PORT SAID	15	141.3	1,005	132	73	46	28	18	70	55
SHEKOU	16	137.8	937	80	68	28	27	25	5	-11
CHIWAN	17	132.8	881	86	80	54	45	20	27	10
TANJUNG PELEPAS	18	131.4	3,891	229	194	67	32	7	11	-7
DJIBOUTI	19	129.4	225	5	120	48	53	21	93	74
BUENAVENTURA	20	124.4	442	13	21	10	21	49	71	51
KAOHSIUNG	21	123.5	2,527	73	59	16	66	33	4	-17
BARCELONA	22	119.3	1,660	201	41	43	23	37	46	24
PORT OF VIRGINIA	23	118.3	1,299	168	60	44	19	40	110	87
COLOMBO	24	117.5	1,598	185	165	70	72	13	33	9
BUSAN	25	114.7	4,854	120	83	51	56	32	36	11
PIPAVAV	26	109.8	222		1	5	6		39	13
TIANJIN	27	109.4	1,011	40	101	50	92	29	20	-7
YARIMCA	28	106.7	550	62	95	77	85	28	58	30
MIAMI	29	105.8	475	64	19	133	81	23	114	85
SINES	30	105.4	46	113	64	90	41	36	28	-2
SINGAPORE	31	103.6	6,301	200	207	118	83	10	12	-19
MAGDALLA	32	103.0	125		10	22	5		45	13
YEOSU	33	102.7	659	56	61	38	57	44	40	7
MERSIN	34	102.3	1,061	195	230	78	82	16	83	49
AQABA	35	101.2	181	23	27	36	79	46	41	6
OSAKA	36	101.0	461	3	20	66	3		77	41
VUNG TAU	37	100.9	34		5	18	47	59	#N/A	#N/A
JEBEL ALI	38	100.2	2,023	267	203	69	37	26	59	21
CORONEL	39	100.2	160		46	27	35	53	158	119
KOBE	40	99.0	1,056	27	25	30	9		50	10
SHIMIZU	41	96.5	327	8	24	24	17		24	-17
QINGDAO	42	95.0	2,480	138	160	98	62	35	3	-39
AMBARLI	43	93.6	914	49	131	68	58	41	61	18
MAWAN	44	92.6	228	171	54	63	25	60	29	-15
XIAMEN	45	92.2	2,144	178	192	107	63	31	26	-19
HALIFAX	46	91.7	249	59	94	112	129	11	25	-21
SOHAR	47	89.7	181		76	41	71	47	69	22
MUNDRA	48	86.6	805	52	14	33	29		44	-4

			# PORTS	292	349	227	183	103		
				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	2020H1	Change
WILMINGTON (NORTH CAROLINA, UNITED STATES)	49	84.2	84	81	96	96	49	50	67	18
HONG KONG	50	83.8	3,986	191	199	114	84	34	7	-43
IMBITUBA	51	83.0	51		22	6	42		#N/A	#N/A
INCHEON	52	82.1	187	34	35	23	44		37	-15
NAGOYA	53	81.6	1,048	11	9	37	52		48	-5
JAWAHARLAL NEHRU PORT	54	79.7	934	25	82	59	20		63	9
PHILADELPHIA	55	74.8	462	231	90	125	1		87	32
TOKYO	56	74.5	955	12	30	39	64		54	-2
LAEM CHABANG	57	74.0	1,353	30	51	155	90	39	51	-6
DAMIETTA	58	72.7	576	148	221	108	61	42	297	239
BREMERHAVEN	59	67.9	1,285	75	112	111	86	55	85	26
BALBOA	60	67.8	1,470	108	92	104	51	63	78	18
TAMPA	61	67.8	35	71	65	73	43		200	139
KHALIFA BIN SALMAN	62	67.7	176		38	42	55		162	100
HAIPHONG	63	67.1	553	130	162	56	30		60	-3
PORT TAMPA BAY	64	64.3	91	74	67	105	36		#N/A	#N/A
GIOIA TAURO	65	62.4	71	234		119	50	48	212	147
POSORJA	66	61.5	155		18		15		126	60
KEELUNG	67	59.8	643	65	91	64	70		64	-3
HAZIRA	68	59.1	24		12	3			#N/A	#N/A
PORT KLANG	69	59.0	2,409	210	204	110	98	43	14	-55
ISKENDERUN	70	59.0	287	114	110	58	67		272	202
SANTA CRUZ DE TENERIFE	71	58.8	121	26	11	140	46		95	24
ITAPOA	72	57.8	466	96	33	61	94		88	16
COLON	73	57.3	1,478	257	174	145	135	17	82	9
MARSAXLOKK	74	55.0	1,486	255	225	83	69	57	101	27
PAITA	75	54.7	213	4	71		31		94	19
BALTIMORE (MARYLAND)	76	54.6	378		40	101	59		119	43
DILISKELESI	77	54.3	200	29	34	65	100		75	-2
LIANYUNGANG	78	53.4	149	19	267	14	73		31	-47
CHENNAI	79	53.4	81		149	79	48		#N/A	#N/A
JOHOR	80	52.6	167	31	36	29			108	28
MUHAMMAD BIN QASIM	81	51.0	536	106	159	103	54		316	235
AARHUS	82	51.0	203	42	146	181		30	43	-39
DALIAN	83	50.9	591	263	243	195	34	24	19	-64
KAMARAJAR	84	50.3	90		32	17			#N/A	#N/A
ALTAMIRA	85	50.1	542	203	139	117	39		98	13

