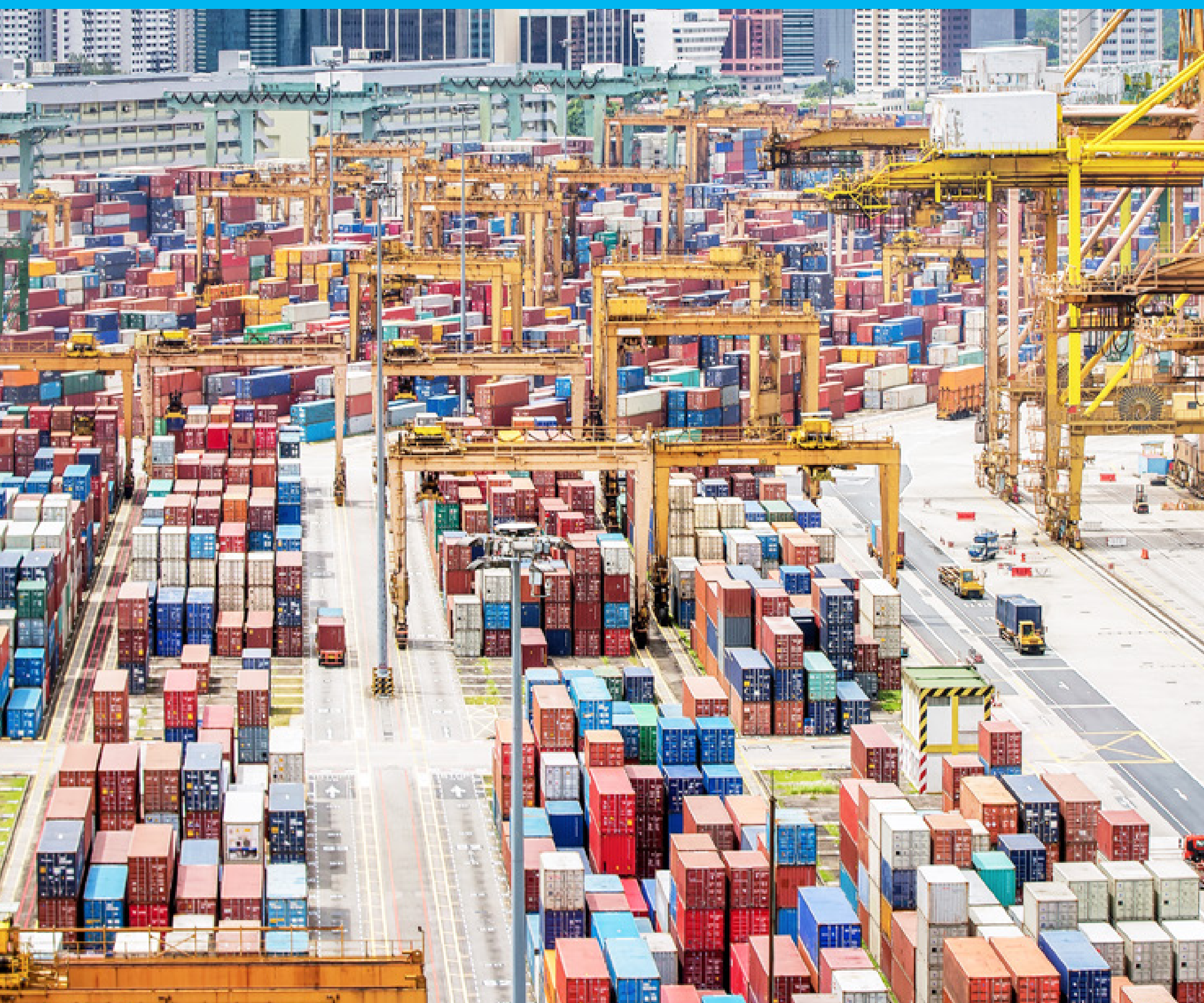
TRANSPORT GLOBAL PRACTICE

The Container Port Performance Index 2020

A Comparable Assessment of Container Port Performance



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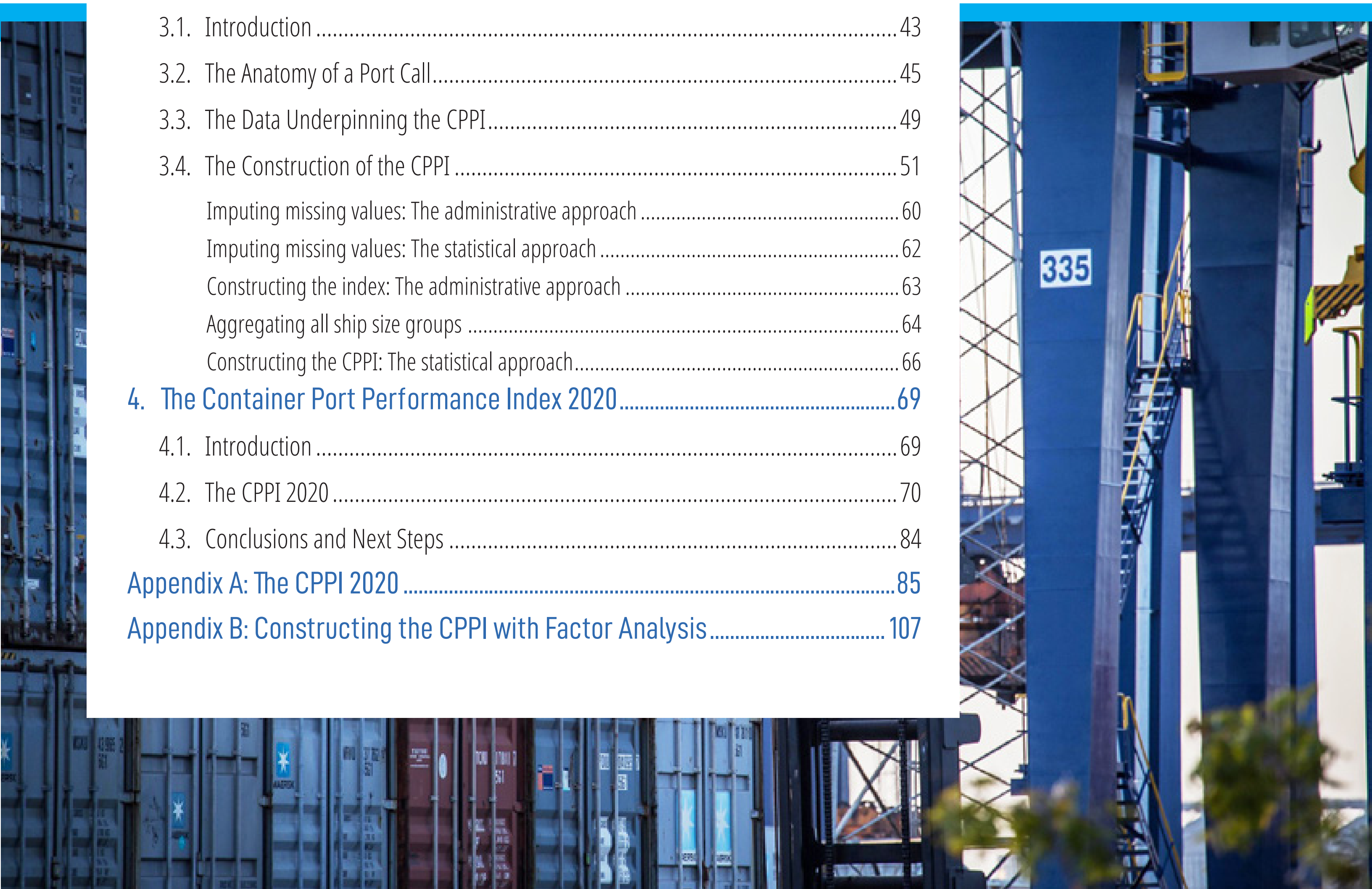

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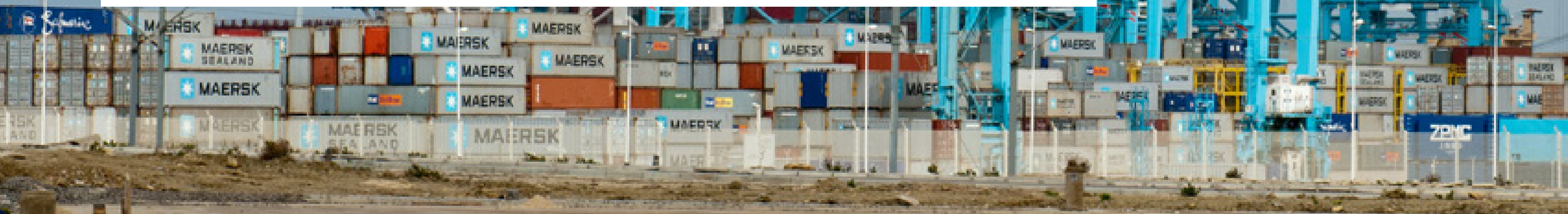

Acknowledgments

This technical report was prepared by a joint team from the Transport Global Practice of the Infrastructure Vice-Presidency at the World Bank and the Maritime & Trade division of the consulting firm IHS Markit.
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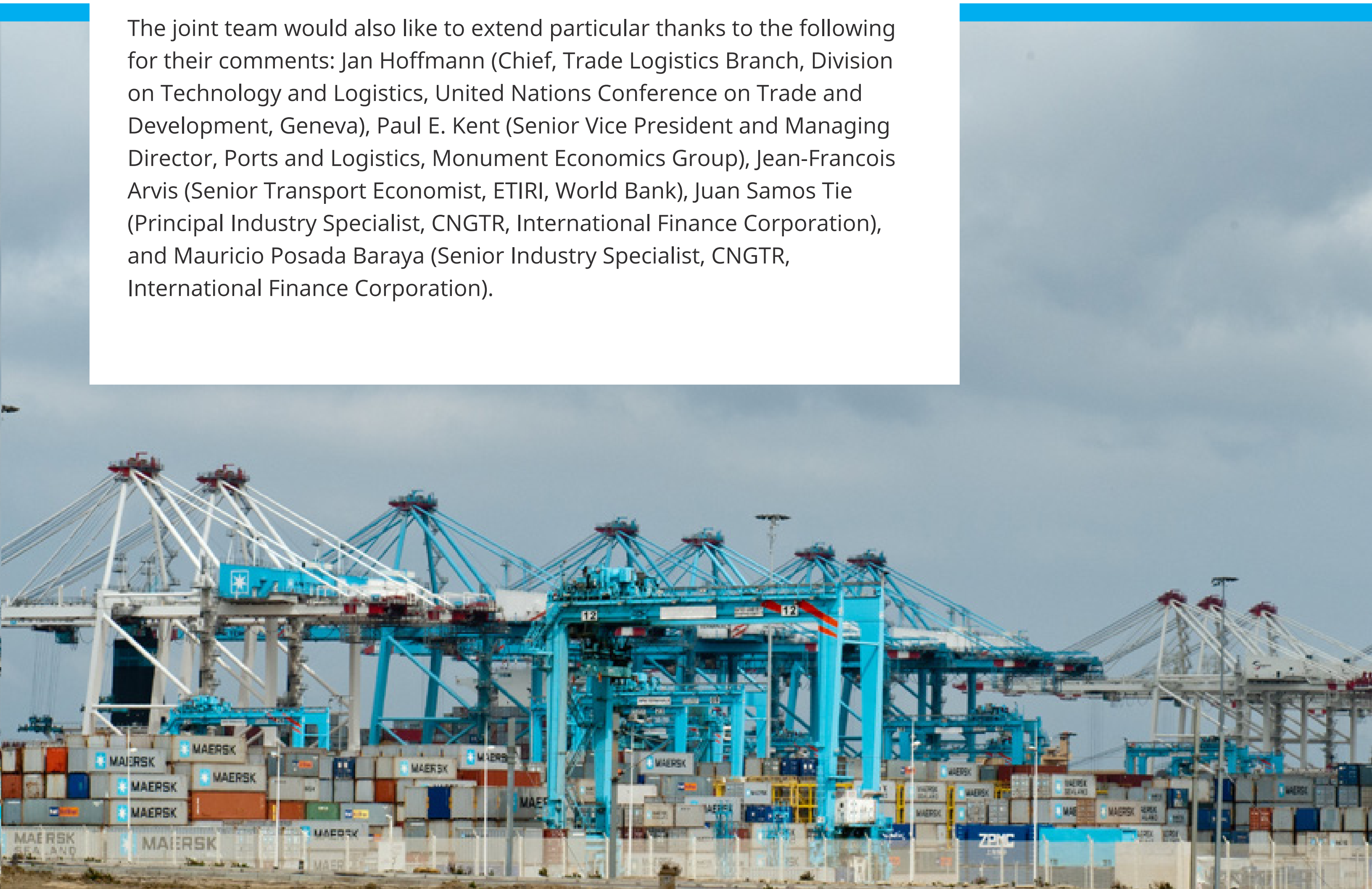
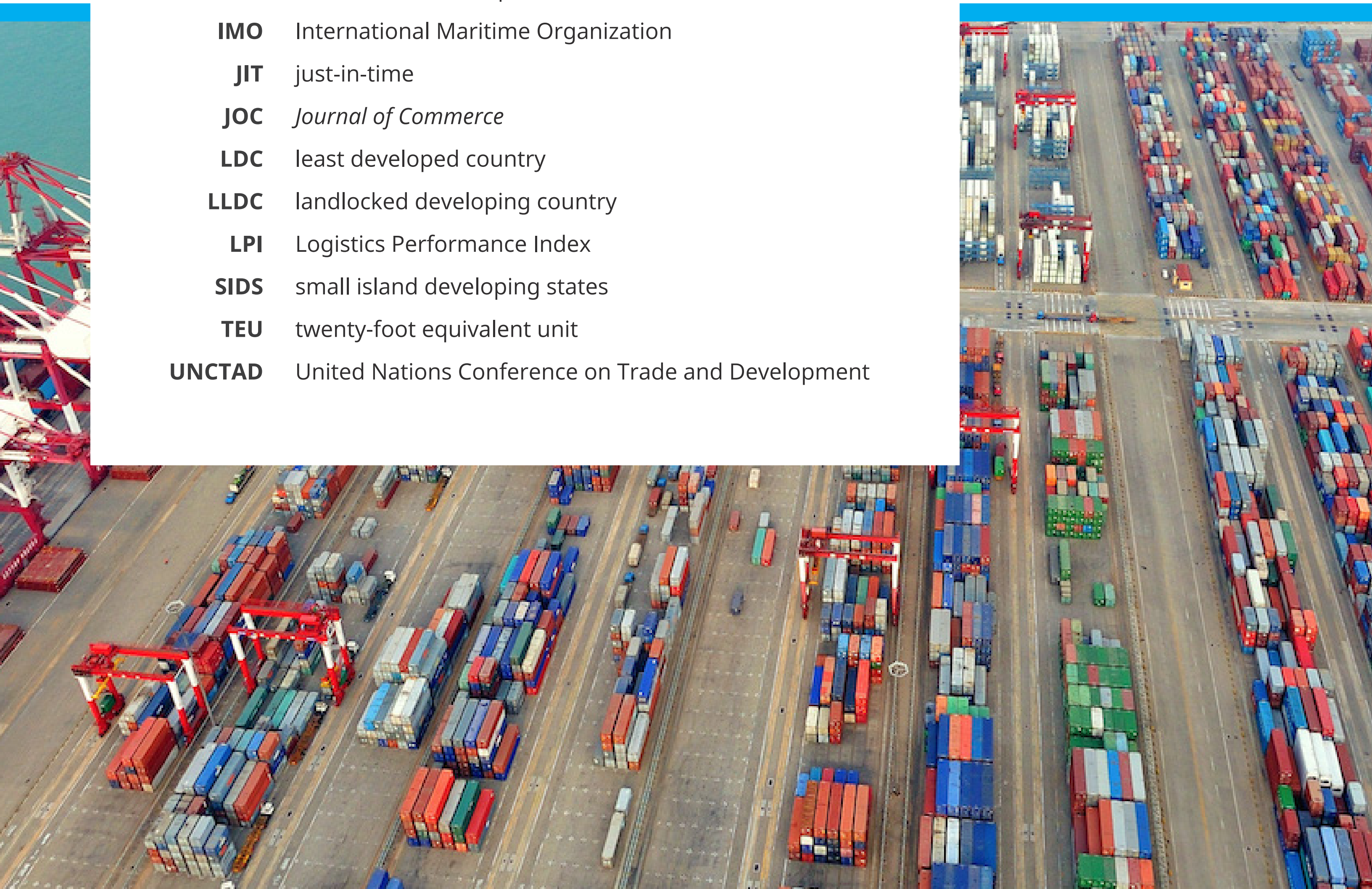


Abbreviations and Acronyms

AIS	automatic identification system
BIMCO	Baltic and international Maritime Council
CFS	container freight station
CI	crane intensity
COVID-19	Coronavirus disease 2019
CPPI 2020	Container Port Performance Index 2020
DBI	Doing Business Index
FA	factor analysis
GCMPH	gross crane moves per port hour
GCI	Global Competitiveness Index
IAPH	International Association of Ports and Harbors
ICD	inland container depot
IMO	International Maritime Organization
JIT	just-in-time
JOC	*Journal of Commerce*
LDC	least developed country
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.

CALL SIZE: number of container moves per call (discharge + Load = Ordered Restows.

CARGO OPERATIONS: Total elapsed time between first and last container move.

CRANE INTENSITY: 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): Factor analysis is 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 and all terminal inspired delays including meal-breaks.

GROSS CRANE PRODUCTIVITY (GCMPH): Call size or total moves divided by total gross crane hours.

HUB PORT: A "hub port" is defined as a port which is called at by deep-sea mainline container ships and serves as a transhipment 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 transhipment container activity.

MOVES: Total container moves. Discharge + ordered restowage moves + load. Excluding hatch covers, gear-boxes, etc. Not adjusted to consider out of gauge containers.

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").

OPERATING HOURS: The time required for container operations between the first and last container lifts.

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.

SHIP SIZE: Nominal capacity in twenty-foot equivalent units, or TEUs.

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

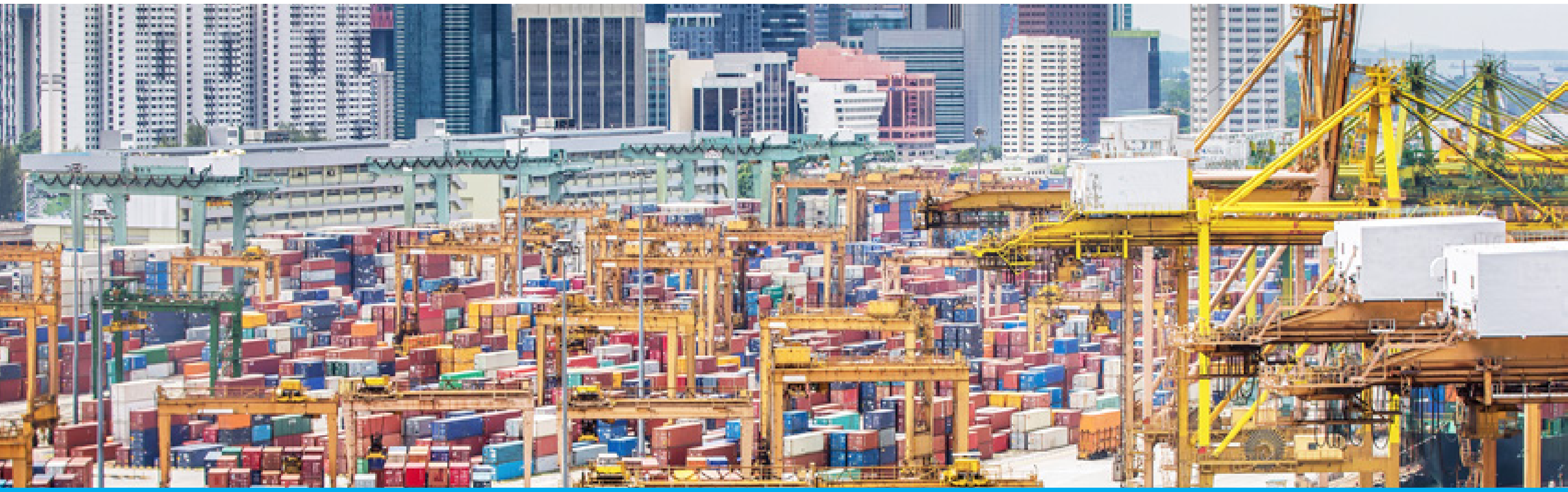
STEAM-IN TIME: The time required to steam-in from the port limits and until all fast alongside the berth.

TWENTY-FOOT EQUIVALENT UNIT (TEU): A standard metric for container throughput, the number of moves loaded and discharged from the vessel, and the physical capacity of a container terminal. A 20-foot container is equal to 1 TEU, and a 40-foot container is equal to 2 TEUs. There is noadjustment for container height. 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 minutes within the zone).

Foreword



The COVID-19 pandemic has underlined the critical role that ports, and their associated logistical chains, play in the global economy. It has also highlighted the need to ensure business continuity and improve the resilience of maritime gateways, as ports act as crucial nodes in the global logistics system, keeping supply chains moving, economies functioning, and people employed. 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 and from land-based modes for imports and exports.

Maritime transport carries more than 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, lower 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 comparable measure (or measures) to assess performance across ports, and time.

However, the introduction of new technologies, increased digitization, and the willingness on the part of industry interests to work collectively toward systemwide improvements now provides the capacity and the opportunity to measure and compare container port performance in a robust and reliable manner for the first time. This technical report, which presents the inaugural edition of the Container Port Performance Index (CPPI 2020), has been produced by the Transport Global Practice of the World Bank, in collaboration with IHS Markit. 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, logistics, and supply chain services. As that reference point, the CPPI is intended to identify gaps and opportunities for improvement and hopefully stimulate a dialogue among key stakeholders and move this essential agenda forward.

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Executive Summary

1. ***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, energy efficient, and reliable mode of transportation over long distances. A significant and growing portion of that volume, accounting for approximately 35 percent of total volumes and over 60 percent of commercial value, are carried by containers. The growth of containerization has led to vast changes in where and how goods are manufactured and processed, an evolving process that has not yet stopped. 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.

The maritime sector offers the most economical, energy efficient, and reliable mode of transportation over long distances.

2. ***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 disruption, 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).

Unfortunately, ports and terminals, particularly for containers, can often be sources of shipment delays, supply chain disruption, additional costs, and reduced competitiveness.

3. ***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 (or measures) to assess performance across ports, and time. The introduction of new technologies, increased digitization, 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 for the first time. This technical paper, which presents the inaugural edition of the Container Port Performance Index (CPPI 2020), has been produced by the World Bank's Transport Global Practice, in collaboration with IHS Markit.

The introduction of new technologies, increased digitization, and the willingness of industry interests has now provided the opportunity to measure and compare container port performance in a robust and reliable manner for the first time.

4. ***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, logistics, and supply chain services. The joint team intends that the methodology, scope, and data, will be enhanced in subsequent annual iterations, reflecting refinement, stakeholder feedback, and improvements in data scope and quality.

The joint team intends that the methodology, scope, and data, will be enhanced in subsequent annual iterations, reflecting refinement, stakeholder feedback, and improvements in data scope and quality.

5. ***The CPPI 2020 has been developed based on total port time in the manner explained in subsequent chapters.*** This first iteration of CPPI utilizes data up to the end of the first six months of 2020 (June 30) and includes ports that had, within a six-month period in the prior twelve months, a minimum of 10 valid port calls. The CCPI 2020 was constructed based on two different methodological approaches, or what have been termed the administrative approach: a pragmatic methodology reflecting expert knowledge and judgment, and the statistical approach, using factor analysis (FA). The rationale of using two approaches was to help ensure the rankings of container port performance reflected as closely as possible actual port performance, while also being statistically robust. The two approaches are explained later in the report, with further details provided in appendix B.

6. ***In chapter 4, table E.1 presents the CPPI 2020 using the two methodological approaches.*** The ranking and score in the left-hand columns result from the use of the statistical approach and the ranking and score in the right-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 3 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 they do not have an offsetting positive score(s) in other cell(s). Further iterations of the CPPI will explore the determinants of the ranking in more detail.

7. ***The use of FA also results in a statistic (a total score), that equals the sum of a weighted average of indices for each of the same five vessel sizes.*** 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 better than average performance. Overall, there is a broad consistency between the rankings that result from the two approaches, with some exceptions. Just under 18 percent of all ports (61 ports) are ranked within three places or less from themselves in the two rankings. Approximately 40 percent (137 ports) are ranked with ten places or less of themselves in the respective rankings, while 80 percent (282 ports) fall within 10 percent of their respective rankings in the two indices.

The resulting total scores are standardized, with a "negative" score indicating a better than average performance.

8. ***The top ranked container ports in the CPPI 2020 are Yokohama port (Japan), in first place, followed by King Abdullah port (Saudi Arabia) in second place.*** These two ports occupy the same two positions irrespective of the methodology. The top 50 ranked ports are dominated by ports in East Asia, with ports in the Middle East and North Africa region, such as King Abdullah port, Salalah in Oman (ranked 6th and 9th respectively), Khalifa port in Abu Dhabi (ranked 26th and 22nd respectively), and Tanger Med (ranked at 27th and 15th respectively) as the notable exceptions. Algeciras is the highest ranked port in Europe (ranked 10th and 32nd respectively), followed by Aarhus (ranked 44th and 43rd respectively). Colombo is the top-ranked port in South Asia (ranked 17th and 33rd respectively). Lazaro Cardenas the highest ranked port in Latin America (ranked 25th and 23rd respectively), with Halifax the highest ranked port in North America (ranked 39th and 25th respectively). No ports in Sub-Saharan Africa (SSA) rank in the global top 50 container ports; Djibouti port ranks the highest (61st and 93rd respectively).

The top 50 ranked ports are dominated by ports in East Asia.

Table E.1. The CPPI 2020: Global Ranking of Container Ports

Statistical approach			Administrative approach		
Port name	Rank	Total score	Port name	Rank	Index points
YOKOHAMA	1	−5.995	YOKOHAMA	1	130
KING ABDULLAH PORT	2	−5.684	KING ABDULLAH PORT	2	114
CHIWAN	3	−5.202	QINGDAO	3	102
GUANGZHOU	4	−5.162	KAOHSIUNG	4	99
KAOHSIUNG	5	−4.669	SHEKOU	5	94
SALALAH	6	−4.531	GUANGZHOU	6	92
HONG KONG, HONG KONG SAR, CHINA	7	−4.276	HONG KONG, HONG KONG SAR, CHINA	7	89
QINGDAO	8	−3.860	ZHOUSHAN	8	88
SHEKOU	9	−3.726	SALALAH	9	87
ALGECIRAS	10	−3.597	YANGSHAN	10	87
BEIRUT	11	−3.378	TANJUNG PELEPAS	11	86
SHIMIZU	12	−3.361	SINGAPORE	12	83
TANJUNG PELEPAS	13	−3.342	NINGBO	13	83
PORT KLANG	14	−3.334	PORT KLANG	14	78
SINGAPORE	15	−3.279	TANGER MEDITERRANEAN	15	76
NAGOYA	16	−3.251	TAIPEI, TAIWAN, CHINA	16	75
COLOMBO	17	−3.209	YANTIAN	17	73
SINES	18	−3.183	CAI MEP	18	68
KOBE	19	−3.127	DALIAN	19	66
ZHOUSHAN	20	−2.963	TIANJIN	20	64
JUBAIL	21	−2.898	FUZHOU	21	61
YEOSU	22	−2.831	KHALIFA PORT	22	60
FUZHOU	23	−2.829	LAZARO CARDENAS	23	60
NINGBO	24	−2.805	SHIMIZU	24	59
LAZARO CARDENAS	25	−2.798	HALIFAX	25	59
KHALIFA PORT	26	−2.795	XIAMEN	26	58
TANGER MEDITERRANEAN	27	−2.769	CHIWAN	27	58
YANGSHAN	28	−2.733	SINES	28	56

Statistical approach			Administrative approach		
Port name	Rank	Total score	Port name	Rank	Index points
YANTIAN	29	−2.724	MAWAN	29	56
TAIPEI, TAIWAN, CHINA	30	−2.681	AGUADULCE (COLOMBIA)	30	56
DA CHAN BAY TERMINAL ONE	31	−2.588	LIANYUNGANG	31	54
MAWAN	32	−2.557	ALGECIRAS	32	53
DALIAN	33	−2.506	COLOMBO	33	53
INCHEON	34	−2.422	CARTAGENA (COLOMBIA)	34	52
TOKYO	35	−2.418	DA CHAN BAY TERMINAL ONE	35	52
HAMAD PORT	36	−2.411	BUSAN	36	51
LIANYUNGANG	37	−2.375	INCHEON	37	51
PIPAVAV	38	−2.371	HAMAD PORT	38	51
HALIFAX	39	−2.365	PIPAVAV	39	48
CAUCEDO	40	−2.355	YEOSU	40	48
BREMERHAVEN	41	−2.265	AQABA	41	47
CARTAGENA (COLOMBIA)	42	−2.185	JEDDAH	42	46
SALVADOR	43	−2.051	AARHUS	43	43
AARHUS	44	−2.036	MUNDRA	44	43
AGUADULCE (COLOMBIA)	45	−2.035	MAGDALLA	45	42
CAI LAN	46	−1.991	BARCELONA	46	42
HAIPHONG	47	−1.953	RIO GRANDE (BRAZIL)	47	42
MAGDALLA	48	−1.943	NAGOYA	48	41
CAI MEP	49	−1.932	SHANGHAI	49	41
MUNDRA	50	−1.902	KOBE	50	39
GEMLIK	51	−1.892	LAEM CHABANG	51	39
BUSAN	52	−1.887	WILHELMSHAVEN	52	39
JEDDAH	53	−1.862	CHARLESTON	53	38
DILISKELESI	54	−1.842	TOKYO	54	38
LAEM CHABANG	55	−1.807	SALVADOR	55	35
JAWAHARLAL NEHRU PORT	56	−1.786	CALLAO	56	34
AMBARLI	57	−1.783	JUBAIL	57	33
PORT SAID	58	−1.652	YARIMCA	58	33

Statistical approach			Administrative approach		
Port name	Rank	Total score	Port name	Rank	Index points
PECEM	59	−1.647	JEBEL ALI	59	33
AQABA	60	−1.594	HAIPHONG	60	33
DJIBOUTI	61	−1.590	AMBARLI	61	32
XIAMEN	62	−1.541	BEIRUT	62	32
SHANGHAI	63	−1.532	JAWAHARLAL NEHRU PORT	63	31
TANJUNG PRIOK	64	−1.521	KEELUNG	64	31
KEELUNG	65	−1.509	ANTWERP	65	31
TRIPOLI (LEBANON)	66	−1.497	TANJUNG PRIOK	66	31
OSAKA	67	−1.440	WILMINGTON (NORTH CAROLINA, USA)	67	30
YARIMCA	68	−1.393	CAUCEDO	68	30
ITAPOA	69	−1.376	SOHAR	69	29
SANTOS	70	−1.376	PORT SAID	70	29
SOHAR	71	−1.375	BUENAVENTURA	71	29
BUENAVENTURA	72	−1.353	SANTOS	72	28
SEPETIBA	73	−1.338	BOSTON (USA)	73	27
RIO GRANDE (BRAZIL)	74	−1.332	CAI LAN	74	27
KARACHI	75	−1.292	DILISKELESI	75	27
BARCELONA	76	−1.224	TRIPOLI (LEBANON)	76	27
POSORJA	77	−1.192	OSAKA	77	27
OSLO	78	−1.192	BALBOA	78	27
QUY NHON	79	−1.163	GEMLIK	79	26
CAT LAI	80	−1.149	KARACHI	80	26
SUAPE	81	−1.129	YOKKAICHI	81	26
LONDON	82	−1.117	COLON	82	25
PHILADELPHIA	83	−1.080	MERSIN	83	25
DANANG	84	−1.053	SEPETIBA	84	24
PORT OF VIRGINIA	85	−1.044	BREMERHAVEN	85	24
ANTWERP	86	−1.011	PECEM	86	23
ZEEBRUGGE	87	−0.988	PHILADELPHIA	87	23
SANTA CRUZ DE TENERIFE	88	−0.970	ITAPOA	88	23

Statistical approach			Administrative approach		
Port name	Rank	Total score	Port name	Rank	Index points
NEW YORK & NEW JERSEY	89	−0.969	PIRAEUS	89	23
GDYNIA	90	−0.942	ROTTERDAM	90	22
SHANTOU	91	−0.935	OSLO	91	20
NAHA	92	−0.883	DAMMAM	92	20
PIRAEUS	93	−0.859	DJIBOUTI	93	19
PUERTO LIMON	94	−0.858	PAITA	94	19
CHARLESTON	95	−0.820	SANTA CRUZ DE TENERIFE	95	19
PORT AKDENIZ	96	−0.820	SAVANNAH	96	18
TAICHUNG	97	−0.814	VERACRUZ	97	18
ULSAN	98	−0.811	ALTAMIRA	98	17
HAKATA	99	−0.758	JACKSONVILLE	99	17
COLON	100	−0.752	TAURANGA	100	17
MOBILE	101	−0.745	MARSAXLOKK	101	16
DAMMAM	102	−0.737	VALPARAISO	102	16
PUERTO BARRIOS	103	−0.731	GDYNIA	103	16
NOUMEA	104	−0.721	QUY NHON	104	16
PAITA	105	−0.705	ITAJAI	105	16
MARSAXLOKK	106	−0.698	PUERTO LIMON	106	16
YOKKAICHI	107	−0.692	PARANAGUA	107	16
MALAGA	108	−0.690	JOHOR	108	15
OMAEZAKI	109	−0.680	CAT LAI	109	15
JOHOR	110	−0.669	PORT OF VIRGINIA	110	15
MOJI	111	−0.663	NAHA	111	15
BATANGAS	112	−0.663	FORT-DE-FRANCE	112	15
BOSTON (USA)	113	−0.631	POINTE-A-PITRE	113	14
BALBOA	114	−0.625	MIAMI	114	14
SIAM SEAPORT	115	−0.613	DANANG	115	13
ROTTERDAM	116	−0.611	HAKATA	116	12
BURGAS	117	−0.611	SHANTOU	117	12
DUNKIRK	118	−0.611	AUCKLAND	118	12

Statistical approach			Administrative approach		
Port name	Rank	Total score	Port name	Rank	Index points
WILHELMSHAVEN	119	−0.598	BALTIMORE (USA)	119	12
SANTA MARTA	120	−0.589	DAKAR	120	12
TARRAGONA	121	−0.588	OMAEZAKI	121	11
CAGAYAN DE ORO	122	−0.582	PUERTO BARRIOS	122	11
AUCKLAND	123	−0.562	MOJI	123	11
NORRKOPING	124	−0.553	NOUMEA	124	11
FORT-DE-FRANCE	125	−0.543	ENSENADA	125	11
GUSTAVIA	126	−0.528	POSORJA	126	10
QINZHOU	127	−0.523	NEW YORK & NEW JERSEY	127	10
FREDERICIA	128	−0.493	CAGAYAN DE ORO	128	10
COPENHAGEN	129	−0.471	MALAGA	129	10
TUTICORIN	130	−0.469	SUAPE	130	10
PUERTO CORTES	131	−0.468	GDANSK	131	10
PORT BRONKA	132	−0.454	MOBILE	132	10
TANJUNG EMAS	133	−0.433	BURGAS	133	9
CHIBA	134	−0.418	TARRAGONA	134	9
SHIBUSHI	135	−0.382	NORRKOPING	135	9
ENSENADA	136	−0.378	SIAM SEAPORT	136	9
SAIGON	137	−0.375	SANTA MARTA	137	9
BALTIMORE (USA)	138	−0.368	FREDERICIA	138	9
PENANG	139	−0.367	TUTICORIN	139	8
KHALIFA BIN SALMAN	140	−0.356	CEBU	140	8
PUERTO BOLIVAR (ECUADOR)	141	−0.347	WELLINGTON	141	8
GIOIA TAURO	142	−0.344	COPENHAGEN	142	8
DAVAO	143	−0.341	TANJUNG EMAS	143	8
CASTELLON	144	−0.339	BATANGAS	144	8
ALTAMIRA	145	−0.324	MANZANILLO (MEXICO)	145	8
RIO HAINA	146	−0.322	TAICHUNG	146	8
POINTE-A-PITRE	147	−0.319	PORT EVERGLADES	147	8

Statistical approach			Administrative approach		
Port name	Rank	Total score	Port name	Rank	Index points
SAN JUAN	148	−0.303	QINZHOU	148	8
SHUAIBA	149	−0.301	PUERTO CORTES	149	7
NAPLES	150	−0.280	CHIBA	150	7
CEBU	151	−0.275	SAIGON	151	7
FREEPORT (BAHAMAS)	152	−0.271	PORT BRONKA	152	7
TANJUNG PERAK	153	−0.269	HAIFA	153	6
PUERTO QUETZAL	154	−0.269	PORT AKDENIZ	154	6
WILMINGTON (NORTH CAROLINA, USA)	155	−0.237	PUERTO BOLIVAR (ECUADOR)	155	6
VIGO	156	−0.233	DAVAO	156	6
PAPEETE	157	−0.227	CASTELLON	157	6
VERACRUZ	158	−0.219	CORONEL	158	6
SAN ANTONIO	159	−0.218	VIGO	159	5
SHUWAIKH	160	−0.216	RIO HAINA	160	5
JACKSONVILLE	161	−0.215	GUSTAVIA	161	5
CALDERA (COSTA RICA)	162	−0.206	KHALIFA BIN SALMAN	162	5
BELL BAY	163	−0.205	BELL BAY	163	5
HELSINGBORG	164	−0.196	SAN JUAN	164	5
POINT LISAS PORTS	165	−0.182	CALDERA (COSTA RICA)	165	4
BORUSAN	166	−0.163	SHIBUSHI	166	4
KALININGRAD	167	−0.159	PAPEETE	167	4
CARTAGENA (SPAIN)	168	−0.153	SALERNO	168	3
BARRANQUILLA	169	−0.137	BARRANQUILLA	169	3
CRISTOBAL	170	−0.135	YUZHNY	170	3
LATAKIA	171	−0.135	HELSINGBORG	171	3
PALERMO	172	−0.125	TANJUNG PERAK	172	3
NASSAU	173	−0.109	SAN ANTONIO	173	3
SALERNO	174	−0.080	PUERTO QUETZAL	174	2
CIVITAVECCHIA	175	−0.072	ULSAN	175	2
WELLINGTON	176	−0.049	RAVENNA	176	2

Statistical approach			Administrative approach		
Port name	Rank	Total score	Port name	Rank	Index points
DAKAR	177	−0.031	POINT LISAS PORTS	177	2
HERAKLION	178	−0.030	LIMASSOL	178	1
RAVENNA	179	−0.025	CARTAGENA (SPAIN)	179	1
CATANIA	180	−0.021	LONDON	180	1
LARVIK	181	−0.015	CIVITAVECCHIA	181	1
PORT FREEPORT	182	−0.008	PALERMO	182	1
VILA DO CONDE	183	0.000	ANCONA	183	0
VITORIA	183	0.000	LARVIK	184	0
OITA	185	0.004	HERAKLION	185	0
KRISTIANSAND	186	0.008	LYTTELTON	186	0
GIJON	187	0.013	LATAKIA	187	0
LYTTELTON	188	0.034	OITA	188	0
ODESSA	189	0.046	NASSAU	189	0
DURRES	190	0.057	CATANIA	190	0
MARIEL	191	0.057	HAMBURG	191	0
LIMASSOL	192	0.063	PHILIPSBURG	192	0
ANCONA	193	0.067	PORT FREEPORT	193	0
PHILIPSBURG	194	0.090	KRISTIANSAND	194	−1
MUUGA—PORT OF TALLINN	195	0.092	BORUSAN	195	−1
VARNA	196	0.094	GIJON	196	−1
BELAWAN	197	0.104	MARIEL	197	−1
YUZHNY	198	0.105	MUUGA—PORT OF TALLINN	198	−1
RIO DE JANEIRO	199	0.126	SHUWAIKH	199	−1
MIAMI	200	0.149	TAMPA	200	−1
BARI	201	0.167	SANTO TOMAS DE CASTILLA	201	−2
VLADIVOSTOK	202	0.182	BELAWAN	202	−2
SANTO TOMAS DE CASTILLA	203	0.185	BARI	203	−2
VOSTOCHNY	204	0.192	TOMAKOMAI	204	−2
TOMAKOMAI	205	0.194	MATADI	205	−2

Statistical approach			Administrative approach		
Port name	Rank	Total score	Port name	Rank	Index points
LEIXOES	206	0.201	NELSON	206	−2
ARICA	207	0.211	NAPLES	207	−2
PORT EVERGLADES	208	0.213	RAUMA	208	−3
MATADI	209	0.238	POTI	209	−3
NELSON	210	0.240	LEIXOES	210	−3
SAINT JOHN	211	0.241	PORT MORESBY	211	−4
TRIESTE	212	0.241	GIOIA TAURO	212	−4
GAVLE	213	0.242	VARNA	213	−4
MERSIN	214	0.275	GAVLE	214	−4
POTI	215	0.278	NEW MANGALORE	215	−4
TEESPORT	216	0.303	FREETOWN	216	−5
PORT MORESBY	217	0.307	ABIDJAN	217	−5
TIANJIN	218	0.310	VITORIA	218	−5
TAURANGA	219	0.333	TOAMASINA	219	−5
FREETOWN	220	0.350	KALININGRAD	220	−5
SAN VICENTE	221	0.361	ALEXANDRIA (EGYPT)	221	−5
VALPARAISO	222	0.365	GRANGEMOUTH	222	−6
BERBERA	223	0.368	RIGA	223	−6
BILBAO	224	0.384	FREEPORT (BAHAMAS)	224	−6
HAIFA	225	0.384	ZEEBRUGGE	225	−6
TAMPA	226	0.411	SAN VICENTE	226	−7
TOAMASINA	227	0.433	PENANG	227	−7
ABIDJAN	228	0.439	SHUAIBA	228	−7
RAUMA	229	0.439	PANJANG	229	−7
CHORNOMORSK	230	0.449	KOPER	230	−7
CALLAO	231	0.450	DURRES	231	−7
NEW MANGALORE	232	0.451	APRA HARBOR	232	−7
UMM QASR	233	0.452	COTONOU	233	−8
ALEXANDRIA (EGYPT)	234	0.482	BRISBANE	234	−8

Statistical approach			Administrative approach		
Port name	Rank	Total score	Port name	Rank	Index points
RIGA	235	0.482	TAKORADI	235	−8
SEATTLE	236	0.487	PUERTO PROGRESO	236	−8
VANCOUVER (CANADA)	237	0.499	NEW ORLEANS	237	−9
CONAKRY	238	0.505	TEESPORT	238	−9
EL DEKHEILA	239	0.509	BLUFF	239	−9
NAPIER	240	0.513	VLADIVOSTOK	240	−9
LA SPEZIA	241	0.548	VILA DO CONDE	241	−9
KOTKA	242	0.558	HOUSTON	242	−9
GRANGEMOUTH	243	0.560	BILBAO	243	−10
COTONOU	244	0.562	KOTKA	244	−10
OWENDO	245	0.563	BERBERA	245	−10
BRISBANE	246	0.569	NANTES–ST NAZAIRE	246	−10
PANJANG	247	0.573	ARICA	247	−11
APRA HARBOR	248	0.610	PORT OF SPAIN	248	−11
ACAJUTLA	249	0.640	ACAJUTLA	249	−11
DAMIETTA	250	0.650	CONAKRY	250	−11
LIVORNO	251	0.658	SAINT JOHN	251	−12
PARANAGUA	252	0.659	DUBLIN	252	−12
CONSTANTZA	253	0.660	STOCKHOLM	253	−13
TAKORADI	254	0.683	MALABO	254	−14
NANTES–ST NAZAIRE	255	0.693	VOSTOCHNY	255	−14
LIRQUEN	256	0.708	EL DEKHEILA	256	−14
BLUFF	257	0.731	CRISTOBAL	257	−14
LE HAVRE	258	0.746	ST PETERSBURG	258	−14
PUERTO PROGRESO	259	0.750	BANGKOK	259	−15
PORT OF SPAIN	260	0.775	MOGADISCIO	260	−15
TEMA	261	0.782	NAPIER	261	−15
DUBLIN	262	0.839	LIRQUEN	262	−15
MALABO	263	0.859	SEATTLE	263	−16

Statistical approach			Administrative approach		
Port name	Rank	Total score	Port name	Rank	Index points
HUENEME	264	0.862	TRIESTE	264	−16
NEW ORLEANS	265	0.865	ODESSA	265	−17
HOUSTON	266	0.878	KLAIPEDA	266	−17
STOCKHOLM	267	0.915	AGADIR	267	−17
BEIRA	268	0.919	CASABLANCA	268	−17
MANAUS	269	0.967	IZMIR	269	−18
ONNE	270	0.994	MANAUS	270	−18
BANGKOK	271	1.024	OWENDO	271	−18
ISKENDERUN	272	1.024	ISKENDERUN	272	−18
MONTEVIDEO	273	1.033	HUENEME	273	−19
VENICE	274	1.042	CHORNOMORSK	274	−19
MANZANILLO (MEXICO)	275	1.070	BATUMI	275	−19
AGADIR	276	1.122	MANILA	276	−19
IZMIR	277	1.136	BRISTOL	277	−19
GENERAL SANTOS	278	1.148	LAE	278	−19
SAVANNAH	279	1.158	RIJEKA	279	−20
HAMBURG	280	1.176	SAMSUN	280	−20
MOGADISCIO	281	1.194	BEIRA	281	−21
CORONEL	282	1.203	GENERAL SANTOS	282	−21
VALENCIA	283	1.211	MONTREAL	283	−22
THESSALONIKI	284	1.229	THESSALONIKI	284	−22
MONTREAL	285	1.231	CONSTANTZA	285	−22
KINGSTON (JAMAICA)	286	1.283	KINGSTON (JAMAICA)	286	−23
LAE	287	1.314	KRIBI DEEP SEA PORT	287	−24
LOME	288	1.332	OTAGO HARBOUR	288	−24
MEJILLONES	289	1.381	LA SPEZIA	289	−24
SOUTHAMPTON	290	1.404	LIVORNO	290	−24
CASABLANCA	291	1.442	ONNE	291	−25
PORT VICTORIA	292	1.457	NOUAKCHOTT	292	−25

Statistical approach			Administrative approach		
Port name	Rank	Total score	Port name	Rank	Index points
SOKHNA	293	1.459	SAN PEDRO (COTE D'IVOIRE)	293	−27
BRISTOL	294	1.462	UMM QASR	294	−27
NOUAKCHOTT	295	1.475	VENICE	295	−27
MUHAMMAD BIN QASIM	296	1.499	LA GUAIRA	296	−28
SAMSUN	297	1.502	DAMIETTA	297	−28
DOUALA	298	1.510	CHATTOGRAM	298	−28
MAPUTO	299	1.533	PORT VICTORIA	299	−28
NOVOROSSIYSK	300	1.626	LE HAVRE	300	−30
KLAIPEDA	301	1.635	NOVOROSSIYSK	301	−30
MELBOURNE	302	1.676	DOUALA	302	−31
KRIBI DEEP SEA PORT	303	1.701	VANCOUVER (CANADA)	303	−31
ST PETERSBURG	304	1.719	TIMARU	304	−32
LA GUAIRA	305	1.737	DUNKIRK	305	−33
CHATTOGRAM	306	1.809	MAPUTO	306	−33
WALVIS BAY	307	1.819	PUERTO CABELLO	307	−34
ITAJAI	308	1.828	VALENCIA	308	−34
PUERTO CABELLO	309	1.829	RIO DE JANEIRO	309	−35
SAVONA–VADO	310	1.897	BUENOS AIRES	310	−37
GDANSK	311	1.944	MEJILLONES	311	−38
RIJEKA	312	1.974	TEMA	312	−40
FELIXSTOWE	313	2.006	MELBOURNE	313	−40
OTAGO HARBOUR	314	2.023	SAVONA–VADO	314	−40
ALGIERS	315	2.076	ASHDOD	315	−42
BATUMI	316	2.175	MUHAMMAD BIN QASIM	316	−42
TIMARU	317	2.225	SOUTHAMPTON	317	−45
KOPER	318	2.237	ALGIERS	318	−49
SAN PEDRO (COTE D'IVOIRE)	319	2.267	FREMANTLE	319	−49
BUENOS AIRES	320	2.391	IQUIQUE	320	−54
GENOA	321	2.420	SOKHNA	321	−55
MANILA	322	2.445	FELIXSTOWE	322	−55

Statistical approach			Administrative approach		
Port name	Rank	Total score	Port name	Rank	Index points
JEBEL ALI	323	2.482	PRINCE RUPERT	323	−56
DAR ES SALAAM	324	2.561	DAR ES SALAAM	324	−58
DUTCH HARBOR	325	2.591	DUTCH HARBOR	325	−60
FREMANTLE	326	2.716	NEMRUT BAY	326	−61
ASHDOD	327	2.797	PORT BOTANY	327	−63
LOS ANGELES	328	2.899	MONTEVIDEO	328	−65
NEMRUT BAY	329	2.970	TACOMA	329	−66
PRINCE RUPERT	330	2.979	BEJAIA	330	−72
MOMBASA	331	3.140	GENOA	331	−74
OAKLAND	332	3.163	LOME	332	−77
LONG BEACH	333	3.175	ADELAIDE	333	−78
PORT REUNION	334	3.302	OAKLAND	334	−79
TACOMA	335	3.628	MOMBASA	335	−79
GUAYAQUIL	336	3.647	WALVIS BAY	336	−80
PORT BOTANY	337	3.907	LOS ANGELES	337	−82
BEJAIA	338	4.054	GUAYAQUIL	338	−84
ADELAIDE	339	4.546	GOTHENBURG	339	−87
LAGOS (NIGERIA)	340	4.646	PORT REUNION	340	−89
GOTHENBURG	341	4.653	LONG BEACH	341	−96
IQUIQUE	342	4.766	LAGOS (NIGERIA)	342	−114
TIN CAN ISLAND	343	4.789	LUANDA	343	−115
PORT LOUIS	344	5.501	TIN CAN ISLAND	344	−118
MARSEILLE	345	5.696	POINTE-NOIRE	345	−128
POINTE-NOIRE	346	5.832	PORT LOUIS	346	−175
CAPE TOWN	347	6.528	CAPE TOWN	347	−177
PORT ELIZABETH	348	7.659	PORT ELIZABETH	348	−183
DURBAN	349	8.082	NGQURA	349	−190
LUANDA	350	8.383	MARSEILLE	350	−238
NGQURA	351	8.401	DURBAN	351	−255

9. ***While the rankings demonstrate a broad consistency resulting from the two approaches, some exceptions exist.*** Three of the most notable discrepancies are Jebel Ali (323rd and 59th in the statistical and administrative approach respectively), Itajai (308th and 105th respectively), and Tianjin, one of the highest ranked ports affected (218th and 20th respectively). The approach taken in the CPPI 2020 has been not to try and explain every discrepancy, but rather to make the methodology and assumptions explicit and let the data speak. In future editions, further refinement of both approaches will hopefully reduce discrepancies, and further enhance their respective complementarity, and the rigor of the CPPI.