			# PORTS	292	349	227	183	103		
				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	2020H1	Change
PUERTO LIMON	86	47.8	397	21	49	47			106	20
TRIPOLI (LEBANON)	87	47.5	113	18	28		60		76	-11
NOUMEA	88	46.9	74	60	144	13			124	36
MANZANILLO (MEXICO)	89	46.7	1,061	277	125	116	78	58	145	56
KARACHI	90	46.4	290		241	91	33		80	-10
YOKKAICHI	91	46.3	216		16	40			81	-10
LAZARO CARDENAS	92	46.0	701	283	141	60	38	65	23	-69
RIO DE JANEIRO	93	46.0	469	17	133	115	87		309	216
SAVONA-VADO	94	45.9	157	99	79	86	96		314	220
KRISHNAPATNAM	95	45.8	115	6	2	92			#N/A	#N/A
ANTWERP	96	45.1	3,514	159	175	129	76	64	65	-31
RIO GRANDE (BRAZIL)	97	44.6	311		70	52	108		47	-50
VISAKHAPATNAM	98	44.5	67		100	72	95		#N/A	#N/A
COCHIN	99	44.3	54		57	34			#N/A	#N/A
JACKSONVILLE	100	44.3	158		128	76	91		99	-1
PIRAEUS	101	43.8	1,408	223	242	106	99	52	89	-12
ENSENADA	102	43.6	159		62	85	97		125	23
SIAM SEAPORT	103	43.5	301	15	48		74		136	33
VERACRUZ	104	43.1	441	115	50	57			97	-7
NANTES SAINT-NAZAIRE	105	41.6	171	174	195	7			246	141
KATTUPALLI	106	41.5	99	48	69	62			#N/A	#N/A
TANJUNG PERAK	107	41.3	291	97	156	31			172	65
VALPARAISO	108	40.3	193	10	249	53	124	61	102	-6
POINTE-À-PITRE	109	40.2	206	107	109	49			113	4
PUERTO QUETZAL	110	36.4	341		189	120	77		174	64
PENANG	111	36.3	107	190	210	20			227	116
SALVADOR	112	36.1	308	104	72	122	105		55	-57
GEMLIK	113	36.1	649	111	58	100	116		79	-34
CAUCEDO	114	34.3	604	153	147	89	107	68	68	-46
NEW ORLEANS	115	34.2	424	61	107	109	110		237	122
PORT EVERGLADES	116	33.7	389	68	119	74	119		147	31
BOSTON (UNITED STATES)	117	33.4	58		47		88		73	-44
GOTHENBURG	118	32.1	248	134	153			56	339	221
HOUSTON	119	32.0	857	119	173	113	101		242	123
NAHA	120	31.9	34			21			111	-9
PECEM	121	29.4	142	32	89	55	139		86	-35
FORT-DE-FRANCE	122	28.5	85	84	171	81			112	-10

			# PORTS	292	349	227	183	103		
				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	2020H1	Change
SEPETIBA	123	28.3	128		77	161	80		84	-39
TANJUNG PRIOK	124	28.2	775	122	169	80			66	-58
TAICHUNG	125	27.6	352	41	86	127			146	21
LIRQUEN	126	26.9	49		201	84	109		262	136
OMAEZAKI	127	26.9	43	7	17				121	-6
HAKATA	128	26.7	280	36	7				116	-12
KOPER	129	26.3	501	179	209	87	40	79	230	101
CHARLESTON	130	26.2	1,399	79	102	102	75	80	53	-77
KINGSTON (JAMAICA)	131	25.4	964	235	216	165	117	45	286	155
MOJI	132	24.9	39	2	42				123	-9
FUZHOU	133	24.7	163	273	111	144	68		21	-112
CRISTOBAL	134	24.2	812	118	232	162	138	38	257	123
VALENCIA	135	23.8	908	227	191	130	102	66	308	173
ZHOUSHAN	136	22.5	352	193	262	152	93	62	8	-128
MALAGA	137	22.3	182	51	81	97	106	77	129	-8
PORT BRONKA	138	22.0	113	103	31				152	14
EL DEKHEILA	139	21.7	201	125	104	132			256	117
SAIGON	140	21.1	150	28	66				151	11
BUENOS AIRES	141	21.0	256		197	82	120		310	169
DA CHAN BAY TERMINAL ONE	142	20.6	131	144	172	121			35	-107
SANTA MARTA	143	20.3	260		13				137	-6
PUERTO CORTES	144	20.1	276	66	52	154			149	5
CAT LAI	145	19.8	556	146	37				109	-36
OSLO	146	18.9	57	54	78				91	-55
LIMASSOL	147	18.4	152	189	103	135			178	31
BORUSAN	148	18.3	119	55	84				195	47
VIGO	149	18.2	272	102	74				159	10
UMM QASR	150	18.0	150		245	71			294	144
WELLINGTON	151	17.8	111		134	131			141	-10
PORT AKDENIZ	152	17.8	146	72	87				154	2
TANJUNG EMAS	153	17.3	122	9	126				143	-10
QUY NHON	154	17.1	43	98	88				104	-50
SHARJAH	155	16.7	71		44				#N/A	#N/A
PUERTO BOLIVAR (ECUADOR)	156	16.7	99		45				155	-1
SAN JUAN	157	16.5	166	95	93				164	7
RIO HAINA	158	16.2	87	100	97				160	2

			# PORTS	292	349	227	183	103		
				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	2020H1	Change
BARRANQUILLA	159	16.0	47	101	98				169	10
TARRAGONA	160	15.9	81	70	105				134	-26
DANANG	161	15.8	180	53	113				115	-46
CIVITAVECCHIA	162	15.6	45	45	122				181	19
MOBILE	163	15.4	293		182	149	104		132	-31
CEBU	164	14.9	44	82	118				140	-24
SHANTOU	165	14.4	110	44	138				117	-48
SAN VICENTE	166	14.4	72		142	151	111		226	60
PAPEETE	167	14.2	43	90	127				167	0
HELSINGBORG	168	14.1	121	93	130				171	3
CHORNOMORSK	169	13.9	128	47	145				274	105
PUERTO BARRIOS	170	13.8	158	38	157				122	-48
MATADI	171	13.7	66	157	106				205	34
NOVOROSSIYSK	172	13.6	344	131	188	141			301	129
PLOČE	173	13.2	30	110	135				#N/A	#N/A
LATAKIA	174	13.1	89	143	123				187	13
MUUGA-PORT OF TALLINN	175	12.8	64	87	148				198	23
FREDERICIA	176	12.8	56	58	158				138	-38
PHILIPSBURG	177	12.7	74	88	151				192	15
PORT-AU-PRINCE	178	12.0	29	184	114				#N/A	#N/A
ANCONA	179	11.8	142	142	143				183	4
HELSINKI	180	11.6	63	188	116				#N/A	#N/A
SUBIC BAY	181	11.6	89	126	155				#N/A	#N/A
NORRKOPING	182	11.3	59		108				135	-47
BAR	183	11.2	100	121	161				#N/A	#N/A
BERBERA	184	10.9	48	39	193				245	61
SHUAIBA	185	10.8	151		117				228	43
KLAIPEDA	186	10.6	105	37	198				266	80
RAVENNA	187	10.0	253	152	167				176	-11
SANTOS	188	9.9	1,176	33	180	136	130		72	-116
SHUWAIKH	189	9.6	161		136				199	10
RIJEKA	190	9.5	244	169	168	157	118	67	279	89
CATANIA	191	9.4	73	135	177				190	-1
SALERNO	192	9.3	181	133	179				168	-24
BARI	193	9.2	54	175	164				203	10
NELSON	194	8.6	93	22	220				206	12
BURGAS	195	8.6	97	181	170				133	-62

			# PORTS	292	349	227	183	103		
				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	2020H1	Change
HAIFA	196	8.5	706	233	286	173	103	51	153	-43
GUSTAVIA	197	8.1	54	1					161	-36
PARANAGUA	198	8.1	617		184	139	123		107	-91
APRA HARBOR	199	7.7	35	116	206				232	33
PUERTO PROGRESO	200	7.5	52	166	190				236	36
RAUMA	201	7.5	75	180	183				208	7
BILBAO	202	7.2	115	123	238		112		243	41
GDANSK	203	6.2	377	162	233	99		74	131	-72
PALERMO	204	5.6	34	35					182	-22
LEIXÕES	205	5.3	194	194	200				210	5
COPENHAGEN	206	5.0	58	57	234				142	-64
ITAJAÍ	207	4.5	542	211	186	95	146		105	-102
CAGAYAN DE ORO	208	4.4	49	69	237				128	-80
ODESSA	209	4.4	286	76	75		142		265	56
LARVIK	210	4.3	42	77					184	-26
KAWASAKI	211	4.2	28		85	170			#N/A	#N/A
NASSAU	212	4.0	117	91					189	-23
TRAPANI	213	4.0	29	94					#N/A	#N/A
RIGA	214	3.9	59		208				223	9
LISBON	215	3.6	33	197	213				#N/A	#N/A
HERAKLION	216	3.3	29	124					185	-31
VITÓRIA	217	3.3	71		212				218	1
BELL BAY	218	3.1	27	128					163	-55
TARTOUS	219	2.8	24	139					#N/A	#N/A
CHU LAI	220	2.8	73	140					#N/A	#N/A
CADIZ	221	2.6	29	147					#N/A	#N/A
MARIEL	222	2.0	34	161					197	-25
KRISTIANSAND	223	1.8	40	165					194	-29
NEMRUT BAY	224	1.7	864	117	121	88	128	78	326	102
VARNA	225	1.5	49	208	223				213	-12
POTI	226	1.4	59	176					209	-17
MAZATLAN	227	1.4	20	217	219				#N/A	#N/A
BORDEAUX	228	1.2	26	183					#N/A	#N/A
ALICANTE	229	1.0	75	85	255				#N/A	#N/A
KOMPONG SOM	230	0.9	31	269	115				#N/A	#N/A
MEJILLONES	231	0.9	113		185		127		311	80
HAMBURG	232	0.2	2,040	207	196	124	115	76	191	-41