10. ***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 WBG/IHS Markit team will continue to refine the methodologies, the scope, where possible increasing the number of ports, and the data. The next iteration, CPPI 2021, will be comparable, facilitating the introduction of trends in container port performance, both overall and potentially by disaggregation by ship or call size. The CPPI 2021 will also seek to investigate and explain divergences between the two approaches, while also gaining a further understanding of key determinants or influences on container port performance. 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.

The overall objective remains the identification of potential improvement to ultimately benefit all public and private stakeholders.

1. Introduction

11. ***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, with volumes carried increasing at an annual average of 3 percent; over the period from 1970 to 2018. In 2019, maritime trade volumes expanded by only 0.5 percent, reaching a total of just over 11 billion tons for the year (UNCTAD 2020). Container trade, which accounts for approximately 35 percent of total volume and for more than 60 percent by value, grew by 2 percent, down from 5.1 percent in 2018. Overall, both maritime and container trade reflect a slowdown in world gross domestic product (GDP) to 2.5 percent, 0.6 percent lower than the 3.1 percent GDP in 2018. Lingering trade tensions and high policy uncertainty undermined growth in global economic output and merchandise trade, and by extension, maritime trade.

12. ***Since the dawn of maritime trade, maritime ports have been central to economic and social development.*** This statement 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 continued shaping the industry. 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 served as a prerequisite to successful, often export-led, growth strategies. Done well, port infrastructure provides the necessary confidence to facilitate investment in production and distribution systems, supporting the expansion of manufacturing and logistics, while creating employment and raising income levels.

Container ports have become critical nodes in global supply chains and are central to the growth stories and strategies of many emerging economies.

13. ***More specifically, how a maritime port performs is a crucial element in determining a country's trade costs.*** Poorly performing ports constrain trade growth, an impact particularly pronounced for landlocked developing countries (LLDCs) and the small island developing states (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 of 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).

Poorly performing ports constrain trade growth.

14. ***More specifically, the efficiency of port infrastructure has also been identified as a key contributor to overall port competitiveness and international trade costs.*** Sanchez et al. (2003) identified a link between port efficiency and the cost of international trade. Clark et al. (2004) found a reduction in a country's trade inefficiencies, specifically transport costs, from the 25th to 75th percentile, resulted in an increase in bilateral trade of around 25 percent. Wilmsmeier et al. (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 would halving the physical distance

between the ports. Hoffmann et al. (2020) analyzed the short- and long-run impacts of the liner shipping bilateral connectivity on South Africa's trade flows, and showed that GDP, the number of common direct connections, and the level of competition have a positive and significant effect on trade flows.

15. ***Unfortunately, ports and terminals, particularly for containers, can often be the main sources of shipment delays, supply chain disruption, 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 World Bank 2013) and has driven numerous efforts to improve performance to strengthen competitiveness.

Far too often instead of facilitating trade, the port increases the cost of imports and exports, reduces competitiveness, and inhibits economic growth and poverty reduction.

16. ***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 along the route served by the vessel would have to be resolved before the vessel arrives at the next port of call, in order to avoid an adverse impact on the efficiency of service operations. As such, port efficiency and port turnaround time on a vessel's scheduled voyage at all ports of call are important subjects for operators. In addition, monitoring port performance has become an increasingly important undertaking in the competitive landscape.

Port efficiency and port turnaround time at all ports of call are important subjects for operators.

17. ***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," reflects the historical challenge of both managing and overseeing the maritime transport sector. While modern ports collect data for performance purposes, it is difficult to compare the outcomes with competitors or with ports in similar circumstances. Managers might know performance is improving year on year, but they might not know whether performance is up to the standards of leading ports with similar profiles. Not surprisingly, the sector has amassed a

long history of attempts to identify and implement a comparative set of indicators to measure port or terminal performance; a brief review of the related literature is provided in chapter 2. However, one of the general challenges of nearly all these approaches has been the quality, consistency, and availability of data, the standardization of definitions employed, and the capacity and willingness of the relevant organizations to collect and transmit the data to a collating body.

18. ***At a slightly higher level, several aggregate indicators provide an indication of the comparative quality and performance of maritime gateways.*** The World Bank Logistics Performance Index, or LPI (Arvis et al. 2018), and Doing Business Index, or DBI (World Bank 2020), on trading across borders, and the World Economic Forum's Global Competitiveness Index (GCI) 4.0 all report on the perceived efficiency of seaport services and border clearance processes. In addition, each indicates 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 they are perception based, means they offer at best an indication of comparative performance with little to guide spatial or operating performance improvements at the level of the individual port. The Liner Shipping Connectivity Index (LSCI) published by the United Nations Conference on Trade and Development (UNCTAD) provides an indicator or a port's position within the liner shipping network. While a port's position is in part determined by the port's performance, the LSCI does not directly measure it. Similar in scope to the CPPI, the LSCI is also limited to container ports.

New technologies, increased digitalization, and industry stakeholder willingness to work collectively toward systemwide improvements now, for the first time, provides the capacity and opportunity to measure and compare container port performance in a robust and reliable manner.

19. ***Digitalization offers an opportunity to measure and compare container port performance in a robust and reliable manner.*** New technologies, increased digitalization, and industry stakeholder willingness to work collectively toward systemwide improvements now, for the first time, 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 2020 are gathered from the IHS Markit Port Performance Program.[1] 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 10 of the world's largest liner shipping companies, which collectively operate 76 percent of global fleet capacity. The nature, source, and scope of the data are discussed in chapter 3.

20. ***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 inaugural edition of the CPPI, the focus is purely on quayside performance to be reflective of 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, and the justification for their use, are presented in summary in chapter 3, with further detail provided in appendix B. The results in terms of the CPPI 2020 are presented in chapter 4, with detailed tables provided in appendix A.

Container port performance is most relevant from the perspective of customer experience and the speed and efficiency with which customer assets are handled.

21. ***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, supra-national organizations, various maritime interests, and other public and private stakeholders engaged in trade, logistics 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.

NOTE

1. For more information on the Port Performance Program, see: https://ihsmarkit.com/products/port-performance.html.

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2. The Measurement of Port Performance

2.1. Introduction

22. ***Chapter 1 underlined the importance of a reliable comparative measure to assess performance across different ports.*** Perhaps not surprisingly, the attempts to identify a comparative set of indicators to measure port or terminal performance stretch back several decades. This chapter offers a brief review of that literature, and it is certainly not intended to be exhaustive. Rather, the intention is to illustrate the broad approaches identified in the literature and comment on the merits and demerits of each. The review has been structured around a simple typology: 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. These three categories are discussed in subsequent sections of this chapter.

2.2. Measures of Operational or Financial Performance

23. ***Some of the initial attempts to define and introduce consistent port performance indicators occurred in the early 1970s.*** In the early 1970s the Secretariat of the United Nations Conference on Trade and Development (UNCTAD), in response to a formal request, prepared a manual on port statistics (UNCTAD 1971), with the objective of providing guidance on better statistical processes for countries and ports. A subsequent publication, on berth throughput (UNCTAD 1974), included a chapter on port performance indicators, but at that time placed less emphasis on containers per se. In the late 1970s, UNCTAD proposed that signatory countries should adopt and follow certain port performance indicators (UNCTAD 1987). The proposal's aim was straightforward: to be able to improve performance, countries first needed to measure performance, beyond the traditional cost accounting measures. Without accurate performance indicators, countries also found it difficult to identify operational constraints, define operational performance measures, and plan port development and enhancement needs.

Some of the initial attempts to define and introduce consistent port performance indicators occurred in the early 1970s.

24. ***The indicators identified and proposed were predominantly related to the operational or financial performance of a port or terminal.*** In the former case, they were based, generally, on measures of throughput volumes—container movements per crane, container movements per hour, berth utilization, the (total) number of employees in the port (divided by the total number of containers). In the latter case, the financial measures were a move toward activity based costing, to instill an understanding of the vessel and cargo revenues, service revenues, labor costs, and required investment for different berths (or berth groups in the vernacular). Table 2.1 summarizes the indicators proposed by UNCTAD in 1976. These were proposed to be calculated monthly for each berth group servicing a cargo class.

Table 2.1. Summary of Performance Indicators

Financial indicators	Operational indicators
Tonnage worked	Arrival date
Berth occupancy revenue per ton of cargo	Waiting time
Cargo handling revenue per ton of cargo	Service time
Labor expenditure	Turnaround time
Capital expenditure per ton of cargo	Tonnage per ship
Contribution per ton of cargo	Fraction of time berthed ships worked
Total contribution	Number of gangs employed per ship per shift
—	Tons per ship-hour in port
—	Tons per gang hours
—	Fraction of time gangs idle

Source: UNCTAD 1976.

25. ***In 1987, UNCTAD published the Manual on a Uniform System of Port Statistics and Performance Indicators.*** Produced for the Port Management Associations of East and Southern Africa as well as West and Central Africa, the manual followed a seminar organized by the World Bank in Ghana in April 1986. The Port Management Association of East and Southern Africa made a similar request to the Sub-Saharan Africa Transport Program in 2018, which provides an indication of the progress in introducing a consistent and comparable set of indicators.

26. ***That same year, UNCTAD partnered with the International Association of Ports and Harbors (IAPH) to produce a monograph on measuring port performance and productivity.*** Monograph No. 6 was prepared by an external party (De Monie 1987, 2–11), who noted the long history and the large number of studies, reports, and conferences on the topic. De Monie also noted the outcome, generally, had left the majority of parties dissatisfied, if not downright frustrated. The reasons for such an outcome were summarized as the following: firstly, the sheer number of different parameters involved; secondly, the lack of reliable, accurate, up-to-date data, collected and collated in a consistent manner; thirdly, the profound influence of local factors on the data collected; and finally, the divergence in data interpretation by different parties.

27. ***In 2004, UNCTAD developed the Liner Shipping Connectivity Index (LSCI).*** The LSCI was initially generated on the country level, and since 2018 has also been developed on the port level in collaboration with MDS Transmodal.[1] The index is generated from data on container ship deployment with six components: (i) The number of weekly calls; (ii) the number of competing carriers; (iii) the number of services; (iv) the size of the largest ship that calls in port; (v) the total deployed container carrying capacity, and (vi) the number of other ports connected through direct services. While not directly measuring performance, the LSCI has been shown to be highly correlated with performance and low trade costs.

28. ***More recently, UNCTAD proposed a port performance scorecard as part of their "TrainForTrade Port Management Program."***[2] The main idea was to bring industry and academic perspectives together in terms of port performance in order to share best practices among port managers, particularly from developing countries. While the focus and emphasis in the academic research will be discussed in the next section, many of the challenges summarized in De Monie (1987) remain relevant today. One could also posit that the intensification of competition between the shipping lines, and the ports themselves, has led to greater caution and less trust in respect of information sharing between public and private stakeholders. The web-based *Port Reform Toolkit* (World Bank 2008) included addressed performance indicators with the notion of a "port time accounting" system, similar but more detailed, to the early work in UNCTAD's *Monograph No. 6* (De Monie 1987). Kent et al. (2014) utilized a similar approach to measure port performance in Central America. But the PORTOPIA (PORTs Observatory for Ports Indicator Analysis) initiative, supported by the European Union and which ended in August 2017, illustrates the ongoing challenge of this type of approach.

The main idea was to bring industry and academic perspectives together in terms of port performance in order to share best practices among port managers.

29. ***Since 2018, UNCTAD has also published median time ships spend in port, based on automatic identification system (AIS) data, in collaboration with MarineTraffic.***[3] While the reporting is done only on the country level, the information is provided not only for container ships, but for all major shipping markets, including dry and liquid bulk ships. Globally, the data show the time spent in port by container ships, on average, equals only one-third of that spent by dry bulk carriers; however, large differences between countries' performances do exist.

2.3. Measures of Efficiency

30. ***The literature on efficiency in the port industry emerged about three decades after the construct of technical efficiency was first proposed.*** The literature on efficiency in the port industry emerged about three decades after Farrell (1957) proposed the concept of "technical efficiency." Farrell's construct estimates the efficiency of a port calculated by measuring the difference between observed production and theoretical potential production, the latter defined by the practices of the "better" performing ports in a sample. The quantification of efficiency is linked to the estimation of a frontier that represents a standard against which efficiency is measured.

The literature on efficiency in the port industry emerged about three decades after Farrell (1957) proposed the concept of "technical efficiency."

31. ***Two approaches have been developed to estimate the technical efficiency frontier:*** linear programming techniques, mainly (i) data envelopment analysis (DEA); and (ii) econometric (stochastic) approaches. Each of the approaches has advantages and disadvantages, and the choice reflects the particular case under study. From a methodological point of view, Cullinane et al. (2006), shows the results obtained using the two approaches are reasonably correlated.

32. ***Since the 1990s, a proliferation of research on the efficiency of ports has emerged.*** The first research, in the 1990s, estimated technical efficiency of ports in the United Kingdom and Spain. Since 2000, the geographical scope of the studies has been extended to South Asia, Latin America, and Eastern and Southern Africa, along with others. Much of the research supports the unsurprising premise that increased efficiency reduces transport costs (see Herrera Dappe et al. 2017; Nordås and Piermartini 2009; and Trujillo et al. 2013). Box 2.1 summarizes one recent study conducted by the World Bank (2018).

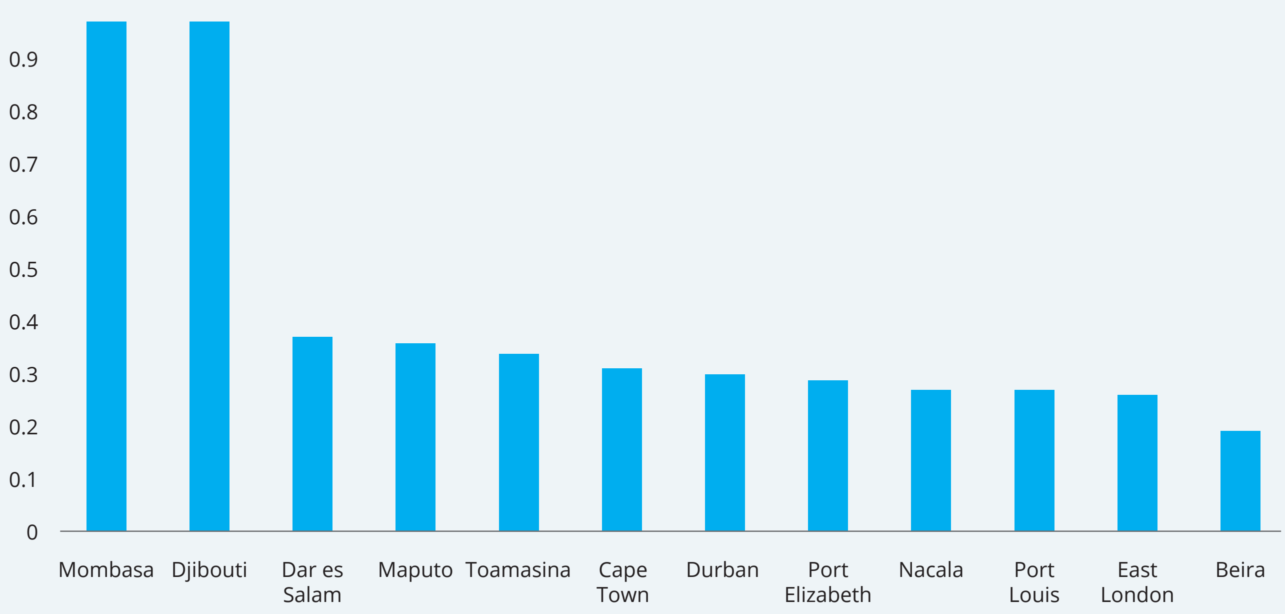
33. ***Some of the results, however, should be interpreted with a note of caution.*** Despite the apparent sophistication of the statistical and econometric approaches, the studies share many of the same challenges as previous attempts. These include differences in the definition and reliability of the input statistics (among the questions to address: Does the container handling space include, or exclude container depots outside or adjacent to the port area? Does it include the general cargo berths where overspill containers are handled?), temporal consistency in the data available from different ports and terminals, public sector mandates to allow more or less storage time, and similar limitations in trust and transparency between terminal operators and port authorities.

Box. 2.1. Port Development and Competition in Eastern and Southern Africa: Prospects and Challenges

The current study measures port efficiency using a stochastic frontier production function. The production frontier shows the maximum output quantity that can be obtained with a given combination of inputs. The efficiency of a port is calculated by measuring the difference between observed production and theoretical potential production, the latter based on the practices of the "better" performing ports in the sample of similar ports. The logic of using a matched sample of similar ports is that the larger ports will reach levels of technical efficiency that are unattainable by ports of the scale of the Eastern and Southern Africa (ESA) ports.

The analysis considered three main input variables: the sum of the length of all container and multi-purpose berths in the port, the total container terminal area of the port, and the combined capacity of the cranes, including ship-to-shore (STS) gantry cranes, and any mobile lifting capacity in the port with a capacity over 15 tons. In addition, several environmental variables were defined to ensure other key contextual factors were reflected in the analysis. These included a dummy variable if there is at least one privately operated terminal, a dummy variable if the port has railway access, and a connectivity index.[4] A time trend was included to reflect the effect of technological change.

Figure B2.1.1. Average Technical Efficiency among ESA Ports, 2008–17



Globally, the port of Mombasa, based on this data, is the most technically efficient port in the ESA, and ranks as the 43rd most efficient container port in the global sample. Dar es Salaam and Durban follow at 64th and 70th positions respectively. The analysis also reveals the main factors found to drive higher efficiency in container terminal operations in the port are: (i) the presence of at least one specialist terminal operator; (ii) the existence of a rail connection to the port; (iii) the existence of transhipment traffic; (iv) a higher score on the LSCI; and (v) reduced time at berth.

Source: World Bank 2018.

34. ***Even if the data are comparable, reliable, and complete, interpretations will differ within each context.*** As in one example, a port or terminal under stress might appear an exemplar in terms of the comparison, as the pressure forces an improvement in the utilization of space, and improvement in operational practices. By contrast, a port under less stress might not face the same pressures, and in some cases encourage higher dwell time for revenue maximization. The picture is obviously nuanced, and the key message is that the various metrics should not be considered alone without carefully considering other indicators within a given context.

2.4. Measures Using Data from Exogenous Sources

35. ***The Journal of Commerce (JOC) Port Productivity Index and the journey to the Container Port Performance Index (CPPI) 2020.*** The year 2009 was one of the worst in terms of losses in the history of container shipping. The financial crisis triggered by the 2008 Lehman Brothers collapse resulted in accumulated losses among container lines reached US$20 billion as they dealt with a sharp drop in global demand, low freight rates and high fuel prices. It was an existential moment for an industry that badly needed to cut costs.

The year 2009 was one of the worst in terms of losses in the history of container shipping.

36. ***In March 2009, at a JOC-organized container shipping conference, a chief executive officer (CEO) of a major shipping line presented the idea of liner shipping companies submitting port call timestamp data for the purpose of performance benchmarking.*** The rationale included the idea that aggregated port call timestamp data could support initiatives to improve port call efficiency, resulting in vessels being moved out of port more quickly, allowing them to meet their schedules or slow steam to the next port. Slow steaming would result in reduced fuel use and lower overall fuel costs. The improved efficiency also held the potential to reduce emissions, although decarbonization initiatives did not have the same level of urgency for the industry at that time as they do today.

37. ***For JOC, the prospect of developing a project that could help drive improvement in container port call efficiency sparked interest and led to the launch of the JOC Port Productivity Project, a precursor of the CPPI.*** In the beginning, the JOC project focused entirely on berth productivity—the number of container moves divided by hours at berth (whether gross or net). In the early years, five major carriers provided data monthly to the initiative. The carriers willingly shared data and were keen to develop and apply the benchmarking to seek out opportunities for improving port call processes. In 2012 the project had generated enough traction to warrant a presentation to the Box Club—formally known as the International Council of Containership Operators—at its annual meeting of liner shipping CEOs in New York. The Box Club update spawned more interest and support among major carriers resulting in new members providing data on a regular basis.

The carriers willingly shared data and were keen to develop and apply the benchmarking to seek out opportunities for improving port call processes.

38. ***From a technical point of view, a step change in the advancement of the CPPI came after IHS Inc.*** acquired or became responsible for managing several data-rich assets. Over 2008 and 2009, IHS fully acquired the former Lloyd's Register of Ships, one of the world's premier vessel characteristics datasets. In 2014, IHS Inc. acquired the JOC Group, which publishes the Journal of Commerce. In addition, the IHS data team manages the International Maritime Organization (IMO) vessel numbering scheme as well as the global fleet tonnage assessment for IMO fees. IHS also owns and operates a premium AIS service with both satellite and terrestrial coverage offering both live and historical ship movements data.