			# PORTS	292	349	227	183	103		
				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	2020H1	Change
WILHELMSHAVEN	233	(0.0)	460	112	163	153	136	69	52	-181
ANTOFAGASTA	234	(0.3)	22		178	93	150		#N/A	#N/A
VENICE	235	(0.4)	106	154	251				295	60
GIJON	236	(0.5)	74	109	259				196	-40
RADES	237	(0.8)	32	213					#N/A	#N/A
GEORGETOWN (GUYANA)	238	(1.0)	31	216					#N/A	#N/A
TOMAKOMAI	239	(1.4)	33	222					204	-35
SAINT JOHN	240	(1.7)	78	187	250				251	11
BLUFF	241	(1.8)	34	228	236				239	-2
CONAKRY	242	(1.8)	143	136	260				250	8
KOTKA	243	(2.0)	94	196	246				244	1
VILA DO CONDE	244	(2.1)	106		244				241	-3
BATUMI	245	(2.2)	80	167	258				275	30
PANJANG	246	(2.8)	44	204	248				229	-17
QINZHOU	247	(3.4)	21	238	239				148	-99
SAMSUN	248	(3.7)	28	244					280	32
JUBAIL	249	(3.8)	220		55	94	113	87	57	-192
BELAWAN	250	(3.9)	114	205	257				202	-48
NEW YORK AND NEW JERSEY	251	(4.3)	1,488	160	226	138	121	75	127	-124
GAVLE	252	(4.8)	36		261				214	-38
IZMIR	253	(4.8)	309	172	224	168			269	16
PORT OF SPAIN	254	(5.6)	107	199	265				248	-6
GDYNIA	255	(6.1)	280	177	214	148	137		103	-152
ST. PETERSBURG	256	(6.3)	396	192	270				258	2
TEESPORT	257	(6.4)	28	186	271				238	-19
CALLAO	258	(6.6)	786	286	181	194	89	54	56	-202
MOGADISCIO	259	(7.6)	87		273				260	1
CALDERA (COSTA RICA)	260	(8.2)	51		275				165	-95
AGADIR	261	(8.7)	67	256	254				267	6
CASABLANCA	262	(9.2)	301	237	266				268	6
MANAUS	263	(9.3)	127		280				270	7
ADELAIDE	264	(9.9)	230		215	158	131		333	69
LA GUAIRA	265	(10.0)	80	232	274				296	31
YANTIAN	266	(10.2)	2,899	137	211	142	144	71	17	-249
TURBO	267	(11.3)	25		290				#N/A	#N/A
FREETOWN	268	(11.8)	130	218	287				216	-52

			# PORTS	292	349	227	183	103		
				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	2020H1	Change
HUENEME	269	(12.0)	37		292				273	4
BEIRA	270	(12.0)	80	92	304				281	11
ACAJUTLA	271	(12.2)	60		293				249	-22
CONSTANTZA	272	(12.7)	355	173	166		149		285	13
SANTO TOMAS DE CASTILLA	273	(13.3)	86	145	303				201	-72
DAVAO	274	(13.7)	165	202	291	156			156	-118
FORTALEZA	275	(14.8)	23		298				#N/A	#N/A
KALININGRAD	276	(14.9)	44		300				220	-56
ALEXANDRIA (EGYPT)	277	(15.3)	238	225	256	171			221	-56
ZEEBRUGGE	278	(15.4)	219	163	187	75	141	81	225	-53
TOAMASINA	279	(16.1)	141	221	299				219	-60
SUAPE	280	(17.5)	259		152	174	143		130	-150
TAKORADI	281	(18.2)	27	224	305				235	-46
QASR AHMED	282	(18.3)	31	252	296				#N/A	#N/A
NAPLES	283	(19.7)	141	83		163	147		207	-76
MONTEVIDEO	284	(20.9)	521	155	154	187	132		328	44
BEJAIA	285	(21.3)	67	248	307				330	45
CORINTO	286	(21.3)	31		313				#N/A	#N/A
PUERTO CABELLO	287	(23.3)	38	262	301				307	20
BRISBANE	288	(24.6)	670	239	231	159	148		234	-54
PORT VICTORIA	289	(25.4)	42		318				299	10
NAPIER	290	(25.7)	179	261	264	176			261	-29
ROTTERDAM	291	(26.8)	2,433	271	252	164	122	70	90	-201
LE HAVRE	292	(26.9)	942	212	202	146	152	73	300	8
MOMBASA	293	(27.2)	269	150	269	192			335	42
MAYOTTE	294	(27.4)	21		323				#N/A	#N/A
POINT LISAS PORTS	295	(28.1)	46	129	327				177	-118
GUAYAQUIL	296	(29.5)	505	14	176	134	145	83	338	42
ARICA	297	(30.0)	122	264	217	147	153		247	-50
OTAGO HARBOUR	298	(30.1)	107		279	189			288	-10
BANGKOK	299	(30.5)	260	272	309				259	-40
DUBLIN	300	(30.6)	29	247	321				252	-48
LAE	301	(31.7)	26	241	325				278	-23
OWENDO	302	(32.6)	68	253	324				271	-31
DAKAR	303	(32.8)	399	276	277	172			120	-183
YANGON	304	(34.1)	29	236	328				#N/A	#N/A
ADEN	305	(34.8)	21		329				#N/A	#N/A

			# PORTS	292	349	227	183	103		
				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	2020H1	Change
ALGIERS	306	(36.2)	38	254	326				318	12
GRANGEMOUTH	307	(36.2)	28	280	312				222	-85
MELBOURNE	308	(37.4)	720	105	218	166	160		313	5
DURRES	309	(37.6)	88	214	331				231	-78
TIMARU	310	(37.7)	75		263	201			304	-6
MONTREAL	311	(39.8)	161		281	200			283	-28
PORT ELIZABETH	312	(46.4)	60		316	193			348	36
LA SPEZIA	313	(47.3)	192	226	285	143	126	84	289	-24
LYTTELTON	314	(47.7)	225		295	203			186	-128
MARSEILLE	315	(49.5)	576	164	140	180	134	86	350	35
SHANGHAI	316	(51.8)	2,540	265	284	150	158		49	-267
YUZHNY	317	(52.2)	106		124	191	162		170	-147
SAN PEDRO (COTE D'IVO-IRE)	318	(53.8)	45	245	339				293	-25
IQUIQUE	319	(53.9)	127	219	253	128	166		320	1
SAN ANTONIO	320	(55.8)	354	151	228	175	140	85	173	-147
MAPUTO	321	(58.7)	79	156	322	202			306	-15
LIVERPOOL (UNITED KING-DOM)	322	(58.8)	28	266	278	205			#N/A	#N/A
PORT LOUIS	323	(61.8)	380	260	289	167	154	72	346	23
PORT BOTANY	324	(63.9)	715	220	247	160	165		327	3
TAURANGA	325	(64.5)	467	290	297	179	114		100	-225
TRIESTE	326	(64.7)	380	170	205	183	125	90	264	-62
MANILA	327	(67.1)	593	278	317	198			276	-51
WALVIS BAY	328	(68.4)	102	141	288	199	155		336	8
ASHDOD	329	(69.3)	493	249	332	169	65	88	315	-14
VLADIVOSTOK	330	(69.8)	51	275	342				240	-90
THESSALONIKI	331	(71.4)	156	274	310	204			284	-47
DUTCH HARBOR	332	(74.6)	20		315	208			325	-7
PORT RÉUNION	333	(85.5)	256	246	294	185	164		340	7
FELIXSTOWE	334	(86.5)	631	240	283	178	157	82	322	-12
FREMANTLE	335	(90.5)	239	182	227	197	171		319	-16
SEATTLE	336	(92.9)	251		268	190	170		263	-73
GENOA	337	(93.6)	793	209	222	182	161	89	331	-6
LIVORNO	338	(96.6)	315	198	240	188	172		290	-48
TIN CAN ISLAND	339	(98.4)	65	215	311	213			344	5
DOUALA	340	(106.2)	112	282	345				302	-38
CHATTOGRAM	341	(109.2)	201	289	344				298	-43

			# PORTS	292	349	227	183	103		
				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	2020H1	Change
ONNE	342	(111.1)	25		308	217			291	-51
BRISTOL	343	(111.7)	22	242	302	216			277	-66
PRINCE RUPERT	344	(114.3)	114		129	210	169		323	-21
TACOMA	345	(119.2)	127		276	196	173		329	-16
SOUTHAMPTON	346	(120.4)	451		150	177	156	94	317	-29
LONDON	347	(124.5)	1,194	230	137	126	133	98	180	-167
COTONOU	348	(130.8)	378	279	337	211			233	-115
LOMÉ	349	(133.2)	168	288	334	209			332	-17
DUNKIRK	350	(142.6)	276	127	132	137	174	91	305	-45
AUCKLAND	351	(142.9)	168	243	320	222			118	-233
FREEPORT (BAHAMAS)	352	(157.1)	140	78	282	206	177		224	-128
SOKHNA	353	(158.5)	132	259	235	123	159	97	321	-32
TEMA	354	(160.6)	665	285	314	184	151	92	312	-42
KRIBI DEEP SEA PORT	355	(174.5)	135	287	338	220			287	-68
NOUAKCHOTT	356	(175.5)	36	281	347				292	-64
BEIRUT	357	(183.4)	394	251	272	207	163	93	62	-295
LAGOS (NIGERIA)	358	(188.3)	125	250	306	226			342	-16
OAKLAND	359	(207.4)	527	206	229	186	167	96	334	-25
ABIDJAN	360	(216.1)	317	292	343	215			217	-143
DAR ES SALAAM	361	(248.8)	139	291	349				324	-37
POINTE-NOIRE	362	(320.3)	260	284	335	218	180		345	-17
NGQURA	363	(359.2)	235		319	212	176	99	349	-14
DURBAN	364	(386.1)	397		341	219	178	95	351	-13
CAPE TOWN	365	(410.7)	174		340	225	182		347	-18
LUANDA	366	(442.4)	174	270	333	223	183		343	-23
SAVANNAH	367	(464.7)	1,370	268	336	214	179	100	96	-271
VANCOUVER (CANADA)	368	(573.5)	414		330	221	168	101	303	-65
LONG BEACH	369	(952.5)	302	258	348	227	175	102	341	-28
LOS ANGELES	370	(954.1)	669		346	224	181	103	337	-33