39. ***The mapping of carrier call data to AIS historical vessel movements data provided a key in the development of CPPI,*** allowing for a new level of quality control due to the capacity to track and verify each individual call. Detailed AIS mapping and geofencing of port and terminal zones as well as the capacity to track vessels with high fidelity on approach and within ports also facilitated the creation of productivity metrics based on an exogenous source. At the same time, through more regular dialogue with the carriers, the program made significant progress in standardizing definitions and terms. The 2016 merger of IHS Inc. with leading financial industry data and information provider Markit—to form IHS Markit—led to further improvement of the collection, management, and quality control processes associated with the port performance data.

40. ***In autumn 2019 the IHS Markit Port Performance Program[5] was presented again to the Box Club, this time in Shanghai.*** One of the reasons the program was added to the Box Club agenda because earlier that year the IMO had identified the potential of port call optimization to contribute toward meeting industry decarbonization targets. The dataset supports identification of gaps and opportunities for improvement in container port call processes and can play a role in supporting initiatives aimed at moving the industry toward just-in-time (JIT) vessel arrivals and the associated benefits of that in terms of reduced fuel consumption and reduced emissions.

41. ***After the 2019 Box Club meeting, the number of carriers supporting the program quickly rose to 10, which combined control over 76 percent of the global container fleet capacity.*** Currently, the Port Performance Program accounts for more than 180,000 port calls and 240 million container moves per year. The performance dataset covers more than 1,000 terminals in over 500 container ports. This critical mass, combined with the high-quality data collection, verification, management and distribution put in place over the past decade has created a valuable resource that for the first time allows us to credibly and objectively measure and compare ocean-side container port and terminal performance on global scale.

Currently, the Port Performance Program accounts for more than 180,000 port calls and 240 million container moves per year.

42. ***IHS Markit and the World Bank are drawing on this resource to partner in the development and publication of the CPPI.*** A more detailed discussion of the data behind the construction of the CPPI, the logic, and different approaches employed, are summarized in chapter 3, while chapter 4 presents the results of the inaugural CPPI 2020.

NOTES

1. UNCTAD offers country- and port-level LSCI data, along with bilateral (country-to-country) LSCI data online: http://stats.unctad.org/maritime/, while MDS Transmodal offers LSCI for the top 100 ports: https://www.portlsci.com.
2. See https://tft.unctad.org/port-management/ for more information on UNCTAD's TrainForTrade's Port Management Program.
3. Explore the MarineTraffic live shipping map online: https://marinetraffic.com.
4. See the Review of Maritime Transport 2020 (UNCTAD 2020) to learn more about the latest iteration of the connectivity index (LSCI) used in this 2018 study.
5. For more information on the Port Performance Program, see: https://ihsmarkit.com/products/port-performance.html.

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3. The Approach and Methodology

3.1. Introduction

43. ***Container (liner) shipping services are generally highly structured, service rotations.*** These services are typically set up with weekly departure frequencies, 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 with modest buffers included in the sea legs between ports.

44. ***The clear advantages of a highly structured service model include: (i) shippers can make long-term supply decisions, and (ii) ports and terminals can 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. As noted previously in the report, 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.

With a well-planned and well-executed pro forma schedule, higher levels of reliability and predictability can be achieved.

45. ***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, increased costs, and increased 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.

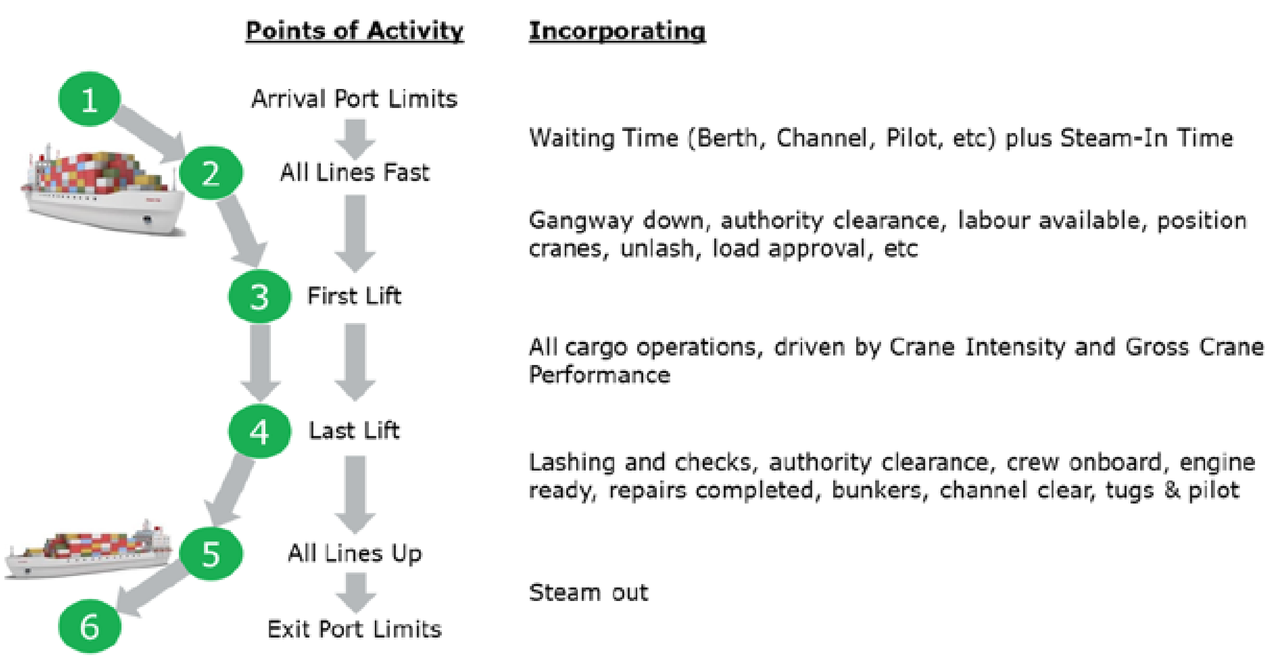
In extreme cases, ships that fall many hours behind their pro forma schedule will start to arrive at ports outside of their agreed windows, causing berth availability challenges for ports and terminals, particularly those with high berth utilization rates.

46. ***Because time is valuable for stakeholders, a logical step is to measure port performance based upon the total amount of time ships are required to spend in port.*** To facilitate this measurement, the Container Port Performance Index (CPPI) 2020 has been developed based on total port time as explained in subsequent report sections. This first CPPI iteration utilizes data through June 30, 2020. Similarly, the next version (CPPI 2021) will utilize data through June 30, 2021. The construction of the CPPI 2020 has employed two different approaches, an administrative approach and a statistical approach, to ensure the resulting ranking of container port performance reflects as closely as possible actual port performance, while 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 4.

3.2. The Anatomy of a Port Call

47. ***Every container port call can be broken down into six distinct steps. Figure 3.1 illustrates these individual steps.*** The term total port hours is defined as the total elapsed time between when a ship reaches a port (either port limits, pilot station, or anchorage zone) to when it departs from the berth after completing 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 any performance loss that pertains to departure delays, such as (i) pilot or tug availability; (ii) readiness of the mooring gang; (iii) channel access and water depths; and (iv) ship readiness, 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 3.1. The Anatomy of a Port Call



Source: Figure graphic provided by IHS Markit, Marine & Trade division

48. ***Ships may spend additional time in a port after the departure from a berth; however, the time associated with these additional activities is excluded from the CPPI.*** Ships might 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 do not necessarily reflect inefficiency or poor performance of the port and are thus excluded from the CPPI.

Ships may spend additional time in a port after the departure from a berth. They might dwell within a port's limits for bunkering, repairs, or simply waiting in safe areas.

49. ***Conversely, ships occasionally might not sail immediately upon completion of cargo operations because they are not operationally ready, have not been released by local authorities, or remain alongside to complete repair works or bukering.*** With the exception of authority clearance delays, none of the other causes of additional port time are reflective of port inefficiency per se. However, the available data are insufficiently granular to see root causes of delays by their nature. The Port Performance Program presumes the percentage of ships idling alongside after completion of cargo operations for reasons unrelated to port performance is modest, and thus continued inclusion will have no significant effect on the CPPI results.

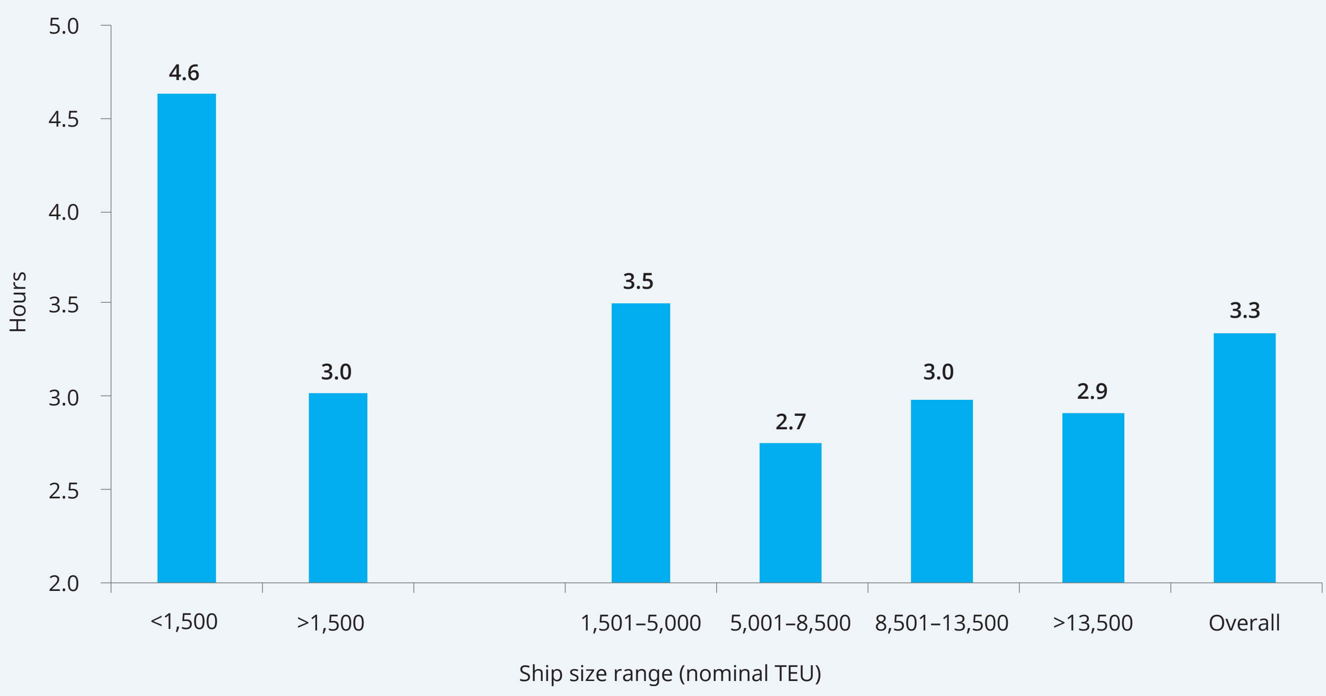
50. ***The other four components of the port call can logically be grouped into two distinct blocks of time.*** The first comprises elapsed time between arrival port limits and all lines fast (steps 1 to 2 in figure 3.1); the second comprises time elapsed between all lines fast and all lines up (steps 2 to 5, also commonly referred to as on-berth time or berth hours). The logic behind this division contends there will always be time consumed between steps 2 and 5, while the bulk of time between steps 1 and 2—excluding actual sailing time—is waiting time that could be reduced to zero.

Waiting time, defined as the period between arrival port limits, which includes the anchorage zone, and all lines fast is generally regarded as pure waste.

51. ***The issue of waiting time in the measurement of port performance.*** Waiting time, defined as the period between arrival port limits, which includes the 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 could be seen as a normative judgment, which would be inconsistent with the program's overarching objective of producing an objective quantitative index.

52. ***On a related note, the CPPI team deliberated in whether to apply a "discount" to waiting time for the smallest segment of ships.*** This question arose because ships with less than 1,500 twenty-foot equivalent units (TEUs) of nominal capacity spend notably more time waiting at hub ports[1] than all other ship size segments (see figure 3.2 and table 3.1, which display "arrival" times; however, this disparity is not present at all hub ports). The disparity could exist because larger ships generally enjoy a higher priority for berthing. It could also be partly explained due to 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.

Figure 3.2. Average Arrival Times at Hub Ports per Ship Size Range



Source: Original calculations for this publication, based on CPPI 2020 data.

Table 3.1. Disparity in Arrival Times at Hub Ports

Port	Ship size less than 1,500 TEU (hours)	Ship size greater than 1,500 TEU (hours)
Cartagena (Colombia)	9.1	2.2
Alexandria (Egypt)	10.4	3.8
Jeddah	9.5	3.0
Valencia	9.7	3.2
Damietta	9.7	4.7
Manzanillo (Mexico)	8.8	4.2
Rotterdam	8.3	4.4
Hamburg	7.8	4.1
Piraeus	6.2	3.2
Balboa	5.2	2.5
Bremerhaven	5.4	3.2
Port Louis	4.8	2.7

Source: Original calculations for this publication, based on CPPI 2020 data.
Note: TEU = twenty-foot equivalent unit

53. ***Because the performance data do not indicate whether waiting time is voluntary or forced, finding a suitable level at which to discount waiting time in this scenario can be challenging.*** Port calls of ships less than 1,500 TEU capacity comprise just 10 percent of total calls in the CPPI, making a minimal impact to the overall CPPI of the disparity in waiting times between ships with less than 1,500 TEU of nominal capacity and other segments. The same applies with respect to this issue being a normative judgment inconsistent with an objective quantitative index.

3.3. The Data Underpinning the CPPI

54. ***The data used to compile the CPPI are taken from the IHS Markit port performance program database.*** Started in 2009, the port performance program goal is to drive efficiency improvements in container port operations and support programs to optimize port calls. The program currently comprises 10 of the world's largest liner shipping companies, which collectively operate 76 percent of global fleet capacity. This unique and highly comprehensive dataset covers 502 ports and 1,014 terminals in 137 countries, with calls by 3,860 individual vessels. On an annual basis, the database comprises more than 180,000 port calls.

Started in 2009, the port performance program goal is to drive efficiency improvements in container port operations and support programs to optimize port calls.

55. ***Because the source data are provided by the larger container ship operators, performance results are slightly skewed toward the larger container ship size classes.*** However, many program participants have sister or subsidiary companies that specialize in intraregional or feeder services or they might operate such services under their main brands. Thus, call data from these services are included in the dataset and, by extension, the CPPI.

56. ***In 2015 and 2016, participating members agreed on standard metric definitions.*** This agreement ensured comparisons could be drawn from consistent empirical data. Member shipping lines provide the port call data to IHS Markit on a monthly basis. The data undergo a thorough checking and validation process, including removal of records falling outside well-defined data quality boundaries that usually exist as a result of data input errors. The data are validated against IHS Markit's geodatasets to ensure full harmonization of location names and vessel. The received data are matched with proprietary historical AIS (automatic identification system) port timestamps for validation, and creation of additional performance metrics.

The port call data provided by member shipping lines, undergo a thorough checking and validation process.

57. ***The AIS matching process involves taking the berth arrival date and time provided by the member shipping lines and searching back through the historical AIS data.*** The objective is to determine the earliest arrival date and time for a port or anchorage zone mapped to the destination port. The search backwards stops at berth arrival minus 144 hours (six days). Searching beyond the 144-hour boundary is not feasible as it would likely result in capturing port arrival dates and times for port calls from previous weeks. These data would consist mainly of feeder ships running on weekly frequencies or mainline ships where a sailing was blanked or voided, or ships being in repair yards immediately prior to a port call.

58. ***The success rate of the AIS matching process ranks consistently around 90 percent.*** The failed match quantity of 10 percent normally relates to locations with a shortage of land-based terrestrial receivers, which requires higher dependence on satellite tracking—a less reliable tracking method in busy port areas. A review of the port-level data indicates those ports where AIS timestamp match ratios are low (see table 3.2). Port hours cannot be calculated without a valid port arrival date and time. These included port calls at a further 75 ports,[2] amounting to a collective 1,043 port calls, though these ports do not feature in the CPPI 2020 iteration.

Table 3.2. Ports with Low Levels of Matched AIS Data

Port name	Matched (percent)	Port name	Matched (percent)
Algiers	37	Latakia	30
Alicante	20	Magdalla	15
Aqaba	35	Muhammad Bin Qasim	20
Bar	9	Mundra	30
Chennai	10	Nassau	22
Chu Lai	30	Pipavav	18
Corinto	29	Ploce	0
Damietta	39	Prachuap Port	0
Fort-De-France	35	Puerto Bolivar (Colombia)	0
Freetown	19	Qingdao	12
Kamarajar	3	Rades	7
Kattupalli	7	San Carlos (Philippines)	0
Kribi Deep Sea Port	30	Subic Bay	13
Krishnapatnam	5		

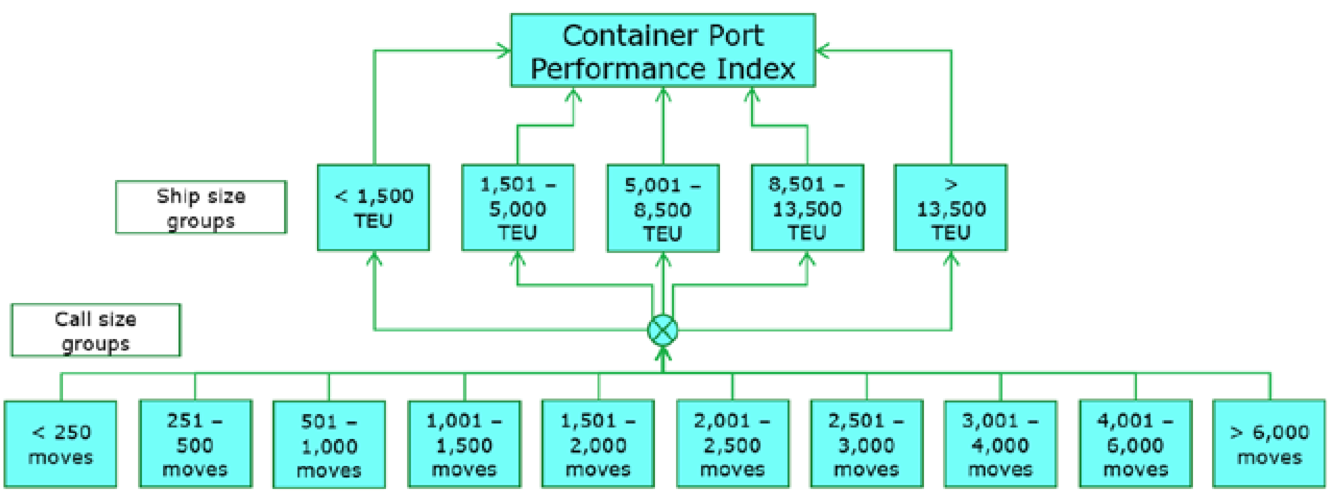
Source: Original calculations for this publication, based on CPPI 2020 data.

3.4. The Construction of the CPPI

59. ***For a port to qualify for inclusion in the CPPI it must have registered at least ten valid port calls where port hours can be calculated within each six-month period.*** Out of the 502 ports where IHS Markit receives port call information, a total of 351 ports (765 terminals and 2,877 individual vessels) are included in the CPPI 2020. Over this time period, 67,798 distinct port calls were recorded in the data, representing more than 50% percent of the world's total container ship port calls. Future iterations of the CPPI will look to include data for additional, often smaller, ports that have significant issues with AIS coverage.

60. ***The CPPI is based on the overarching metric of port hours per ship call.*** However, to account for significant differences in ship calls determined by: (i) greater or lesser workloads; and (ii) smaller or larger capacity ships, calls are analyzed in ten narrow call size groups and five ship size groups that generally reflect the types of ships deployed on specific trades and services (figure 3.3).

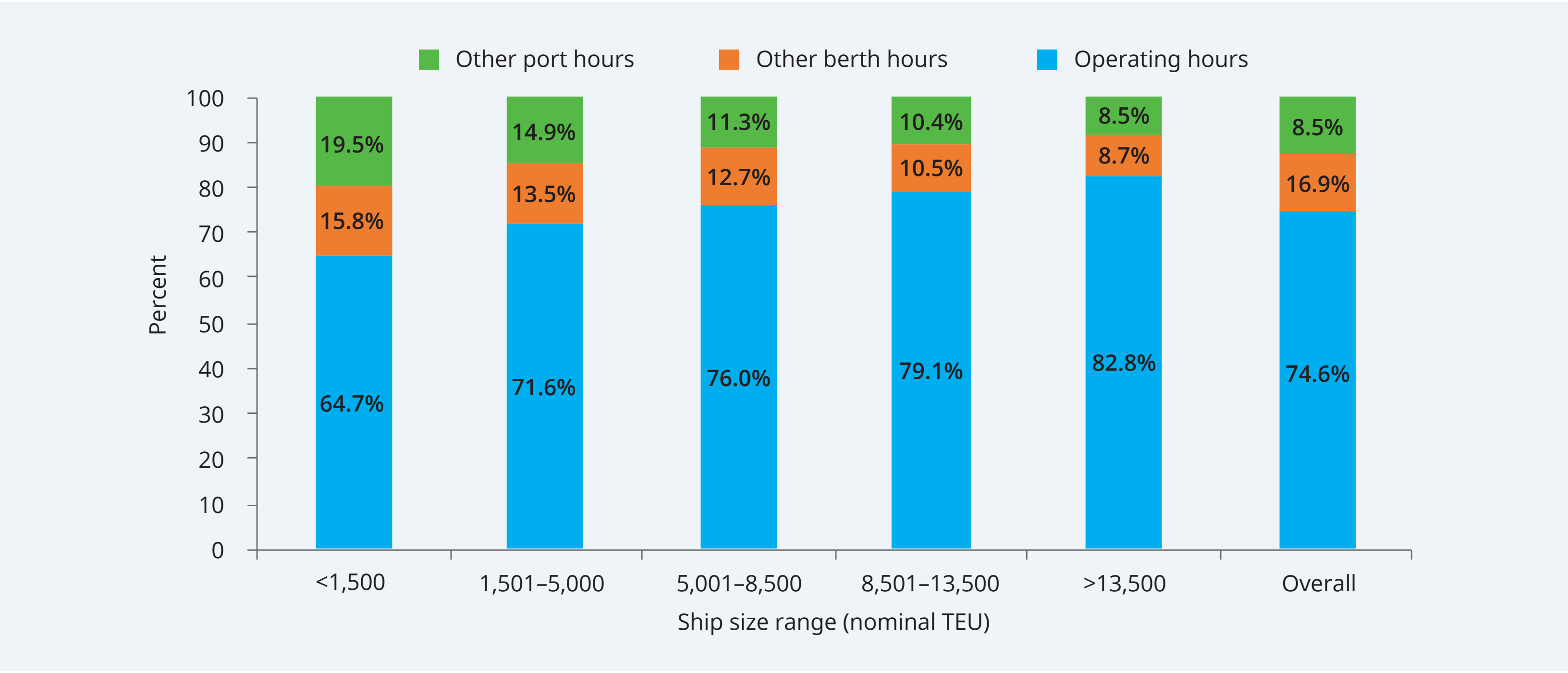
Figure 3.3. The Structure of the CPPI



Source: Original calculations for this publication, based on CPPI 2020 data.
Note: TEU = twenty-foot equivalent unit

61. ***An average of approximately 75 percent of total port time is consumed by container handling operations.*** As figure 3.4 shows, the ratio of time spent on handling operations increases as ship size increases, and is driven by larger call sizes. Call size does not affect the amount of time spent on arrival, or start and finish processes. Rather, these processes are influenced by ship size. Mooring operations and lashing completion generally take longer on larger ships, although this delay is somewhat offset by larger ships potentially enjoying a slightly higher priority and assignment of resources.

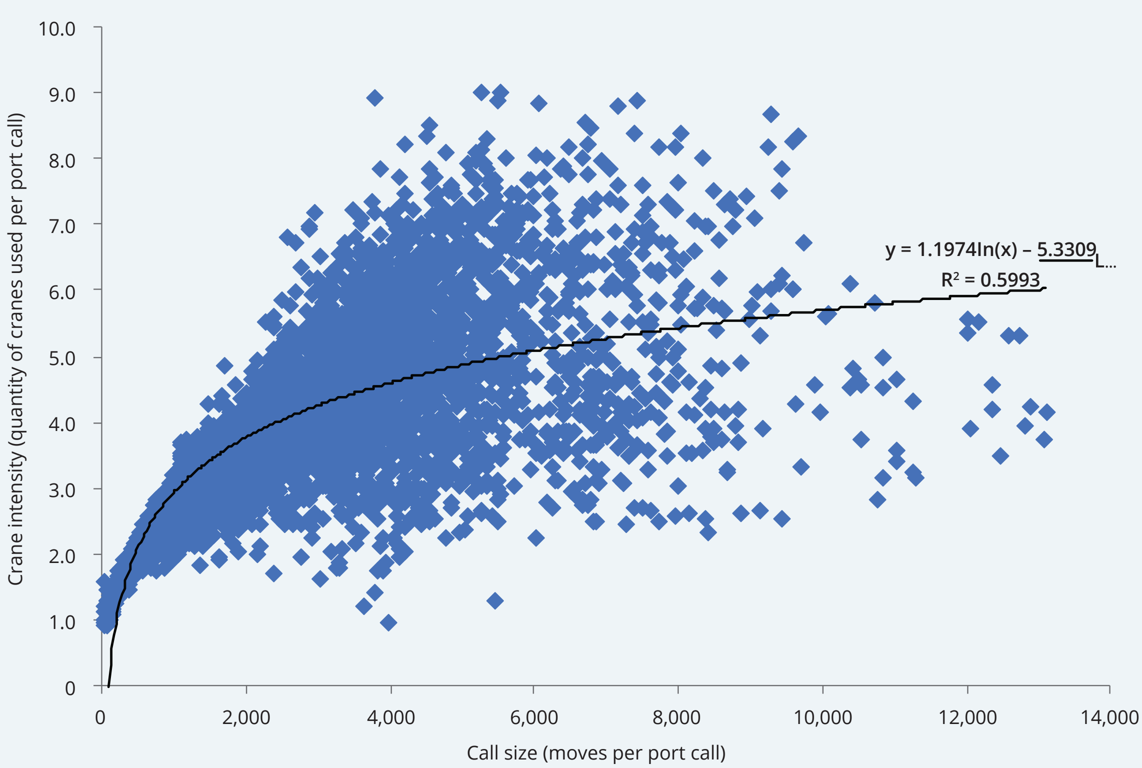
Figure 3.4. In-Port Time per Port Stay Step or Process[3]



Source: Original calculations for this publication, based on CPPI 2020 data.
Note: TEU = twenty-foot equivalent unit

62. ***A correlation of close to 60 percent is observed between call size and crane intensity using a logarithmic trend line.*** As figure 3.5 illustrates, crane intensity 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 crane intensity of around nine cranes per ship, it is interesting to note that for calls exceeding 11,000 moves, crane intensity is always below 6.0. This consistent result reflects a global representation; 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 lie factors relating to how close together adjacent cranes can operate. Additional constraints from the stowage plan can also have an impact if an excessively intense area of work is concentrated in one part of the ship.

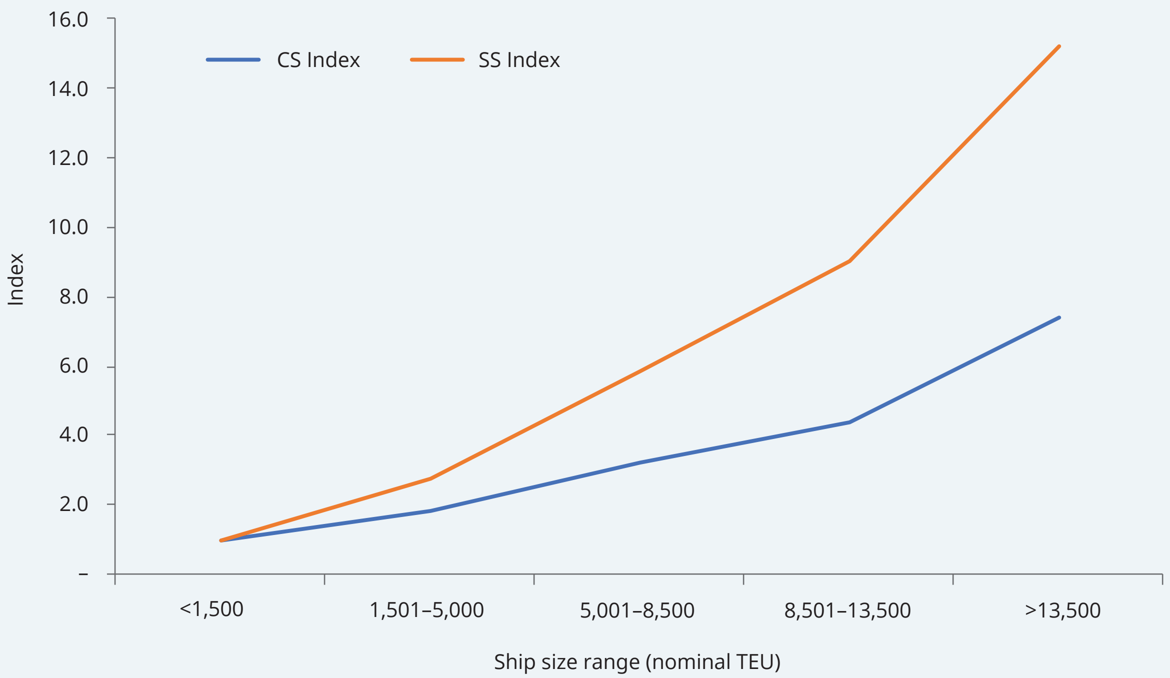
Figure 3.5. Regression Analysis: Crane Intensity[4] versus Call Size



Source: Original calculations for this publication, based on CPPI 2020 data.

63. ***Average call size increases as ship size increases, but not proportionately with ship size (see figure 3.6).*** 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 TEU 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 (i) a port can physically handle vessels of an increased size; and (ii) availability of sufficient containers to be loaded and unloaded to justify a stop by a larger-scale vessel.

Figure 3.6. Relationship between Global Ship Size Index and Call Size Index

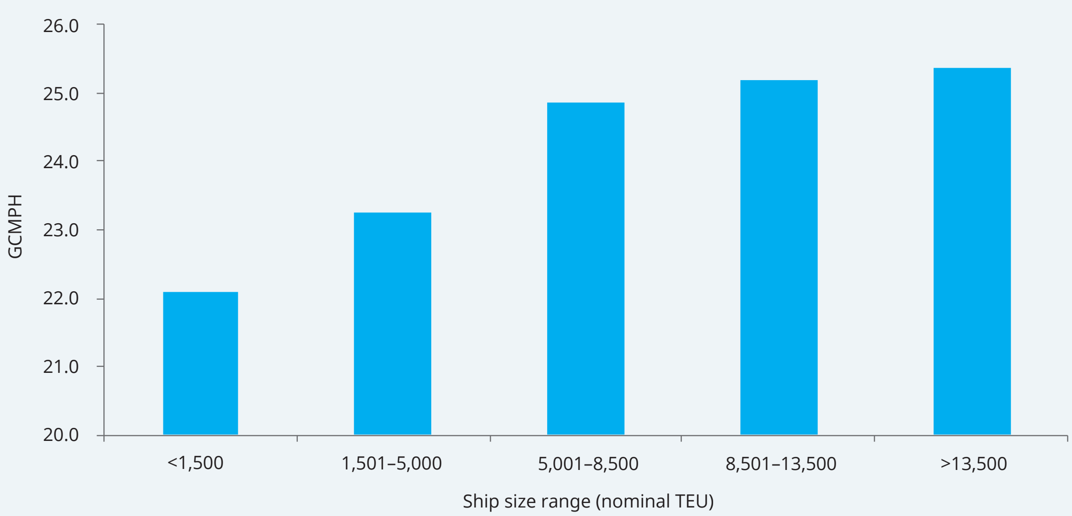


Source: Original calculations for this publication, based on CPPI 2020 data.

64. ***The gross crane productivity (or GCMPH) by ship size group displayed in figure 3.7 represents a global average across all ports.*** The average gross crane productivity performance for ship size groups demonstrates a limited variation in ships with capacities of 5,001 to 8,500 TEU and larger. Average gross crane productivity is lower for the two smaller ship size groups, albeit by a maximum of around 14 percent between the groups comprising ships under 1,500 TEU and above 13,500 TEU. 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.

65. ***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 call size performance observed in ships with capacities of 5,000 TEU and under. Analysis of crane intensity and crane productivity shows that crane intensity has a major impact on operating time, and by extension 75 percent of total port time. The evidence shows, therefore, that in order for the CPPI to be realistic, both ship and call size segments should be reflected in the index construction.

Figure 3.7. Gross Crane Productivity or Gross Crane Moves per Hour (GCMPH)

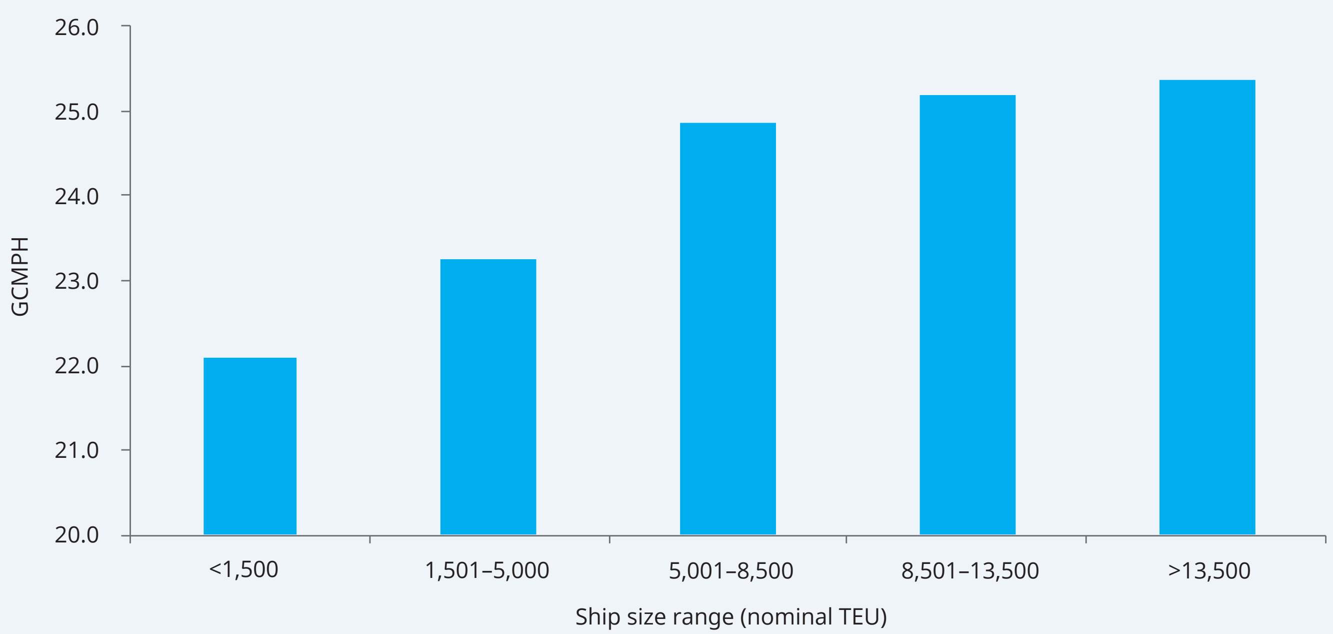


Source: Original calculations for this publication, based on CPPI 2020 data.

66. ***When comparing port performance and efficiency, taking note of and accounting for the extent of this impact is essential.*** This can be done in two ways: by applying a weighting by call size, or by examining performance within call size groups narrow enough to effectively neutralize the influence of call size and crane intensity. After extensively testing both methods, findings indicate the former can generate some volatile results when applied across a broad range of ports and ship sizes, and therefore the index development team chose the latter as being the more reliable for the CPPI methodology.

67. ***A progressive increase trend in crane intensity emerges as the data move through the call size groups.*** As shown in figure 3.8, this trend peaks and flattens once CPPI data pass the 6,000 moves per call range, leading to the presumption that crane intensity does not have a major influence when call size exceeds 6,000 moves per call.

Figure 3.8. Average Crane Intensity per Defined Call Size Range



Source: Original calculations for this publication, based on CPPI 2020 data.

68. ***In order to assess the sensitivity within each call size group across all 351 qualifying ports, the CPPI considers the median call size between all ports within a call size group, with a tolerance range of 10 percent above and below the median created (see table 3.3).*** In the five call size groups, from 1,001–1,500 to 3,001–4.000 inclusive, most ports have an average call size well within this tolerance range. When one goes beyond the threshold of 4,000 moves per call, call size has much less of an impact on crane intensity, since the number of deployable cranes is limited by the overall number of available or deployed cranes and 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 five call size groups from 1,001–1,500 to 3,001–4,000. However, for those ports with an average call size above the tolerance range, it would be possible to increase crane intensity to match the higher call sizes, and therefore the CPPI results indicate these ports are not being penalized unfairly.

Table 3.3. Call Size Sensitivity

Call size sensitivity	Call Size group (number of moves)									
	<250	251–500	501–1,000	1,001–1,500	1,501–2,000	2,001–2,500	2,501–3,000	3,001–4,000	4,001–6,000	>6,000
Average	180	378	730	1,231	1,730	2,232	2,734	3,435	4,721	7,712
Median	189	379	728	1,216	1,714	2,226	2,728	3,405	4,668	7,174
Range low	171	341	655	1,095	1,543	2,003	2,455	3,064	4,201	6,457
Range high	208	417	801	1,338	1,886	2,448	3,000	3,745	5,135	7,892
Total ports	270	324	318	260	218	173	135	116	81	41
Within range	141	230	226	239	212	173	135	111	64	25
Percentage in range	52.2%	71.0%	71.1%	91.9%	97.2%	100.0%	100.0%	95.7%	79.0%	61.0%

Source: Original calculations for this publication, based on CPPI 2020 data.

69. ***A practical consideration to keep in mind when looking at the data is the need to keep to a workable number of call size groups***. A workable number of call size groups ensures the data are not overly diluted; therefore, the CPPI does not include additional call size groups for below 1,000 moves per call. After examining multiple options, the CPPI team found an efficiency comparison based on these ten defined call size groups to be both objective and relevant, while also neutralizing the influence of call size and crane intensity.

70. ***In addition, the application of ship size groups is less important than call size groups, particularly once the call data is already split into ten call size groups.*** However, one objective of the CPPI is to highlight—through comparison—the performance gaps, which in turn reveal opportunities to save fuel and reduce emissions. The analysis should therefore account for the fact that larger ships consume more fuel, and thus present a greater potential opportunity to save fuel and reduce emissions.

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71. ***For this reason, the CPPI methodology includes five different ship size groups.*** Five is considered the optimum number of ship size groups to account for larger ships using more fuel without overly diluting the data (see table 3.4). Each group is defined by 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 gross registered tonnage or length overall.

72. ***Some 43 percent of all calls in the database were made by ships with capacity of between 1,500 and 5,000 TEU.*** The other two midrange ship size bands are also well represented. As expected, the CPPI shows a lower concentration of calls in the smallest and largest ship size bands. Nevertheless, the database holds a sufficiently high quantity of data to produce representative benchmarking in the smallest and largest ship size bands.

Table 3.4. Ship Size Groups

Nominal TEU capacity range	Description
Less than 1,500 TEU	Comprising the smallest sizes of ships, this group is almost exclusively feeder ves-sels, which often connect small outlying ports with regional hub ports. Some in-traregional services will also have ships in this size range.
1,500 to 5,000 TEU	A vast quantity of these classic Panamax ships is deployed on intraregional trades. They are found on Intra-Asian trades and north–south trades to and from Africa, Latin America, and Oceania, as well as on transatlantic services.
5,000 to 8,500 TEU	Vessels within this size group are mainly deployed on the north–south trade-lanes. Vessel cascading and improv-ing port capabilities has allowed them to start emerging as stock vessels for Africa and Latin America trades as well as Oceania, with some presence on transatlantic and Asia–Middle East trades as well.
8,500 to 13,500 TEU	These Neo-Panamax vessels are largely deployed on east–west trades, particu-larly 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 fea-ture on Asia–Middle East trades, with some deployed on Asia–Mediterranean rotations.
Greater than 13,500 TEU	These ultra-large container ships (ULCS) are mainly deployed on Asia–Europe (serving both northern Europe and the Mediterranean) and the Asia–USA trades, especially on transpacific services calling at North America's west coast ports.

Source: World Bank analysis.
Note: TEU = twenty-foot equivalent unit.

73. ***Of the potential 50 (5 × 10) ship and call size categories, seven of the categories have insufficient data for meaningful analysis (as indicated by the gray cells in table 3.5); therefore, these categories have been omitted from the CPPI.*** Some of the other call size bands within ship size ranges contain limited data; however, the data are considered sufficient for inclusion and analysis. Data for each ship size group are extracted from the full dataset, 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 elapsed time from all lines fast to all lines released. With 43 potential ship and call size combinations per qualifying port, many combinations will naturally occur where no actual data exists.

Table 3.5. Call Size and Ship Size Combinations: Percentage of Calls

Ship size group (TEU)	Call Size group (number of moves)									
	<250	251–500	501–1,000	1,001–1,500	1,501–2,000	2,001–2,500	2,501–3,000	3,001–4,000	4,001–6,000	>6,000
1) <1,500	27.0%	39.6%	28.5%	4.9%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
2) 1,501–5,000	9.8%	24.8%	36.1%	17.1%	7.7%	2.7%	1.0%	0.7%	0.2%	0.0%
3) 5,001–8,500	2.6%	9.7%	27.4%	23.2%	15.6%	9.5%	5.2%	4.5%	1.9%	0.3%
4) 8,501–13,500	1.3%	6.7%	19.1%	18.2%	16.3%	11.9%	9.0%	10.0%	5.2%	2.1%
5) >13,500	0.2%	1.3%	5.5%	7.9%	10.5%	11.6%	11.2%	22.1%	22.4%	7.5%

Source: Original calculations for this publication, based on CPPI 2020 data.

74. ***In preparing the CPPI and its subsequent rankings, the objective has been to reflect as closely as possible actual port performance, while also remaining statistically robust.*** With respect to the largest ports—the top 100 ports by annual move count—the CPPI has been able to work with ample, real empirical data present in each of the 43 distinct ship size and call size categories. However, for smaller ports many categories have been populated with little to no data, particularly those with only a few hundred calls in total. If these unpopulated categories are ignored, the performance appraisal 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

75. ***The CPPI addresses this undeserved handicap with two different approaches: An administrative approach and a statistical approach.*** In the case of the former, the approach involved assigning values to empty categories based upon data available when a port has registered a data point within a specific ship size range.

Table 3.6. Quantity of Ports Included per Ship Size Group

Ship size range (nominal TEU)	Number of ports included	Base call size (number of moves)
Less than 1,500	219	251–500
1,500–5,000	331	501–1000
5,000–8,500	213	1001–1500
8,500–13,500	162	1501–2000
More than 13,500	99	2001–2500

Source: Original calculations for this publication, based on CPPI 2020 data.

76. ***For each ship size group, the call size group that has the largest quantity of data representation is selected (see table 3.6).*** Ideally, this is a midrange call size group because the lowest and highest demonstrate some uniqueness. In cases where no actual data are available for the base call size group, the next highest group is examined to find an actual dataset. 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.

77. ***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-rate 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 hours for each arrival and berth hours than the average, it is most probable that would be the case in the adjacent call size group. The arrival and berth hours are imputed individually of each other.

78. ***Table 3.7 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. The index assumes that would also have been the case had the port registered actual calls in the 501 to 1,000 and 1,501 to 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.

Table 3.7. An Example of Imputing Missing Values[5]

Port	Call size group (hours)		
	501–1,000 moves	1,001–1,500 moves	1,501–2,000 moves
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 calculations for this publication, based on CPPI 2020 data.

79. ***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 a port's ability to add cranes to larger call size groups, which might not be true in all cases. On the other hand, it would be illogical to blindly assume 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

80. ***A slightly more sophisticated approach is using a likelihood-based method to impute those missing values.*** In respect of the current dataset, 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 assumption is that the missing values are random, that is, not due to some bias in the sample selection; and the second assumption is that all variables under consideration are normally distributed. Within the context of the dataset, these are considered realistic assumptions. 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. The "sampling" is repeated a number of times to remove the risk of outliers, and negative numbers are set to zero (as berth time can never be negative).[6]

Constructing the index: The administrative approach

81. ***Aggregating arrival and berth hours into total port hours.*** Previously, the report indicated a case could be made for penalizing waiting time, which can be regarded as pure waste. However, as expressed earlier this would be a normative judgment. Accordingly, in the CPPI 2020, both arrival and berth hours are weighted as 1.0 and the two time segments are summed to form total port hours.

82. ***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. Thus, 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. Because larger call size group have far fewer calls than smaller call size groups, this also needs to be reflected in the construction of the CPPI to retain maximum objectivity.

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.

83. ***The method applied to each call size group individually is that the port's average port hours is compared with the group average as a percentage or rather a ratio.*** The result of that comparison is weighted by the ratio of port calls in each call size group **(within each ship size group)** for the entire group of ports (table 3.3, earlier in the chapter, provided the ratios).[7] Table 3.8 illustrates how the method is applied to one ship size group (5,001 to 8,500 TEU) and one base call size group (1,001 to 1,500 moves).

Table 3.8. Port Hours Performance Appraisal

Port	Port hours	Score	Call size group weight	Result
Example port	19.72	1.152	0.232	0.2672
Group average	22.71			

Source: Original calculations for this publication, based on CPPI 2020 data.

84. ***In this illustrative example, the subject port used 15.2 percent fewer hours than the average of the entire group (19.72 hours versus 22.71 percent).*** The result is a (ratio) score of 1.152. Since 23.2 percent of all port calls in the 5,001–8,500 TEU ship size group were in the call size group of 1,001–1,500 moves, the 1.152 score is multiplied by ratio 0.232 for an overall result of 0.2672 "points." Within our tables, we have then multiplied this by 100 to achieve an easier to read number (26.72). The better the performance versus the average of the group, the higher (or lower – negative) the overall result will be.

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

86. ***However, the imputation method might unfairly appraise some ports that recorded data only 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 requires 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 ports with a greater diversity of call sizes are likely to achieve.

Aggregating all ship size groups

87. ***No allowance was made for ports that did not handle ships within specific ship size groups during the period under consideration.*** Earlier in the chapter, table 3.6 presented the quantity of ports being included per ship size group. Allowance was not given primarily because 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 attempting to compare the performance of major mainline ports with those of far smaller ports; however, this comparison is neither objective nor valuable.

88. ***This factor does not contribute significantly to the comparison between similarly sized ports.*** In aggregating the scores from the various ship size groups into the overall CPPI in the administrative approach, a factor was built, in the form of an index (see table 3.9), to differentiate the importance and significance of better performance on larger ships over smaller ones, based on the relative fuel consumption between different ship sizes. For each ship size group, a typical mid-range example ship was selected. Based upon the expected deployment of such ships, the index defines and weights a range of sea legs, using a typical pro forma service speed, and considering the impact on fuel consumption that one hour longer (or shorter) in port would be likely to yield.

Table 3.9. Assumptions to Determine a Fuel Consumption Index

Nominal TEU capacity range	Expected deployment	Sea leg	Weight (percent)	Index value
Less than 1,500 TEU	Feeders Intraregional	Singapore–Surabaya Rotterdam–Dublin Kingston–Port-Au-Prince Busan–Qingdao	25 25 25 25	0.46
1,500 to 5,000 TEU	Intraregional Africa Latin America Oceania Transatlantic	Shanghai–Manila Rotterdam–Genoa Algeciras–Tema Charleston–Santos Xiamen–Brisbane Felixstowe–New York	30 30 10 10 10 10	1.00
5,000 to 8,500 TEU	Africa Latin America Oceania Transatlantic Asia–Middle East	Hong Kong port–Tema Charleston–Santos Xiamen–Brisbane Felixstowe–New York Shanghai–Dubai	20 20 20 20 20	1.54
8,500 to 13,500 TEU	Transpacific Asia–Middle East Asia–Mediterranean	Busan–Charleston (via Panama) Hong Kong port–Los Angeles Shanghai–Dubai Singapore–Piraeus	25 25 25 25	1.97
Greater than 13,500 TEU	Asia–Mediterranean Asia–North Europe Transpacific	Singapore–Piraeus Singapore–Rotterdam Hong Kong port–Los Angeles	40 40 20	2.57

Source: Original calculations for this publication, based on CPPI 2020 data.