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

TABLE A.2. • The CPPI 2021 (the Statistical Approach)

Port Name	Rank	Index Value
AARHUS	89	19.86
ABIDJAN	360	-101.37
ACAJUTLA	259	-3.66
ADELAIDE	256	-3.27
ADEN	282	-7.65
AGADIR	275	-5.93
ALEXANDRIA (EGYPT)	281	-6.87
ALGECIRAS	10	67.90
ALGIERS	300	-13.47
ALICANTE	211	1.75
ALTAMIRA	77	22.00
AMBARLI	37	41.96
ANCONA	166	5.79
ANTOFAGASTA	278	-6.27
ANTWERP	79	21.42
APRA HARBOR	197	3.20
AQABA	31	45.80
ARICA	309	-16.25
ASHDOD	341	-48.09
AUCKLAND	350	-60.72
BALBOA	56	28.95
BALTIMORE (MARYLAND)	69	23.48
BANGKOK	303	-14.22
BAR	182	4.68
BARCELONA	18	54.89
BARI	195	3.59
BARRANQUILLA	168	5.69
BATUMI	228	0.13
BEIRA	268	-5.23
BEIRUT	356	-73.80
BEJAIA	287	-10.24
BELAWAN	230	-0.13
BELL BAY	210	1.78
BERBERA	160	6.52

Port Name	Rank	Index Value
BILBAO	196	3.21
BLUFF	236	-0.69
BORDEAUX	222	0.92
BORUSAN	147	7.83
BOSTON (UNITED STATES)	119	12.07
BREMERHAVEN	53	31.52
BRISBANE	280	-6.82
BRISTOL	347	-55.24
BUENAVENTURA	20	54.52
BUENOS AIRES	128	10.41
BURGAS	215	1.63
BUSAN	25	50.70
CADIZ	218	1.33
CAGAYAN DE ORO	225	0.44
CAI MEP	12	64.39
CALDERA (COSTA RICA)	276	-6.23
CALLAO	267	-5.21
CAPE TOWN	365	-179.78
CARTAGENA (COLOMBIA)	13	62.61
CASABLANCA	260	-3.89
CAT LAI	144	8.00
CATANIA	194	3.73
CAUCEDO	96	18.56
CEBU	163	6.08
CHARLESTON	130	10.14
CHATTOGRAM	343	-49.91
CHENNAI	95	18.61
CHIWAN	19	54.77
CHORNOMORSK	155	7.13
CHU LAI	208	2.05
CIVITAVECCHIA	170	5.51
COCHIN	103	17.17
COLOMBO	23	51.36
COLON	105	17.07
CONAKRY	244	-1.26
CONSTANTZA	261	-3.98

Port Name	Rank	Index Value
COPENHAGEN	219	1.28
CORINTO	284	-8.66
CORONEL	47	36.16
COTONOU	348	-57.42
CRISTOBAL	162	6.15
DA CHAN BAY TERMINAL ONE	122	11.52
DAKAR	308	-16.22
DALIAN	80	21.36
DAMIETTA	57	28.41
DAMMAM	15	58.84
DANANG	151	7.35
DAR ES SALAAM	361	-103.29
DAVAO	273	-5.75
DILISKELESI	67	23.96
DJIBOUTI	22	52.77
DOUALA	340	-44.73
DUBLIN	301	-13.68
DUNKIRK	336	-41.58
DURBAN	363	-146.89
DURRES	322	-26.46
DUTCH HARBOR	333	-39.00
EL DEKHEILA	131	9.99
ENSENADA	90	19.65
FELIXSTOWE	337	-41.77
FORTALEZA	271	-5.56
FORT-DE-FRANCE	129	10.35
FREDERICIA	180	4.80
FREEPORT (BAHAMAS)	354	-69.78
FREETOWN	272	-5.70
FREMANTLE	324	-30.25
FUZHOU	112	14.76
GAVLE	253	-2.82
GDANSK	241	-0.90
GDYNIA	217	1.33
GEMLIK	102	17.37
GENOA	339	-43.09

Port Name	Rank	Index Value
GEORGETOWN (GUYANA)	240	-0.84
GIJON	231	-0.14
GIOIA TAURO	75	22.16
GOTHENBURG	113	14.70
GRANGEMOUTH	311	-18.69
GUANGZHOU	8	71.93
GUAYAQUIL	298	-12.96
GUSTAVIA	174	5.34
HAIFA	189	4.26
HAIPHONG	58	27.35
HAKATA	121	11.75
HALIFAX	24	51.22
HAMAD PORT	4	79.56
HAMBURG	265	-4.53
HAZIRA	66	24.05
HELSINGBORG	169	5.68
HELSINKI	177	4.95
HERAKLION	214	1.65
HONG KONG	45	36.87
HOUSTON	118	12.11
HUENEME	279	-6.44
IMBITUBA	106	16.91
INCHEON	51	33.49
IQUIQUE	313	-19.95
ISKENDERUN	72	22.95
ITAJAÍ	138	8.41
ITAPOA	59	26.64
IZMIR	245	-1.31
JACKSONVILLE	98	18.28
JAWAHARLAL NEHRU PORT	49	34.66
JEBEL ALI	38	40.16
JEDDAH	9	71.70
JOHOR	74	22.22
JUBAIL	207	2.05
KALININGRAD	264	-4.44
KAMARAJAR	73	22.87