89. ***The CPPI focuses primarily on micro-delays and assumes these would be recovered on long-haul ocean legs, rather than 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 values are adjusted so that larger ship size groups have lower indices than smaller ones, the overall ranking results can change radically. 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 4 as well as appendix A (table A.2).

Constructing the CPPI: The statistical approach

90. ***An alternative approach to constructing an index of container port performance is to use a statistical technique such as factor analysis.*** The advantage of factor analysis (FA) is its ability to examine a large dataset 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, the impact is seen through relationships 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 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.

91. ***At the level of the individual port, the measured variables include the average time expended for the different stages, under various categories, such as different call size bands and 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 lies in the inability to 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: Imagine three ports, each with four different types of time cost, as shown in table 3.10.

Table 3.10. 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 calculations for this publication, based on CPPI 2020 data.

92. ***As observed in table 3.10, costs 2, 3, and 4 are simply multiples of cost 1.*** Although each port has four variables, one variable alone is enough to rank the efficiency of these three ports (A > B > C). Of course, this example represents an extreme case, but the idea can be generalized if these variables are correlated to a less extreme extent. In that case, the factors are computed as a linear combination of costs 1 through 4. However, if costs 1 through 4 are completely independent of each other, this method makes no sense. Fortunately, this is not the case for the CPPI dataset. Thus, for each port, we can compute its score on all factors and then combine those scores together to reach a final efficiency score.

93. ***Note that in the statistical approach using FA, the scores are not calculated for each call size range.*** On the contrary, the whole dataset, including the smaller ports, is used simultaneously to obtain latent factors. This sharply contrasts with the administrative approach. The statistical approach factors in all the correlations among hours for various call size bands which is—purely from a statistical perspective—more efficient. However, one downside of this approach is that FA does not consider 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.

94. ***Neither methodology is better than the other; rather, the two different approaches complement each other.*** This complementarity encouraged the CPPI team, while deciding on the direction to take in the inaugural edition of the index, to use both approaches—a decision that would help ensure the resulting rankings of container port performance reflect as closely as possible actual port performance, while also being statistically robust. Chapter 4 presents the CPPI 2020 from both approaches, explaining divergences, where possible.

NOTES

1. A "hub port" is defined as a port called at by deep-sea mainline container ships and serves as a transhipment point for smaller outlying, or feeder, ports within its geographical region. Typically, at least 35 percent of its total throughput would be hub and spoke transhipment container activity. In larger hub ports anywhere from 60 to 80 percent of throughput will be transhipment.
2. The list of ports omitted from the CPPI 2020 due to insufficient calls is provided in table A.4 at the end of appendix A.
3. Definitions employed in figure 3.4:
    - 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.
    - Operating hours = The time required for container operations between the first and last container lifts.
4. Crane intensity is calculated by total accumulated gross crane hours divided by operating hours.
5. 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.
6. The precise approach to producing a robust dataset is detailed in appendix B.
7. The actual equation is: (Group Average Port Hours / Example Port Hours) × Call Size Group Weight.

4. The Container Port Performance Index 2020

4.1. Introduction

95. ***The CPPI 2020 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 rankings reflect as closely as possible actual port performance, while also being statistically robust. This first inaugural edition utilizes data through June 30, 2020, and while the ranking reflects the performance over the previous twelve months, a qualifier is raised to reflect the impact of the COVID-19 pandemic on port performance in the first six months of the year. The next edition of the CPPI (CPPI 2021) will offer some comparative analysis of the year-on-year changes in the ranking.

96. ***This chapter discusses the resulting rankings of container port performance, based on the two different approaches.*** Section 4.2 discusses the two approaches, along with the rankings for the best performing container ports. Appendix A includes the full ranking of all ports by each approach separately and presented alphabetically. Table A.1 shares the CPPI 2020 data based on the administrative approach, while table A.2 presents the data based on the statistical approach. To conclude the report, section 4.3 presents some areas of further work and planned developments for future iterations of the CPPI. Understanding and eliminating divergences between the two methodologies will be part of that agenda.

4.2. The CPPI 2020

97. ***Table 4.1 presents the rankings of container port performance in the CPPI 2020, which resulted from using both the statistical and administrative approaches.*** The ranking and score in the left-hand columns includes results from the statistical approach; the ranking and score in the right-hand columns shows results from the administrative approach. The index points used to construct the ranking in the administrative approach reflect the approach as outlined in the previous chapter, which is an aggregate of the performance of the port, weighted relative to the average, across call and vessel size (see table A.1 for the detailed ranking 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 they do not have an offsetting positive score or scores in other cells.

98. ***The use of factor analysis (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.*** 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 total scores are standardized, with a “negative” score indicating a better than average performance (table A.2 presents the complete rankings generated from the statistical approach). Overall,

a broad consistency emerges between the rankings that result from the two approaches, with some exceptions. Just under 18 percent of all ports (61 ports) are ranked within three places or less from themselves in the dual rankings provided in table 4.1. Approximately 40 percent (137 ports) are ranked with ten places or less of themselves in the respective ranking, while 80 percent (282 ports) fall within 10 percent of their respective rankings in the two indices.

99. ***The two top ranked container ports in the CPPI 2020 are Yokohama por (Japan) in first place, followed by King Abdullah Port (Saudi Arabia) in second place.*** These two ports occupy the same positions in the rankings generated by both approaches. East Asia ports dominate the top 50 ranked ports, with several ports in the Middle East and North Africa region, such as King Abdullah port in Saudi Arabia, Salalah in Oman (ranked 6th and 9th in the statistical (or FA) and administrative approaches respectively), Khalifa port in Abu Dhabi (ranked 26th and 22nd respectively), and Tanger Med (ranked at 27th and 15th respectively) as the notable exceptions. Algeciras is the highest ranked port in Europe (ranked 10th and 32nd respectively), followed by Aarhus (ranked 44th and 43rd respectively). Colombo is the top-ranked port in South Asia (ranked 17th and 33rd respectively). Lazaro Cardenas the highest ranked port in Latin America (ranked 25th and 23rd respectively), with Halifax being the highest ranked port in North America (ranked 39th and 25th respectively). No ports in Sub-Saharan Africa appear in the global top 50 container ports; Djibouti port ranks the highest (61st and 93rd respectively).

Table 4.1. The CPPI 2020: Global Ranking of Container Ports

Statistical approach			Administrative approach		
Port name	**Rank**	**Total score**	**Port name**	**Rank**	**Index points**
YOKOHAMA	1	−5.995	YOKOHAMA	1	130
KING ABDULLAH PORT	2	−5.684	KING ABDULLAH PORT	2	114
CHIWAN	3	−5.202	QINGDAO	3	102
GUANGZHOU	4	−5.162	KAOHSIUNG	4	99
KAOHSIUNG	5	−4.669	SHEKOU	5	94
SALALAH	6	−4.531	GUANGZHOU	6	92

Statistical approach			Administrative approach		
Port name	Rank	Total score	Port name	Rank	Index points
HONG KONG, HONG KONG SAR, CHINA	7	−4.276	HONG KONG, HONG KONG SAR, CHINA	7	89
QINGDAO	8	−3.860	ZHOUSHAN	8	88
SHEKOU	9	−3.726	SALALAH	9	87
ALGECIRAS	10	−3.597	YANGSHAN	10	87
BEIRUT	11	−3.378	TANJUNG PELEPAS	11	86
SHIMIZU	12	−3.361	SINGAPORE	12	83
TANJUNG PELEPAS	13	−3.342	NINGBO	13	83
PORT KLANG	14	−3.334	PORT KLANG	14	78
SINGAPORE	15	−3.279	TANGER MEDITERRANEAN	15	76
NAGOYA	16	−3.251	TAIPEI, TAIWAN, CHINA	16	75
COLOMBO	17	−3.209	YANTIAN	17	73
SINES	18	−3.183	CAI MEP	18	68
KOBE	19	−3.127	DALIAN	19	66
ZHOUSHAN	20	−2.963	TIANJIN	20	64
JUBAIL	21	−2.898	FUZHOU	21	61
YEOSU	22	−2.831	KHALIFA PORT	22	60
FUZHOU	23	−2.829	LAZARO CARDENAS	23	60
NINGBO	24	−2.805	SHIMIZU	24	59
LAZARO CARDENAS	25	−2.798	HALIFAX	25	59
KHALIFA PORT	26	−2.795	XIAMEN	26	58
TANGER MEDITERRANEAN	27	−2.769	CHIWAN	27	58
YANGSHAN	28	−2.733	SINES	28	56
YANTIAN	29	−2.724	MAWAN	29	56
TAIPEI, TAIWAN, CHINA	30	−2.681	AGUADULCE (COLOMBIA)	30	56
DA CHAN BAY TERMINAL ONE	31	−2.588	LIANYUNGANG	31	54
MAWAN	32	−2.557	ALGECIRAS	32	53
DALIAN	33	−2.506	COLOMBO	33	53
INCHEON	34	−2.422	CARTAGENA (COLOMBIA)	34	52
TOKYO	35	−2.418	DA CHAN BAY TERMINAL ONE	35	52
HAMAD PORT	36	−2.411	BUSAN	36	51

Statistical approach			Administrative approach		
Port name	Rank	Total score	Port name	Rank	Index points
LIANYUNGANG	37	−2.375	INCHEON	37	51
PIPAVAV	38	−2.371	HAMAD PORT	38	51
HALIFAX	39	−2.365	PIPAVAV	39	48
CAUCEDO	40	−2.355	YEOSU	40	48
BREMERHAVEN	41	−2.265	AQABA	41	47
CARTAGENA (COLOMBIA)	42	−2.185	JEDDAH	42	46
SALVADOR	43	−2.051	AARHUS	43	43
AARHUS	44	−2.036	MUNDRA	44	43
AGUADULCE (COLOMBIA)	45	−2.035	MAGDALLA	45	42
CAI LAN	46	−1.991	BARCELONA	46	42
HAIPHONG	47	−1.953	RIO GRANDE (BRAZIL)	47	42
MAGDALLA	48	−1.943	NAGOYA	48	41
CAI MEP	49	−1.932	SHANGHAI	49	41
MUNDRA	50	−1.902	KOBE	50	39
GEMLIK	51	−1.892	LAEM CHABANG	51	39
BUSAN	52	−1.887	WILHELMSHAVEN	52	39
JEDDAH	53	−1.862	CHARLESTON	53	38
DILISKELESI	54	−1.842	TOKYO	54	38
LAEM CHABANG	55	−1.807	SALVADOR	55	35
JAWAHARLAL NEHRU PORT	56	−1.786	CALLAO	56	34
AMBARLI	57	−1.783	JUBAIL	57	33
PORT SAID	58	−1.652	YARIMCA	58	33
PECEM	59	−1.647	JEBEL ALI	59	33
AQABA	60	−1.594	HAIPHONG	60	33
DJIBOUTI	61	−1.590	AMBARLI	61	32
XIAMEN	62	−1.541	BEIRUT	62	32
SHANGHAI	63	−1.532	JAWAHARLAL NEHRU PORT	63	31
TANJUNG PRIOK	64	−1.521	KEELUNG	64	31
KEELUNG	65	−1.509	ANTWERP	65	31
TRIPOLI (LEBANON)	66	−1.497	TANJUNG PRIOK	66	31

Statistical approach			Administrative approach		
Port name	Rank	Total score	Port name	Rank	Index points
OSAKA	67	−1.440	WILMINGTON (NORTH CAROLINA, USA)	67	30
YARIMCA	68	−1.393	CAUCEDO	68	30
ITAPOA	69	−1.376	SOHAR	69	29
SANTOS	70	−1.376	PORT SAID	70	29
SOHAR	71	−1.375	BUENAVENTURA	71	29
BUENAVENTURA	72	−1.353	SANTOS	72	28
SEPETIBA	73	−1.338	BOSTON (USA)	73	27
RIO GRANDE (BRAZIL)	74	−1.332	CAI LAN	74	27
KARACHI	75	−1.292	DILISKELESI	75	27
BARCELONA	76	−1.224	TRIPOLI (LEBANON)	76	27
POSORJA	77	−1.192	OSAKA	77	27
OSLO	78	−1.192	BALBOA	78	27
QUY NHON	79	−1.163	GEMLIK	79	26
CAT LAI	80	−1.149	KARACHI	80	26
SUAPE	81	−1.129	YOKKAICHI	81	26
LONDON	82	−1.117	COLON	82	25
PHILADELPHIA	83	−1.080	MERSIN	83	25
DANANG	84	−1.053	SEPETIBA	84	24
PORT OF VIRGINIA	85	−1.044	BREMERHAVEN	85	24
ANTWERP	86	−1.011	PECEM	86	23
ZEEBRUGGE	87	−0.988	PHILADELPHIA	87	23
SANTA CRUZ DE TENERIFE	88	−0.970	ITAPOA	88	23
NEW YORK & NEW JERSEY	89	−0.969	PIRAEUS	89	23
GDYNIA	90	−0.942	ROTTERDAM	90	22
SHANTOU	91	−0.935	OSLO	91	20
NAHA	92	−0.883	DAMMAM	92	20
PIRAEUS	93	−0.859	DJIBOUTI	93	19
PUERTO LIMON	94	−0.858	PAITA	94	19
CHARLESTON	95	−0.820	SANTA CRUZ DE TENERIFE	95	19
PORT AKDENIZ	96	−0.820	SAVANNAH	96	18

Statistical approach			Administrative approach		
Port name	Rank	Total score	Port name	Rank	Index points
TAICHUNG	97	−0.814	VERACRUZ	97	18
ULSAN	98	−0.811	ALTAMIRA	98	17
HAKATA	99	−0.758	JACKSONVILLE	99	17
COLON	100	−0.752	TAURANGA	100	17
MOBILE	101	−0.745	MARSAXLOKK	101	16
DAMMAM	102	−0.737	VALPARAISO	102	16
PUERTO BARRIOS	103	−0.731	GDYNIA	103	16
NOUMEA	104	−0.721	QUY NHON	104	16
PAITA	105	−0.705	ITAJAI	105	16
MARSAXLOKK	106	−0.698	PUERTO LIMON	106	16
YOKKAICHI	107	−0.692	PARANAGUA	107	16
MALAGA	108	−0.690	JOHOR	108	15
OMAEZAKI	109	−0.680	CAT LAI	109	15
JOHOR	110	−0.669	PORT OF VIRGINIA	110	15
MOJI	111	−0.663	NAHA	111	15
BATANGAS	112	−0.663	FORT−DE−FRANCE	112	15
BOSTON (USA)	113	−0.631	POINTE−A−PITRE	113	14
BALBOA	114	−0.625	MIAMI	114	14
SIAM SEAPORT	115	−0.613	DANANG	115	13
ROTTERDAM	116	−0.611	HAKATA	116	12
BURGAS	117	−0.611	SHANTOU	117	12
DUNKIRK	118	−0.611	AUCKLAND	118	12
WILHELMSHAVEN	119	−0.598	BALTIMORE (USA)	119	12
SANTA MARTA	120	−0.589	DAKAR	120	12
TARRAGONA	121	−0.588	OMAEZAKI	121	11
CAGAYAN DE ORO	122	−0.582	PUERTO BARRIOS	122	11
AUCKLAND	123	−0.562	MOJI	123	11
NORRKOPING	124	−0.553	NOUMEA	124	11
FORT−DE−FRANCE	125	−0.543	ENSENADA	125	11
GUSTAVIA	126	−0.528	POSORJA	126	10

Statistical approach			Administrative approach		
Port name	Rank	Total score	Port name	Rank	Index points
QINZHOU	127	−0.523	NEW YORK & NEW JERSEY	127	10
FREDERICIA	128	−0.493	CAGAYAN DE ORO	128	10
COPENHAGEN	129	−0.471	MALAGA	129	10
TUTICORIN	130	−0.469	SUAPE	130	10
PUERTO CORTES	131	−0.468	GDANSK	131	10
PORT BRONKA	132	−0.454	MOBILE	132	10
TANJUNG EMAS	133	−0.433	BURGAS	133	9
CHIBA	134	−0.418	TARRAGONA	134	9
SHIBUSHI	135	−0.382	NORRKOPING	135	9
ENSENADA	136	−0.378	SIAM SEAPORT	136	9
SAIGON	137	−0.375	SANTA MARTA	137	9
BALTIMORE (USA)	138	−0.368	FREDERICIA	138	9
PENANG	139	−0.367	TUTICORIN	139	8
KHALIFA BIN SALMAN	140	−0.356	CEBU	140	8
PUERTO BOLIVAR (ECUADOR)	141	−0.347	WELLINGTON	141	8
GIOIA TAURO	142	−0.344	COPENHAGEN	142	8
DAVAO	143	−0.341	TANJUNG EMAS	143	8
CASTELLON	144	−0.339	BATANGAS	144	8
ALTAMIRA	145	−0.324	MANZANILLO (MEXICO)	145	8
RIO HAINA	146	−0.322	TAICHUNG	146	8
POINTE-A-PITRE	147	−0.319	PORT EVERGLADES	147	8
SAN JUAN	148	−0.303	QINZHOU	148	8
SHUAIBA	149	−0.301	PUERTO CORTES	149	7
NAPLES	150	−0.280	CHIBA	150	7
CEBU	151	−0.275	SAIGON	151	7
FREEPORT (BAHAMAS)	152	−0.271	PORT BRONKA	152	7
TANJUNG PERAK	153	−0.269	HAIFA	153	6
PUERTO QUETZAL	154	−0.269	PORT AKDENIZ	154	6
WILMINGTON (NORTH CAROLINA, USA)	155	−0.237	PUERTO BOLIVAR (ECUADOR)	155	6

Statistical approach			Administrative approach		
Port name	Rank	Total score	Port name	Rank	Index points
VIGO	156	−0.233	DAVAO	156	6
PAPEETE	157	−0.227	CASTELLON	157	6
VERACRUZ	158	−0.219	CORONEL	158	6
SAN ANTONIO	159	−0.218	VIGO	159	5
SHUWAIKH	160	−0.216	RIO HAINA	160	5
JACKSONVILLE	161	−0.215	GUSTAVIA	161	5
CALDERA (COSTA RICA)	162	−0.206	KHALIFA BIN SALMAN	162	5
BELL BAY	163	−0.205	BELL BAY	163	5
HELSINGBORG	164	−0.196	SAN JUAN	164	5
POINT LISAS PORTS	165	−0.182	CALDERA (COSTA RICA)	165	4
BORUSAN	166	−0.163	SHIBUSHI	166	4
KALININGRAD	167	−0.159	PAPEETE	167	4
CARTAGENA (SPAIN)	168	−0.153	SALERNO	168	3
BARRANQUILLA	169	−0.137	BARRANQUILLA	169	3
CRISTOBAL	170	−0.135	YUZHNY	170	3
LATAKIA	171	−0.135	HELSINGBORG	171	3
PALERMO	172	−0.125	TANJUNG PERAK	172	3
NASSAU	173	−0.109	SAN ANTONIO	173	3
SALERNO	174	−0.080	PUERTO QUETZAL	174	2
CIVITAVECCHIA	175	−0.072	ULSAN	175	2
WELLINGTON	176	−0.049	RAVENNA	176	2
DAKAR	177	−0.031	POINT LISAS PORTS	177	2
HERAKLION	178	−0.030	LIMASSOL	178	1
RAVENNA	179	−0.025	CARTAGENA (SPAIN)	179	1
CATANIA	180	−0.021	LONDON	180	1
LARVIK	181	−0.015	CIVITAVECCHIA	181	1
PORT FREEPORT	182	−0.008	PALERMO	182	1
VILA DO CONDE	183	0.000	ANCONA	183	0
VITORIA	183	0.000	LARVIK	184	0

Statistical approach			Administrative approach		
Port name	Rank	Total score	Port name	Rank	Index points
OITA	185	0.004	HERAKLION	185	0
KRISTIANSAND	186	0.008	LYTTELTON	186	0
GIJON	187	0.013	LATAKIA	187	0
LYTTELTON	188	0.034	OITA	188	0
ODESSA	189	0.046	NASSAU	189	0
DURRES	190	0.057	CATANIA	190	0
MARIEL	191	0.057	HAMBURG	191	0
LIMASSOL	192	0.063	PHILIPSBURG	192	0
ANCONA	193	0.067	PORT FREEPORT	193	0
PHILIPSBURG	194	0.090	KRISTIANSAND	194	−1
MUUGA—PORT OF TALLINN	195	0.092	BORUSAN	195	−1
VARNA	196	0.094	GIJON	196	−1
BELAWAN	197	0.104	MARIEL	197	−1
YUZHNY	198	0.105	MUUGA—PORT OF TALLINN	198	−1
RIO DE JANEIRO	199	0.126	SHUWAIKH	199	−1
MIAMI	200	0.149	TAMPA	200	−1
BARI	201	0.167	SANTO TOMAS DE CASTILLA	201	−2
VLADIVOSTOK	202	0.182	BELAWAN	202	−2
SANTO TOMAS DE CASTILLA	203	0.185	BARI	203	−2
VOSTOCHNY	204	0.192	TOMAKOMAI	204	−2
TOMAKOMAI	205	0.194	MATADI	205	−2
LEIXOES	206	0.201	NELSON	206	−2
ARICA	207	0.211	NAPLES	207	−2
PORT EVERGLADES	208	0.213	RAUMA	208	−3
MATADI	209	0.238	POTI	209	−3
NELSON	210	0.240	LEIXOES	210	−3
SAINT JOHN	211	0.241	PORT MORESBY	211	−4
TRIESTE	212	0.241	GIOIA TAURO	212	−4
GAVLE	213	0.242	VARNA	213	−4

Statistical approach			Administrative approach		
Port name	Rank	Total score	Port name	Rank	Index points
MERSIN	214	0.275	GAVLE	214	−4
POTI	215	0.278	NEW MANGALORE	215	−4
TEESPORT	216	0.303	FREETOWN	216	−5
PORT MORESBY	217	0.307	ABIDJAN	217	−5
TIANJIN	218	0.310	VITORIA	218	−5
TAURANGA	219	0.333	TOAMASINA	219	−5
FREETOWN	220	0.350	KALININGRAD	220	−5
SAN VICENTE	221	0.361	ALEXANDRIA (EGYPT)	221	−5
VALPARAISO	222	0.365	GRANGEMOUTH	222	−6
BERBERA	223	0.368	RIGA	223	−6
BILBAO	224	0.384	FREEPORT (BAHAMAS)	224	−6
HAIFA	225	0.384	ZEEBRUGGE	225	−6
TAMPA	226	0.411	SAN VICENTE	226	−7
TOAMASINA	227	0.433	PENANG	227	−7
ABIDJAN	228	0.439	SHUAIBA	228	−7
RAUMA	229	0.439	PANJANG	229	−7
CHORNOMORSK	230	0.449	KOPER	230	−7
CALLAO	231	0.450	DURRES	231	−7
NEW MANGALORE	232	0.451	APRA HARBOR	232	−7
UMM QASR	233	0.452	COTONOU	233	−8
ALEXANDRIA (EGYPT)	234	0.482	BRISBANE	234	−8
RIGA	235	0.482	TAKORADI	235	−8
SEATTLE	236	0.487	PUERTO PROGRESO	236	−8
VANCOUVER (CANADA)	237	0.499	NEW ORLEANS	237	−9
CONAKRY	238	0.505	TEESPORT	238	−9
EL DEKHEILA	239	0.509	BLUFF	239	−9
NAPIER	240	0.513	VLADIVOSTOK	240	−9
LA SPEZIA	241	0.548	VILA DO CONDE	241	−9
KOTKA	242	0.558	HOUSTON	242	−9

Statistical approach			Administrative approach		
Port name	Rank	Total score	Port name	Rank	Index points
GRANGEMOUTH	243	0.560	BILBAO	243	−10
COTONOU	244	0.562	KOTKA	244	−10
OWENDO	245	0.563	BERBERA	245	−10
BRISBANE	246	0.569	NANTES–ST NAZAIRE	246	−10
PANJANG	247	0.573	ARICA	247	−11
APRA HARBOR	248	0.610	PORT OF SPAIN	248	−11
ACAJUTLA	249	0.640	ACAJUTLA	249	−11
DAMIETTA	250	0.650	CONAKRY	250	−11
LIVORNO	251	0.658	SAINT JOHN	251	−12
PARANAGUA	252	0.659	DUBLIN	252	−12
CONSTANTZA	253	0.660	STOCKHOLM	253	−13
TAKORADI	254	0.683	MALABO	254	−14
NANTES–ST NAZAIRE	255	0.693	VOSTOCHNY	255	−14
LIRQUEN	256	0.708	EL DEKHEILA	256	−14
BLUFF	257	0.731	CRISTOBAL	257	−14
LE HAVRE	258	0.746	ST PETERSBURG	258	−14
PUERTO PROGRESO	259	0.750	BANGKOK	259	−15
PORT OF SPAIN	260	0.775	MOGADISCIO	260	−15
TEMA	261	0.782	NAPIER	261	−15
DUBLIN	262	0.839	LIRQUEN	262	−15
MALABO	263	0.859	SEATTLE	263	−16
HUENEME	264	0.862	TRIESTE	264	−16
NEW ORLEANS	265	0.865	ODESSA	265	−17
HOUSTON	266	0.878	KLAIPEDA	266	−17
STOCKHOLM	267	0.915	AGADIR	267	−17
BEIRA	268	0.919	CASABLANCA	268	−17
MANAUS	269	0.967	IZMIR	269	−18
ONNE	270	0.994	MANAUS	270	−18
BANGKOK	271	1.024	OWENDO	271	−18

Statistical approach			Administrative approach		
Port name	Rank	Total score	Port name	Rank	Index points
ISKENDERUN	272	1.024	ISKENDERUN	272	−18
MONTEVIDEO	273	1.033	HUENEME	273	−19
VENICE	274	1.042	CHORNOMORSK	274	−19
MANZANILLO (MEXICO)	275	1.070	BATUMI	275	−19
AGADIR	276	1.122	MANILA	276	−19
IZMIR	277	1.136	BRISTOL	277	−19
GENERAL SANTOS	278	1.148	LAE	278	−19
SAVANNAH	279	1.158	RIJEKA	279	−20
HAMBURG	280	1.176	SAMSUN	280	−20
MOGADISCIO	281	1.194	BEIRA	281	−21
CORONEL	282	1.203	GENERAL SANTOS	282	−21
VALENCIA	283	1.211	MONTREAL	283	−22
THESSALONIKI	284	1.229	THESSALONIKI	284	−22
MONTREAL	285	1.231	CONSTANTZA	285	−22
KINGSTON (JAMAICA)	286	1.283	KINGSTON (JAMAICA)	286	−23
LAE	287	1.314	KRIBI DEEP SEA PORT	287	−24
LOME	288	1.332	OTAGO HARBOUR	288	−24
MEJILLONES	289	1.381	LA SPEZIA	289	−24
SOUTHAMPTON	290	1.404	LIVORNO	290	−24
CASABLANCA	291	1.442	ONNE	291	−25
PORT VICTORIA	292	1.457	NOUAKCHOTT	292	−25
SOKHNA	293	1.459	SAN PEDRO (COTE D'IVOIRE)	293	−27
BRISTOL	294	1.462	UMM QASR	294	−27
NOUAKCHOTT	295	1.475	VENICE	295	−27
MUHAMMAD BIN QASIM	296	1.499	LA GUAIRA	296	−28
SAMSUN	297	1.502	DAMIETTA	297	−28
DOUALA	298	1.510	CHATTOGRAM	298	−28
MAPUTO	299	1.533	PORT VICTORIA	299	−28
NOVOROSSIYSK	300	1.626	LE HAVRE	300	−30

Statistical approach			Administrative approach		
Port name	Rank	Total score	Port name	Rank	Index points
KLAIPEDA	301	1.635	NOVOROSSIYSK	301	−30
MELBOURNE	302	1.676	DOUALA	302	−31
KRIBI DEEP SEA PORT	303	1.701	VANCOUVER (CANADA)	303	−31
ST PETERSBURG	304	1.719	TIMARU	304	−32
LA GUAIRA	305	1.737	DUNKIRK	305	−33
CHATTOGRAM	306	1.809	MAPUTO	306	−33
WALVIS BAY	307	1.819	PUERTO CABELLO	307	−34
ITAJAI	308	1.828	VALENCIA	308	−34
PUERTO CABELLO	309	1.829	RIO DE JANEIRO	309	−35
SAVONA–VADO	310	1.897	BUENOS AIRES	310	−37
GDANSK	311	1.944	MEJILLONES	311	−38
RIJEKA	312	1.974	TEMA	312	−40
FELIXSTOWE	313	2.006	MELBOURNE	313	−40
OTAGO HARBOUR	314	2.023	SAVONA–VADO	314	−40
ALGIERS	315	2.076	ASHDOD	315	−42
BATUMI	316	2.175	MUHAMMAD BIN QASIM	316	−42
TIMARU	317	2.225	SOUTHAMPTON	317	−45
KOPER	318	2.237	ALGIERS	318	−49
SAN PEDRO (COTE D'IVOIRE)	319	2.267	FREMANTLE	319	−49
BUENOS AIRES	320	2.391	IQUIQUE	320	−54
GENOA	321	2.420	SOKHNA	321	−55
MANILA	322	2.445	FELIXSTOWE	322	−55
JEBEL ALI	323	2.482	PRINCE RUPERT	323	−56
DAR ES SALAAM	324	2.561	DAR ES SALAAM	324	−58
DUTCH HARBOR	325	2.591	DUTCH HARBOR	325	−60
FREMANTLE	326	2.716	NEMRUT BAY	326	−61
ASHDOD	327	2.797	PORT BOTANY	327	−63
LOS ANGELES	328	2.899	MONTEVIDEO	328	−65
NEMRUT BAY	329	2.970	TACOMA	329	−66
PRINCE RUPERT	330	2.979	BEJAIA	330	−72

Statistical approach			Administrative approach		
Port name	**Rank**	**Total score**	**Port name**	**Rank**	**Index points**
MOMBASA	331	3.140	GENOA	331	−74
OAKLAND	332	3.163	LOME	332	−77
LONG BEACH	333	3.175	ADELAIDE	333	−78
PORT REUNION	334	3.302	OAKLAND	334	−79
TACOMA	335	3.628	MOMBASA	335	−79
GUAYAQUIL	336	3.647	WALVIS BAY	336	−80
PORT BOTANY	337	3.907	LOS ANGELES	337	−82
BEJAIA	338	4.054	GUAYAQUIL	338	−84
ADELAIDE	339	4.546	GOTHENBURG	339	−87
LAGOS (NIGERIA)	340	4.646	PORT REUNION	340	−89
GOTHENBURG	341	4.653	LONG BEACH	341	−96
IQUIQUE	342	4.766	LAGOS (NIGERIA)	342	−114
TIN CAN ISLAND	343	4.789	LUANDA	343	−115
PORT LOUIS	344	5.501	TIN CAN ISLAND	344	−118
MARSEILLE	345	5.696	POINTE−NOIRE	345	−128
POINTE−NOIRE	346	5.832	PORT LOUIS	346	−175
CAPE TOWN	347	6.528	CAPE TOWN	347	−177
PORT ELIZABETH	348	7.659	PORT ELIZABETH	348	−183
DURBAN	349	8.082	NGQURA	349	−190
LUANDA	350	8.383	MARSEILLE	350	−238
NGQURA	351	8.401	DURBAN	351	−255

100. Conversely, the rankings reflect some significant discrepancies in a limited number of ports. Three of the most notable discrepancies are Jebel Ali (323rd and 59th in the FA and administrative approach respectively), Itajai (308th and 105th respectively), and Tianjin, one of the highest ranked ports affected (218th and 20th respectively). Rather than explaining every discrepancy, the approach taken in the CPPI 2020 attempts to make the methodology and assumptions explicit and let the data speak. In future editions, further refinement of both approaches will hopefully reduce discrepancies, and further enhance their respective complementarity, and the rigor of the CPPI.

4.3. Conclusions and Next Steps

101. ***The rationale behind the CPPI focuses on using the available empirical data to create an objective measure to then compare container port performance across ports, and eventually over time.*** The intention is 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, logistics, and supply chain services.

102. ***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 WBG/IHS Markit team will continue to refine the methodologies and scope, increasing the number of ports as well as the data where possible. The next iteration (CPPI 2021) will be comparable, facilitating the introduction of trends in container port performance, both overall and potentially by disaggregation by ship or call size. The CPPI 2021 will also seek to investigate and explain divergences between the two approaches, while also gaining a further understanding of key determinants or influences on container port performance. The overall objective remains the identification of opportunities for improvement, which will ultimately benefit all public and private stakeholders in the sector.

Appendix A: The CPPI 2020

Table A.1. The CPPI 2020: Administrative Approach

			Weight	0.46		1.00		1.54		1.97		2.57
			<1,500 TEU		1,501–5,000 TEU		5,001–8,500 TEU		8,501–13,500 TEU		>13,500 TEU	
Port name	**Rank**	**Total points**	**Rank**	**Points**	**Rank**	**Points**	**Rank**	**Points**	**Rank**	**Points**	**Rank**	**Points**
AARHUS	43	43.45	17	7.1	28	10.0		—		—	18	11.7
ABIDJAN	217	(4.67)		—	222	(1.8)	149	(1.9)		—		—
ACAJUTLA	249	(11.08)		—	287	(11.1)		—		—		—
ADELAIDE	333	(78.35)		—	242	(3.6)	205	(22.4)	150	(20.4)		—
AGADIR	267	(17.01)	177	(4.4)	302	(15.0)		—		—		—
AGUADULCE (COLOMBIA)	30	55.65		—	80	7.3		—	13	12.3	25	9.4
ALEXANDRIA (EGYPT)	221	(5.49)	196	(7.2)	226	(2.2)		—		—		—
ALGECIRAS	32	52.90	83	2.7	118	5.3	75	6.6	44	8.3	30	7.8
ALGIERS	318	(48.92)	207	(9.7)	326	(44.5)		—		—		—
ALTAMIRA	98	16.77	43	4.6	73	7.7	95	4.5		—		—

			Weight	0.46		1.00		1.54		1.97		2.57
			<1,500 TEU		1,501–5,000 TEU		5,001–8,500 TEU		8,501–13,500 TEU		>13,500 TEU	
Port name	**Rank**	**Total points**	**Rank**	**Points**	**Rank**	**Points**	**Rank**	**Points**	**Rank**	**Points**	**Rank**	**Points**
AMBARLI	61	32.35	86	2.4	161	3.0	77	6.2	45	8.2	61	1.0
ANCONA	183	0.48	70	3.4	214	(1.1)		—		—		—
ANTWERP	65	30.76	104	1.4	157	3.2	101	3.7	72	4.5	43	4.8
APRA HARBOR	232	(7.46)	178	(4.5)	254	(5.4)		—		—		—
AQABA	41	46.92		—	108	6.0	133	0.2	34	9.4	27	8.6
ARICA	247	(10.55)	168	(3.3)	198	(0.3)	163	(5.7)		—		—
ASHDOD	315	(41.91)	174	(4.2)	282	(10.1)	187	(12.7)		—	72	(4.0)
AUCKLAND	118	11.70		—	103	6.2	104	3.6		—		—
BALBOA	78	26.58	131	(0.5)	156	3.4	117	2.3	69	4.7	47	4.1
BALTIMORE (USA)	119	11.64		—	179	1.4	132	0.6	71	4.7		—
BANGKOK	259	(14.58)	191	(6.1)	289	(11.8)		—		—		—
BARCELONA	46	41.83	89	2.3	92	6.6	57	8.5	51	7.2	54	2.7
BARI	203	(1.92)	136	(0.9)	220	(1.5)		—		—		—
BARRANQUILLA	169	3.29	72	3.2	174	1.8		—		—		—
BATANGAS	144	7.88		—	66	7.9		—		—		—
BATUMI	275	(18.89)	147	(1.5)	307	(18.2)		—		—		—
BEIRA	281	(20.59)		—	313	(20.6)		—		—		—
BEIRUT	62	31.86	36	5.3	45	8.8	64	8.1	70	4.7	65	(0.4)
BEJAIA	330	(71.85)	219	(27.7)	327	(59.1)		—		—		—
BELAWAN	202	(1.77)	119	0.2	223	(1.9)		—		—		—
BELL BAY	163	4.84	87	2.3	150	3.8		—		—		—
BERBERA	245	(9.98)		—	281	(10.0)		—		—		—
BILBAO	243	(9.58)	143	(1.3)	275	(9.0)		—		—		—
BLUFF	239	(8.62)		—	272	(8.6)		—		—		—
BORUSAN	195	(0.67)		—	208	(0.7)		—		—		—
BOSTON (USA)	73	27.47		—	71	7.7	61	8.2	80	3.6		—
BREMERHAVEN	85	23.53	109	0.6	146	3.9	102	3.6	89	3.0	52	3.0

			Weight	0.46		1.00		1.54		1.97		2.57
			<1,500 TEU		1,501–5,000 TEU		5,001–8,500 TEU		8,501–13,500 TEU		>13,500 TEU	
Port name	**Rank**	**Total points**	**Rank**	**Points**	**Rank**	**Points**	**Rank**	**Points**	**Rank**	**Points**	**Rank**	**Points**
BRISBANE	234	(7.78)	140	(1.1)	178	1.6	156	(4.6)	112	(0.9)		—
BRISTOL	277	(19.33)	206	(9.6)	301	(14.9)		—		—		—
BUENAVENTURA	71	28.58		—	68	7.8	35	9.4	88	3.2		—
BUENOS AIRES	310	(36.93)		—	207	(0.6)	153	(3.7)	144	(15.5)		—
BURGAS	133	9.46	81	2.9	56	8.1		—		—		—
BUSAN	36	51.23	38	5.1	70	7.8	59	8.3	101	1.0	21	10.3
CAGAYAN DE ORO	128	9.92	53	4.0	60	8.1		—		—		—
CAI LAN	74	27.43		—	14	11.2	18	10.5		—		—
CAI MEP	18	67.63		—	5	12.1	22	10.4	48	7.4	24	9.7
CALDERA (COSTA RICA)	165	4.07	59	3.7	167	2.4		—		—		—
CALLAO	56	34.14	106	1.1	202	(0.4)	119	2.0	93	2.1	20	10.4
CAPE TOWN	347	(177.22)	121	(0.0)	305	(17.7)	209	(34.1)	161	(54.3)		—
CARTAGENA (COLOMBIA)	34	52.26	57	3.8	18	10.8	8	11.4	20	11.2		—
CARTAGENA (SPAIN)	179	1.39	75	3.0		—		—		—		—
CASABLANCA	268	(17.29)	194	(6.6)	294	(12.8)	141	(0.9)		—		—
CASTELLON	157	5.83	114	0.3	140	4.0	127	1.1		—		—
CAT LAI	109	15.37	11	8.3	10	11.6		—		—		—
CATANIA	190	(0.20)	129	(0.4)		—		—		—		—
CAUCEDO	68	29.64	99	1.8	55	8.2	80	5.9	62	5.8		—
CEBU	140	8.21	24	6.5	119	5.2		—		—		—
CHARLESTON	53	38.00		—	109	5.8	78	6.1	74	4.4	39	5.5
CHATTOGRAM	298	(27.94)		—	320	(27.9)		—		—		—
CHIBA	150	7.05		—	85	7.0		—		—		—
CHIWAN	27	57.96	9	8.5	27	10.1	29	9.7	21	11.1	53	2.8
CHORNOMORSK	274	(18.88)	62	3.7	218	(1.4)	186	(12.4)		—		—

			Weight	0.46		1.00		1.54		1.97		2.57
			<1,500 TEU		1,501–5,000 TEU		5,001–8,500 TEU		8,501–13,500 TEU		>13,500 TEU	
Port name	**Rank**	**Total points**	**Rank**	**Points**	**Rank**	**Points**	**Rank**	**Points**	**Rank**	**Points**	**Rank**	**Points**
CIVITAVECCHIA	181	0.84	97	1.8		—		—		—		—
COLOMBO	33	52.51	88	2.3	131	4.6	70	7.3	32	9.6	35	6.5
COLON	82	25.37	80	2.9	91	6.7	129	1.1	91	2.2	45	4.4
CONAKRY	250	(11.26)	151	(1.7)	284	(10.5)		—		—		—
CONSTANTZA	285	(22.18)	63	3.7	194	0.5	160	(5.1)	132	(8.4)		—
COPENHAGEN	142	7.92	71	3.3	99	6.4		—		—		—
CORONEL	158	5.53		—	117	5.3	184	(11.6)	97	1.4	38	5.9
COTONOU	233	(7.73)	60	3.7	259	(6.6)	148	(1.8)		—		—
CRISTOBAL	257	(14.15)		—	183	1.3	154	(4.0)	125	(4.7)		—
DA CHAN BAY TERMINAL ONE	35	52.25		—	30	9.9	13	11.1	8	12.8		—
DAKAR	120	11.51	115	0.3	190	0.7	72	7.0		—		—
DALIAN	19	66.24		—	132	4.6	54	8.6	5	13.1	26	8.8
DAMIETTA	297	(27.91)	149	(1.6)	257	(6.0)	146	(1.7)	76	4.3	85	(10.5)
DAMMAM	92	20.03		—	130	4.7	109	3.1	85	3.4	60	1.5
DANANG	115	12.84	2	10.5	63	8.0		—		—		—
DAR ES SALAAM	324	(57.80)		—	324	(30.8)	201	(17.5)		—		—
DAVAO	156	5.87	154	(1.7)	258	(6.6)	52	8.6		—		—
DILISKELESI	75	27.19	14	7.6	35	9.5	39	9.2		—		—
DJIBOUTI	93	19.43	73	3.2	112	5.6	112	2.8	83	3.4	62	0.5
DOUALA	302	(30.79)	193	(6.6)	319	(27.8)		—		—		—
DUBLIN	252	(12.14)	204	(9.5)	269	(7.8)		—		—		—
DUNKIRK	305	(32.53)	55	4.0	164	2.5	40	9.1	131	(7.9)	88	(13.7)
DURBAN	351	(255.28)	200	(7.8)	312	(19.2)	194	(16.1)	158	(30.6)	98	(57.4)
DURRES	231	(7.38)	135	(0.9)	261	(7.0)		—		—		—
DUTCH HARBOR	325	(59.57)		—	308	(18.3)	206	(26.8)		—		—
EL DEKHEILA	256	(13.98)	96	1.9	200	(0.3)	177	(9.4)		—		—
ENSENADA	125	10.61		—	143	3.9	115	2.6	98	1.3		—
FELIXSTOWE	322	(54.78)	148	(1.5)	241	(3.6)	164	(5.7)	129	(7.1)	86	(10.8)

			Weight	0.46		1.00		1.54		1.97		2.57
			<1,500 TEU		1,501–5,000 TEU		5,001–8,500 TEU		8,501–13,500 TEU		>13,500 TEU	
Port name	**Rank**	**Total points**	**Rank**	**Points**	**Rank**	**Points**	**Rank**	**Points**	**Rank**	**Points**	**Rank**	**Points**
FORT-DE-FRANCE	112	14.51	157	(1.8)	94	6.5	83	5.7		—		—
FREDERICIA	138	8.58	51	4.1	90	6.7		—		—		—
FREEPORT (BAHA-MAS)	224	(6.29)		—	114	5.5	144	(1.2)	126	(5.0)		—
FREETOWN	216	(4.55)	170	(3.7)	233	(2.9)		—		—		—
FREMANTLE	319	(49.22)		—	210	(0.9)	171	(7.5)	146	(18.7)		—
FUZHOU	21	60.89		—	67	7.8	47	8.9	19	11.3	34	6.7
GAVLE	214	(4.02)	126	(0.3)	244	(3.9)		—		—		—
GDANSK	131	9.82	44	4.6	171	2.1		—		—	58	2.2
GDYNIA	103	16.17	48	4.3	95	6.5	89	5.0		—		—
GEMLIK	79	26.35	26	5.9	31	9.9	45	8.9		—		—
GENERAL SANTOS	282	(21.35)		—	314	(21.3)		—		—		—
GENOA	331	(73.70)	112	0.3	187	0.9	166	(6.3)	134	(8.8)	90	(18.5)
GIJON	196	(0.86)	111	0.3	213	(1.0)		—		—		—
GIOIA TAURO	212	(3.62)		—		—	145	(1.7)	100	1.0	69	(1.2)
GOTHENBURG	339	(86.64)	125	(0.3)	193	0.5		—		—	96	(33.8)
GRANGEMOUTH	222	(5.67)	213	(12.3)		—		—		—		—
GUANGZHOU	6	92.29	46	4.4	6	11.9	12	11.2	9	12.8	10	13.9
GUAYAQUIL	338	(84.32)		—	225	(2.2)	183	(11.0)	133	(8.7)	91	(18.7)
GUSTAVIA	161	5.10	1	11.1		—		—		—		—
HAIFA	153	6.39	127	(0.4)	231	(2.8)	165	(5.9)	110	(0.7)	31	7.7
HAIPHONG	60	32.52	107	1.1	163	2.6	56	8.5	43	8.3		—
HAKATA	116	12.45	79	2.9	15	11.1		—		—		—
HALIFAX	25	58.64	76	3.0	75	7.6	79	6.0	46	7.8	22	9.8
HAMAD PORT	38	50.55		—	38	9.3	25	10.1	26	10.2	57	2.2
HAMBURG	191	(0.23)	134	(0.7)	217	(1.4)	131	0.7	99	1.3	67	(0.8)
HELSINGBORG	171	3.20	85	2.5	172	2.0		—		—		—

			Weight	0.46		1.00		1.54		1.97		2.57
			<1,500 TEU		1,501–5,000 TEU		5,001–8,500 TEU		8,501–13,500 TEU		>13,500 TEU	
Port name	Rank	Total points	Rank	Points	Rank	Points	Rank	Points	Rank	Points	Rank	Points
HERAKLION	185	0.09	118	0.2		—		—		—		—
HONG KONG PORT, HONG KONG SAR, CHINA	7	88.78	15	7.5	22	10.7	5	12.5	15	11.8	14	12.5
HOUSTON	242	(9.33)		—	199	(0.3)	137	(0.5)	122	(4.2)		—
HUENEME	273	(18.87)		—	311	(18.9)		—		—		—
INCHEON	37	50.90	19	6.9	51	8.6	38	9.2	10	12.6		—
IQUIQUE	320	(54.39)	34	5.4	227	(2.5)		—	156	(27.6)		—
ISKENDERUN	272	(18.49)	28	5.9	93	6.5	68	7.6	149	(20.1)		—
ITAJAI	105	15.79		—	134	4.5	16	10.7	118	(2.7)		—
ITAPOA	88	23.05		—	180	1.4	67	7.7	67	5.0		—
IZMIR	269	(17.51)	164	(2.5)	240	(3.6)	176	(8.3)		—		—
JACKSONVILLE	99	16.65		—		—	85	5.6	78	4.1		—
JAWAHARLAL NEHRU PORT	63	31.34		—	72	7.7	84	5.7	47	7.5		—
JEBEL ALI	59	32.62		—	230	(2.7)	50	8.8	60	6.1	49	3.8
JEDDAH	42	45.79	176	(4.3)	153	3.6	48	8.8	73	4.5	28	8.5
JOHOR	108	15.43	84	2.7	152	3.6	73	6.9		—		—
JUBAIL	57	33.35		—		—	81	5.9	56	6.5	46	4.4
KALININGRAD	220	(5.46)		—	255	(5.5)		—		—		—
KAOHSIUNG	4	99.09	8	8.5	11	11.5	27	9.9	17	11.5	3	17.8
KARACHI	80	26.01		—	44	8.9	103	3.6	61	5.9		—
KEELUNG	64	30.92	32	5.5	39	9.1	65	8.1	82	3.5		—
KHALIFA BIN SALMAN	162	4.98		—	135	4.4		—	106	0.3		—
KHALIFA PORT	22	59.99		—	113	5.5	30	9.7	49	7.4	23	9.7
KING ABDULLAH PORT	2	114.31		—	2	15.1	6	12.5	4	13.9	2	20.5