Port Name	Rank	Index Value
KAOHSIUNG	16	57.23
KARACHI	81	21.14
KATTUPALLI	97	18.52
KAWASAKI	255	-2.99
KEELUNG	76	22.00
KHALIFA BIN SALMAN	60	26.37
KHALIFA PORT	5	78.31
KING ABDULLAH PORT	1	89.43
KINGSTON (JAMAICA)	142	8.06
KLAIPEDA	175	5.33
KOBE	33	44.06
KOMPONG SOM	262	-4.14
KOPER	164	5.99
KOTKA	229	0.08
KRIBI DEEP SEA PORT	357	-77.73
KRISHNAPATNAM	86	20.22
KRISTIANSAND	226	0.43
LA GUAIRA	258	-3.56
LA SPEZIA	299	-13.39
LAE	305	-14.92
LAEM CHABANG	52	31.71
LAGOS (NIGERIA)	358	-79.58
LARVIK	203	2.62
LATAKIA	179	4.82
LAZARO CARDENAS	181	4.79
LE HAVRE	297	-12.85
LEIXÕES	209	2.01
LIANYUNGANG	63	25.41
LIMASSOL	158	6.71
LIRQUEN	117	12.31
LISBON	227	0.34
LIVERPOOL (UNITED KINGDOM)	326	-31.04
LIVORNO	335	-40.39
LOMÉ	352	-62.96
LONDON	353	-69.56
LONG BEACH	370	-321.89

Port Name	Rank	Index Value
LOS ANGELES	369	-274.17
LUANDA	366	-189.35
LYTTELTON	310	-18.31
MAGDALLA	42	38.27
MALAGA	124	10.93
MANAUS	248	-1.93
MANILA	329	-32.37
MANZANILLO (MEXICO)	55	29.02
MAPUTO	323	-26.82
MARIEL	216	1.44
MARSAXLOKK	78	21.72
MARSEILLE	307	-15.66
MATADI	184	4.49
MAWAN	71	22.98
MAYOTTE	295	-12.26
MAZATLAN	246	-1.32
MEJILLONES	233	-0.35
MELBOURNE	296	-12.52
MERSIN	30	46.42
MIAMI	40	38.62
MOBILE	143	8.03
MOGADISCIO	252	-2.49
MOJI	123	11.05
MOMBASA	293	-11.26
MONTEVIDEO	254	-2.86
MONTREAL	312	-19.25
MUHAMMAD BIN QASIM	70	23.29
MUNDRA	46	36.63
MUUGA-PORT OF TALLINN	156	6.92
NAGOYA	39	38.91
NAHA	120	12.03
NANTES SAINT-NAZAIRE	107	16.68
NAPIER	288	-10.38
NAPLES	263	-4.36
NASSAU	205	2.59
NELSON	185	4.40

Port Name	Rank	Index Value
NEMRUT BAY	199	3.09
NEW ORLEANS	110	15.75
NEW YORK AND NEW JERSEY	257	-3.29
NGQURA	364	-160.73
NINGBO	7	74.63
NORRKOPING	191	3.83
NOUAKCHOTT	349	-59.65
NOUMEA	88	19.99
NOVOROSSIYSK	157	6.86
OAKLAND	359	-86.23
ODESSA	171	5.45
OMAEZAKI	127	10.54
ONNE	344	-52.56
OSAKA	41	38.34
OSLO	139	8.40
OTAGO HARBOUR	294	-11.54
OWENDO	304	-14.84
PAITA	91	19.50
PALERMO	198	3.15
PANJANG	243	-1.24
PAPEETE	172	5.41
PARANAGUA	148	7.78
PECEM	132	9.87
PENANG	111	15.03
PHILADELPHIA	64	25.35
PHILIPSBURG	178	4.93
PIPAVAV	32	44.93
PIRAEUS	85	20.29
PLOČE	192	3.82
POINT LISAS PORTS	291	-10.71
POINTE-À-PITRE	109	16.18
POINTE-NOIRE	362	-124.70
PORT AKDENIZ	145	7.98
PORT-AU-PRINCE	186	4.39
PORT BOTANY	319	-23.34
PORT BRONKA	136	8.66

Port Name	Rank	Index Value
PORT ELIZABETH	317	-22.21
PORT EVERGLADES	92	19.00
PORT KLANG	61	26.34
PORT LOUIS	321	-24.15
PORT OF SPAIN	251	-2.32
PORT OF VIRGINIA	26	50.35
PORT RÉUNION	331	-34.90
PORT SAID	14	61.24
PORT TAMPA BAY	65	24.19
PORT VICTORIA	286	-9.71
POSORJA	68	23.77
POTI	223	0.69
PRINCE RUPERT	346	-52.81
PUERTO BARRIOS	202	2.64
PUERTO BOLIVAR (ECUADOR)	176	5.32
PUERTO CABELLO	285	-9.51
PUERTO CORTES	137	8.46
PUERTO LIMON	82	21.05
PUERTO PROGRESO	220	1.21
PUERTO QUETZAL	134	9.09
QASR AHMED	290	-10.40
QINGDAO	36	42.75
QINZHOU	234	-0.44
QUY NHON	154	7.15
RADES	232	-0.33
RAUMA	204	2.61
RAVENNA	193	3.74
RIGA	212	1.69
RIJEKA	237	-0.70
RIO DE JANEIRO	94	18.66
RIO GRANDE (BRAZIL)	99	17.96
RIO HAINA	159	6.55
ROTTERDAM	302	-14.20
SAIGON	125	10.83
SAINT JOHN	235	-0.69
SALALAH	2	85.34

Port Name	Rank	Index Value
SALERNO	201	2.74
SALVADOR	141	8.11
SAMSUN	250	-2.11
SAN ANTONIO	316	-20.54
SAN JUAN	149	7.76
SAN PEDRO (COTE D'IVOIRE)	315	-20.40
SAN VICENTE	167	5.76
SANTA CRUZ DE TENERIFE	87	20.03
SANTA MARTA	153	7.21
SANTO TOMAS DE CASTILLA	274	-5.78
SANTOS	135	9.04
SAVANNAH	367	-214.18
SAVONA-VADO	114	14.25
SEATTLE	328	-31.55
SEPETIBA	116	12.74
SHANGHAI	318	-23.02
SHANTOU	150	7.71
SHARJAH	161	6.18
SHEKOU	21	54.38
SHIMIZU	44	37.47
SHUAIBA	187	4.35
SHUWAIKH	188	4.31
SIAM SEAPORT	104	17.12
SINES	35	43.69
SINGAPORE	34	44.05
SOHAR	48	35.06
SOKHNA	345	-52.63
SOUTHAMPTON	351	-62.76
ST. PETERSBURG	249	-2.00
SUAPE	292	-10.94
SUBIC BAY	173	5.38
TACOMA	342	-48.86
TAICHUNG	133	9.76
TAKORADI	289	-10.38
TAMPA	62	25.54
TANGER-MEDITERRANEAN	6	77.57

Port Name	Rank	Index Value
TANJUNG EMAS	140	8.21
TANJUNG PELEPAS	17	55.76
TANJUNG PERAK	100	17.77
TANJUNG PRIOK	115	14.21
TARRAGONA	165	5.86
TARTOUS	213	1.68
TAURANGA	327	-31.41
TEESPORT	247	-1.67
TEMA	355	-71.92
THESSALONIKI	330	-33.02
TIANJIN	27	49.62
TIMARU	314	-20.03
TIN CAN ISLAND	334	-40.30
TOAMASINA	269	-5.34
TOKYO	50	34.21
TOMAKOMAI	242	-0.91
TRAPANI	206	2.18
TRIESTE	332	-37.40
TRIPOLI (LEBANON)	93	18.69
TURBO	270	-5.44
UMM QASR	126	10.58
VALENCIA	200	2.97
VALPARAISO	83	20.96
VANCOUVER (CANADA)	368	-239.50
VARNA	239	-0.81
VENICE	224	0.61
VERACRUZ	84	20.93
VIGO	146	7.94
VILA DO CONDE	238	-0.74
VISAKHAPATNAM	101	17.50
VITÓRIA	221	0.93
VLADIVOSTOK	325	-30.67
VUNG TAU	266	-5.04
WALVIS BAY	338	-42.40
WELLINGTON	183	4.67
WILHELMSHAVEN	152	7.33

Port Name	Rank	Index Value
WILMINGTON (NORTH CAROLINA, UNITED STATES)	54	30.18
XIAMEN	43	37.94
YANGON	306	-15.12
YANGSHAN	3	80.42
YANTIAN	277	-6.24
YARIMCA	28	46.84
YOKKAICHI	108	16.60
YOKOHAMA	11	66.59
YEOSU	29	46.59
YUZHNY	320	-23.91
ZEEBRUGGE	283	-8.14
ZHOUSHAN	190	3.91

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

Appendix B: Constructing the CPPI with Matrix Factorization

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 contains the following five categories of ship size:

- Feeders: <1,500 TEUs
- Intra-regional: 1,500–5,000 TEUs
- Intermediate: 5,000–8,500 TEUs
- Neo-Panamax: 8,500–13,500 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 very 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 1,501–5,000 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 ∑, the EM algorithm provides an estimate of the two parameters μ and ∑ via maximum likelihood.

Missing values are imputed using their conditional expectation. In this approach, given a row with available values and missing values , the missing values are imputed by their conditional expectation given the available data, where the expected value is computed only over the non-negative values of 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. • Simple 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 denote average port time of port i in call size j.
- Let denote the average of the average port time of all ports in the given call size.
- Let 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 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 $CPPI_i$ denote the CPPI index for ship size i (i = 1, . . . ,5).

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

*where (*α1, *α*2, *α*3, *α*4, *α*5) = (*0.46, 1.00, 1.54, 1.97, 2.57).*

Reference

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**.

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