			Weight	0.46		1.00		1.54		1.97		2.57
			<1,500 TEU		1,501–5,000 TEU		5,001–8,500 TEU		8,501–13,500 TEU		>13,500 TEU	
Port name	**Rank**	**Total points**	**Rank**	**Points**	**Rank**	**Points**	**Rank**	**Points**	**Rank**	**Points**	**Rank**	**Points**
KINGSTON (JAMAICA)	286	(22.76)	167	(3.3)	139	4.0	49	8.8	119	(3.1)	87	(12.8)
KLAIPEDA	266	(16.79)	58	3.7	309	(18.5)		—		—		—
KOBE	50	39.40	10	8.3	12	11.5	66	7.8	59	6.2		—
KOPER	230	(6.94)	91	2.1	170	2.3	142	(1.0)	90	3.0	75	(5.7)
KOTKA	244	(9.87)	163	(2.3)	273	(8.8)		—		—		—
KRIBI DEEP SEA PORT	287	(23.64)	217	(20.3)	300	(14.3)		—		—		—
KRISTIANSAND	194	(0.64)	145	(1.4)		—		—		—		—
LA GUAIRA	296	(27.60)	209	(9.8)	316	(23.1)		—		—		—
LA SPEZIA	289	(24.02)	146	(1.4)	267	(7.6)	138	(0.5)	115	(1.9)	73	(4.3)
LAE	278	(19.34)	210	(11.2)	299	(14.2)		—		—		—
LAEM CHABANG	51	39.04	22	6.5	42	8.9	100	3.9	55	6.6	51	3.1
LAGOS (NIGERIA)	342	(113.72)		—	321	(28.1)	212	(55.6)		—		—
LARVIK	184	0.11	117	0.2		—		—		—		—
LATAKIA	187	0.04	152	(1.7)	189	0.8		—		—		—
LAZARO CARDENAS	23	59.92		—	62	8.0	9	11.4	40	8.7	33	6.7
LE HAVRE	300	(29.67)	139	(1.1)	192	0.6	152	(2.0)	127	(5.7)	76	(6.0)
LEIXOES	210	(3.49)	183	(4.8)	215	(1.3)		—		—		—
LIANYUNGANG	31	54.38		—	98	6.4	10	11.3	36	9.1	42	4.9
LIMASSOL	178	1.41	169	(3.5)	149	3.8	135	(0.5)		—		—
LIRQUEN	262	(15.33)		—	120	5.1	134	(0.0)	135	(10.3)		—
LIVORNO	290	(24.04)	197	(7.5)	209	(0.9)	188	(12.8)		—		—
LOME	332	(77.24)		—	270	(7.8)	211	(45.1)		—		—
LONDON	180	1.30	103	1.4	121	5.1	125	1.2	50	7.2	78	(7.9)
LONG BEACH	341	(96.28)	92	2.1	188	0.9	105	3.3	136	(10.7)	95	(31.9)
LOS ANGELES	337	(81.67)		—	203	(0.4)	173	(7.8)	120	(3.8)	92	(24.0)

		Weight	0.46		1.00		1.54		1.97		2.57
		<1,500 TEU		1,501–5,000 TEU		5,001–8,500 TEU		8,501–13,500 TEU		>13,500 TEU	
Port name	Rank	Total points	Rank	Points	Rank	Points	Rank	Points	Rank	Points	Rank	Points
LUANDA	343	(114.84)	116	0.3	297	(13.0)	204	(21.8)	160	(34.7)		—
LYTTELTON	186	0.08		—	162	2.9	147	(1.8)		—		—
MAGDALLA	45	42.39		—	77	7.4	69	7.6	14	11.8		—
MALABO	254	(13.57)		—	298	(13.6)		—		—		—
MALAGA	129	9.91	105	1.3	129	4.8	111	2.9		—		—
MANAUS	270	(17.99)		—	306	(18.0)		—		—		—
MANILA	276	(19.33)	202	(9.1)	247	(4.2)	169	(7.1)		—		—
MANZANILLO (MEX-ICO)	145	7.84	214	(13.9)	79	7.3	130	0.8	86	3.3	63	(0.3)
MAPUTO	306	(33.45)		—	280	(9.6)	193	(15.5)		—		—
MARIEL	197	(0.88)	158	(1.9)		—		—		—		—
MARSAXLOKK	101	16.47	166	(3.1)	236	(3.3)	108	3.1	68	4.8	55	2.7
MARSEILLE	350	(238.49)	141	(1.2)	205	(0.4)	180	(9.9)	153	(24.6)	99	(67.7)
MATADI	205	(2.28)	184	(4.9)		—		—		—		—
MAWAN	29	55.67		—	24	10.5	2	13.2	12	12.6		—
MEJILLONES	311	(38.26)		—	65	7.9	87	5.3	141	(14.0)	84	(10.4)
MELBOURNE	313	(40.21)		—	238	(3.4)	159	(5.0)	143	(14.7)		—
MERSIN	83	25.30	95	2.0	185	1.1	114	2.7	96	1.7	37	6.1
MIAMI	114	13.96	61	3.7	136	4.2	110	3.0	94	1.7		—
MOBILE	132	9.73		—	142	4.0	90	4.8	111	(0.9)		—
MOGADISCIO	260	(15.09)	186	(5.2)	293	(12.7)		—		—		—
MOJI	123	10.71		—	21	10.7		—		—		—
MOMBASA	335	(78.90)	187	(5.3)	278	(9.3)	210	(43.6)		—		—
MONTEVIDEO	328	(65.15)	39	5.1	155	3.5	185	(12.3)	155	(26.4)		—
MONTREAL	283	(21.59)		—	315	(21.6)		—		—		—
MUHAMMAD BIN QASIM	316	(42.02)		—	237	(3.4)	168	(6.6)	142	(14.4)		—
MUNDRA	44	42.74		—	20	10.7	62	8.2	27	9.9		—

			Weight	0.46		1.00		1.54		1.97		2.57
			<1,500 TEU		1,501–5,000 TEU		5,001–8,500 TEU		8,501–13,500 TEU		>13,500 TEU	
Port name	Rank	Total points	Rank	Points	Rank	Points	Rank	Points	Rank	Points	Rank	Points
MUUGA—PORT OF TALLINN	198	(0.99)		—	212	(1.0)		—		—		—
NAGOYA	48	41.34	5	8.7	7	11.8	58	8.4	57	6.4		—
NAHA	111	14.65		—		—	33	9.5		—		—
NANTES–ST NAZAIRE	246	(10.26)	171	(3.9)	271	(8.5)		—		—		—
NAPIER	261	(15.25)		—	191	0.7	182	(10.3)		—		—
NAPLES	207	(2.49)	20	6.7	40	9.0	179	(9.5)		—		—
NASSAU	189	(0.14)	124	(0.3)		—		—		—		—
NELSON	206	(2.46)		—	228	(2.5)		—		—		—
NEMRUT BAY	326	(60.83)	74	3.2	141	4.0	122	1.5		—	94	(26.7)
NEW MANGALORE	215	(4.47)	208	(9.7)		—		—		—		—
NEW ORLEANS	237	(8.60)		—	182	1.3	158	(5.0)	113	(1.1)		—
NEW YORK & NEW JERSEY	127	10.44	54	4.0	115	5.5	97	4.3	108	0.2	70	(1.5)
NGQURA	349	(190.20)	159	(2.0)	279	(9.5)	198	(17.1)	152	(24.3)	97	(41.1)
NINGBO	13	83.03	27	5.9	33	9.7	19	10.5	22	10.7	12	13.0
NORRKOPING	135	9.14	41	4.7	88	7.0		—		—		—
NOUAKCHOTT	292	(25.32)	215	(14.6)	310	(18.6)		—		—		—
NOUMEA	124	10.63	31	5.5	57	8.1		—		—		—
NOVOROSSIYSK	301	(30.45)	162	(2.2)	263	(7.1)	190	(14.5)		—		—
OAKLAND	334	(78.72)	156	(1.8)	175	1.8	167	(6.3)	137	(12.0)	89	(18.0)
ODESSA	265	(16.61)	13	7.8	145	3.9		—	138	(12.2)		—
OITA	188	(0.08)	122	(0.2)		—		—		—		—
OMAEZAKI	121	10.99		—	16	11.0		—		—		—
ONNE	291	(24.94)		—	317	(24.9)		—		—		—
OSAKA	77	26.92		—	34	9.6	11	11.3		—		—

			Weight	0.46		1.00		1.54		1.97		2.57
			<1,500 TEU		1,501–5,000 TEU		5,001–8,500 TEU		8,501–13,500 TEU		>13,500 TEU	
Port name	**Rank**	**Total points**	**Rank**	**Points**	**Rank**	**Points**	**Rank**	**Points**	**Rank**	**Points**	**Rank**	**Points**
OSLO	91	20.15	82	2.8	1	18.9		—		—		—
OTAGO HARBOUR	288	(23.73)		—	166	2.4	197	(17.0)		—		—
OWENDO	271	(18.43)	212	(11.9)	296	(12.9)		—		—		—
PAITA	94	19.43		—	100	6.2	55	8.6		—		—
PALERMO	182	0.77	101	1.7		—		—		—		—
PANJANG	229	(6.92)	188	(5.4)	248	(4.4)		—		—		—
PAPEETE	167	3.64	78	3.0	169	2.3		—		—		—
PARANAGUA	107	15.52		—	195	(0.0)	113	2.7	63	5.8		—
PECEM	86	23.27		—	76	7.6	107	3.2	64	5.4		—
PENANG	227	(6.82)		—	184	1.1	161	(5.2)		—		—
PHILADELPHIA	87	23.11		—	52	8.5	34	9.5		—		—
PHILIPSBURG	192	(0.27)	102	1.5	211	(1.0)		—		—		—
PIPAVAV	39	48.40		—	9	11.6	4	12.6	37	8.8		—
PIRAEUS	89	22.98	175	(4.3)	168	2.3	98	4.2	92	2.2	44	4.6
POINT LISAS PORTS	177	1.62	66	3.5		—		—		—		—
POINTE-A-PITRE	113	14.42	128	(0.4)	96	6.5	88	5.3		—		—
POINTE-NOIRE	345	(128.49)	218	(25.1)	304	(16.5)	207	(29.8)	157	(27.7)		—
PORT AKDENIZ	154	6.32	29	5.8	151	3.7		—		—		—
PORT BOTANY	327	(62.93)	185	(5.0)	235	(3.1)	189	(13.1)	147	(19.0)		—
PORT BRONKA	152	6.60	69	3.5	124	5.0		—		—		—
PORT ELIZABETH	348	(182.71)		—	274	(8.8)	208	(33.0)	162	(62.5)		—
PORT EVERGLADES	147	7.63	98	1.8	154	3.5	118	2.1		—		—
PORT FREEPORT	193	(0.35)			—201	(0.3)		—		—		—
PORT KLANG	14	78.19	56	3.9	84	7.1	28	9.9	18	11.3	16	12.4
PORT LOUIS	346	(175.17)	211	(11.4)	291	(12.0)	200	(17.4)	159	(31.9)	93	(26.6)

			Weight	0.46		1.00		1.54		1.97		2.57
			<1,500 TEU		1,501–5,000 TEU		5,001–8,500 TEU		8,501–13,500 TEU		>13,500 TEU	
Port name	Rank	Total points	Rank	Points	Rank	Points	Rank	Points	Rank	Points	Rank	Points
PORT MORESBY	211	(3.60)	110	0.5	243	(3.8)		—		—		—
PORT OF SPAIN	248	(10.58)	198	(7.6)	262	(7.1)		—		—		—
PORT OF VIRGINIA	110	14.77	133	(0.6)	127	4.9	120	2.0	77	4.1	64	(0.3)
PORT REUNION	340	(89.43)	192	(6.4)	285	(10.7)	195	(16.2)	154	(25.8)		—
PORT SAID	70	29.08	130	(0.5)	104	6.2	82	5.7	117	(2.5)	32	7.5
PORT VICTORIA	299	(28.31)		—	322	(28.3)		—		—		—
POSORJA	126	10.50		—	36	9.5		—	103	0.5		—
POTI	209	(2.69)	190	(5.8)		—		—		—		—
PRINCE RUPERT	323	(56.06)		—		—	202	(18.9)	140	(13.7)		—
PUERTO BARRIOS	122	10.77	42	4.7	50	8.6		—		—		—
PUERTO BOLIVAR (ECUADOR)	155	6.15		—	105	6.2		—		—		—
PUERTO CABELLO	307	(33.87)		—	325	(33.9)		—		—		—
PUERTO CORTES	149	7.16	93	2.1	102	6.2		—		—		—
PUERTO LIMON	106	15.63		—	78	7.4	86	5.4		—		—
PUERTO PROGRESO	236	(8.43)	195	(7.0)	253	(5.2)		—		—		—
PUERTO QUETZAL	174	2.38		—	158	3.1	140	(0.8)	107	0.2		—
QINGDAO	3	102.37		—	29	9.9	1	14.3	3	15.3	7	15.7
QINZHOU	148	7.57	150	(1.7)	54	8.3		—		—		—
QUY NHON	104	16.14	33	5.4	3	13.7		—		—		—
RAUMA	208	(2.65)	123	(0.2)	229	(2.6)		—		—		—
RAVENNA	176	1.93	40	4.8	197	(0.3)		—		—		—
RIGA	223	(5.97)	153	(1.7)	252	(5.2)		—		—		—

			Weight	0.46		1.00		1.54		1.97		2.57
			<1,500 TEU		1,501–5,000 TEU		5,001–8,500 TEU		8,501–13,500 TEU		>13,500 TEU	
Port name	**Rank**	**Total points**	**Rank**	**Points**	**Rank**	**Points**	**Rank**	**Points**	**Rank**	**Points**	**Rank**	**Points**
RIJEKA	279	(19.51)	77	3.0	138	4.1	150	(1.9)		—	81	(8.6)
RIO DE JANEIRO	309	(34.73)		—	69	7.8	116	2.3	151	(23.4)		—
RIO GRANDE (BRAZIL)	47	41.54		—	46	8.8	36	9.4	35	9.3		—
RIO HAINA	160	5.14	94	2.0	137	4.2		—		—		—
ROTTERDAM	90	22.41	180	(4.7)	176	1.8	91	4.8	84	3.4	50	3.4
SAIGON	151	6.94		—	89	6.9		—		—		—
SAINT JOHN	251	(11.59)	120	0.1	286	(10.9)	136	(0.5)		—		—
SALALAH	9	87.45	144	(1.3)	13	11.4	24	10.3	6	13.1	11	13.6
SALERNO	168	3.44	137	(0.9)	147	3.9		—		—		—
SALVADOR	55	35.29		—	47	8.7	93	4.6	28	9.9		—
SAMSUN	280	(19.87)	205	(9.5)	303	(15.5)		—		—		—
SAN ANTONIO	173	2.53		—	224	(2.1)	155	(4.4)	116	(2.5)	36	6.3
SAN JUAN	164	4.60	100	1.7	148	3.8		—		—		—
SAN PEDRO (COTE D'IVOIRE)	293	(27.01)		—	318	(27.0)		—		—		—
SAN VICENTE	226	(6.50)		—	173	1.9	162	(5.4)		—		—
SANTA CRUZ DE TENERIFE	95	18.66	65	3.6	196	(0.2)		—	41	8.7		—
SANTA MARTA	137	8.66		—	49	8.7		—		—		—
SANTO TOMAS DE CASTILLA	201	(1.71)		—	221	(1.7)		—		—		—
SANTOS	72	28.25		—	123	5.1	60	8.3	66	5.3		—
SAVANNAH	96	18.19	108	1.1	106	6.1	94	4.5	79	3.6	68	(1.0)
SAVONA-VADO	314	(40.38)	155	(1.8)	204	(0.4)	175	(8.1)	139	(13.6)		—
SEATTLE	263	(16.29)		—	206	(0.4)	157	(4.8)	123	(4.3)		—
SEPETIBA	84	24.32		—	25	10.5	74	6.8	95	1.7		—
SHANGHAI	49	41.30	7	8.5	19	10.7	17	10.7	25	10.3	71	(3.9)

			Weight	0.46		1.00		1.54		1.97		2.57
			<1,500 TEU		1,501–5,000 TEU		5,001–8,500 TEU		8,501–13,500 TEU		>13,500 TEU	
Port name	**Rank**	**Total points**	**Rank**	**Points**	**Rank**	**Points**	**Rank**	**Points**	**Rank**	**Points**	**Rank**	**Points**
SHANTOU	117	12.02		—	87	7.0	106	3.3		—		—
SHEKOU	5	93.69	21	6.6	43	8.9	14	10.9	16	11.7	5	16.3
SHIBUSHI	166	3.71	12	8.1		—		—		—		—
SHIMIZU	24	59.39	4	9.5	17	10.9	7	12.2	7	12.9		—
SHUAIBA	228	(6.89)		—	260	(6.9)		—		—		—
SHUWAIKH	199	(1.32)		—	216	(1.3)		—		—		—
SIAM SEAPORT	136	8.72		—	48	8.7		—		—		—
SINES	28	56.19		—	37	9.3	99	4.0	30	9.7	29	8.4
SINGAPORE	12	83.12	52	4.1	53	8.4	32	9.5	38	8.8	6	15.9
SOHAR	69	29.49		—	159	3.0	37	9.2	54	7.0	66	(0.6)
SOKHNA	321	(54.65)		—	165	2.4	196	(16.8)	121	(4.0)	82	(9.1)
SOUTHAMPTON	317	(44.52)	142	(1.2)	266	(7.6)	124	1.2	128	(6.1)	83	(10.2)
ST PETERSBURG	258	(14.24)	181	(4.7)	292	(12.1)		—		—		—
STOCKHOLM	253	(13.50)	203	(9.3)	276	(9.2)		—		—		—
SUAPE	130	9.88		—	101	6.2	121	1.8	105	0.4		—
TACOMA	329	(66.41)		—	283	(10.4)	192	(14.6)	145	(17.1)		—
TAICHUNG	146	7.74	18	7.0	133	4.5		—		—		—
TAIPEI, TAIWAN CHINA	16	75.41		—		—		—	2	16.6	4	16.6
TAKORADI	235	(7.89)	132	(0.6)	268	(7.6)		—		—		—
TAMPA	200	(1.40)		—	110	5.7	128	1.1	124	(4.4)		—
TANGER MEDI-TERRANEAN	15	76.09	45	4.4	82	7.2	21	10.4	31	9.6	15	12.4
TANJUNG EMAS	143	7.91		—	64	7.9		—		—		—
TANJUNG PELEPAS	11	85.62	64	3.7	74	7.7	26	10.1	23	10.5	8	15.5
TANJUNG PERAK	172	2.88		—	144	3.9	139	(0.7)		—		—
TANJUNG PRIOK	66	30.57	138	(1.0)	126	4.9	76	6.3	87	3.3	48	3.9

			Weight	0.46		1.00		1.54		1.97		2.57
			<1,500 TEU		1,501–5,000 TEU		5,001–8,500 TEU		8,501–13,500 TEU		>13,500 TEU	
Port name	Rank	Total points	Rank	Points	Rank	Points	Rank	Points	Rank	Points	Rank	Points
TARRAGONA	134	9.19	47	4.4	83	7.2		—		—		—
TAURANGA	100	16.52	216	(17.6)	81	7.3	96	4.4	65	5.4		—
TEESPORT	238	(8.61)	165	(2.5)	265	(7.4)		—		—		—
TEMA	312	(39.91)		—	256	(5.9)	174	(7.9)	109	(0.3)	80	(8.3)
THESSALONIKI	284	(21.76)	179	(4.6)	251	(5.1)	178	(9.5)		—		—
TIANJIN	20	64.01	199	(7.8)	97	6.5	42	9.0	33	9.5	19	11.1
TIMARU	304	(31.50)		—	219	(1.5)	203	(19.5)		—		—
TIN CAN ISLAND	344	(117.73)		—	323	(29.2)	213	(57.5)		—		—
TOAMASINA	219	(5.04)		—	250	(5.0)		—		—		—
TOKYO	54	37.68	50	4.2	58	8.1	46	8.9	52	7.1		—
TOMAKOMAI	204	(1.93)	173	(4.2)		—		—		—		—
TRIESTE	264	(16.41)	90	2.3	177	1.7	126	1.1		—	79	(8.1)
TRIPOLI (LEBANON)	76	26.93	6	8.5	181	1.3	53	8.6	75	4.3		—
TUTICORIN	139	8.29	30	5.6	111	5.7		—		—		—
ULSAN	175	1.97		—	125	5.0	151	(1.9)		—		—
UMM QASR	294	(27.28)		—	290	(12.0)	181	(9.9)		—		—
VALENCIA	308	(34.16)	201	(8.8)	239	(3.6)	170	(7.1)	104	0.5	77	(6.4)
VALPARAISO	102	16.25		—	128	4.8	44	8.9	114	(1.2)		—
VANCOUVER (CAN-ADA)	303	(30.98)		—	245	(3.9)	172	(7.6)	130	(7.8)		—
VARNA	213	(3.78)	161	(2.1)	232	(2.8)		—		—		—
VENICE	295	(27.37)	160	(2.0)	246	(4.0)	191	(14.6)		—		—
VERACRUZ	97	18.16	113	0.3	116	5.4	63	8.2		—		—
VIGO	159	5.36	37	5.2	160	3.0		—		—		—
VILA DO CONDE	241	(9.24)		—	277	(9.2)		—		—		—
VITORIA	218	(5.03)		—	249	(5.0)		—		—		—
VLADIVOSTOK	240	(9.11)	172	(4.0)	264	(7.3)		—		—		—

		Weight	0.46		1.00		1.54		1.97		2.57
		<1,500 TEU		1,501–5,000 TEU		5,001–8,500 TEU		8,501–13,500 TEU		>13,500 TEU	
Port name	Rank	Total points	Rank	Points	Rank	Points	Rank	Points	Rank	Points	Rank	Points
VOSTOCHNY	255	(13.76)	189	(5.8)	288	(11.1)		—		—		—
WALVIS BAY	336	(79.59)	182	(4.7)	295	(12.9)	199	(17.2)	148	(19.3)		—
WELLINGTON	141	8.12		—	107	6.0	123	1.4		—		—
WILHELM-SHAVEN	52	38.84	35	5.3	86	7.0	71	7.3	58	6.2	56	2.3
WILMINGTON (NORTH CAROLINA, USA)	67	30.06		—	59	8.1	31	9.7	81	3.6		—
XIAMEN	26	58.04	49	4.2	32	9.7	41	9.0	29	9.7	41	5.2
YANGSHAN	10	86.53	3	9.7	8	11.6	15	10.8	24	10.5	13	12.9
YANTIAN	17	72.53	25	6.2	61	8.1	43	9.0	39	8.8	17	11.9
YARIMCA	58	33.01	68	3.5	234	(3.1)	92	4.7	53	7.0	40	5.2
YOKKAICHI	81	25.63		—	4	12.2	51	8.8		—		—
YOKOHAMA	1	129.74	23	6.5	26	10.5	3	12.8	1	18.4	1	23.5
YEOSU	40	48.08	67	3.5	41	9.0	20	10.4	42	8.5	59	1.8
YUZHNY	170	3.25		—	122	5.1	143	(1.2)		—		—
ZEEBRUGGE	225	(6.41)	16	7.3	186	1.0		—	102	0.9	74	(4.9)
ZHOUSHAN	8	87.63		—	23	10.7	23	10.3	11	12.6	9	14.1

Source: Original calculations for this publication, based on CPPI 2020 data.
Note: TEU = twenty-foot equivalent unit

Table A.2. The CPPI 2020: Statistical Approach

Port name	Rank	Total score	Port name	Rank	Total score
AARHUS	44	−2.036	BEIRUT	11	−3.378
ABIDJAN	228	0.439	BEJAIA	338	4.054
ACAJUTLA	249	0.640	BELAWAN	197	0.104
ADELAIDE	339	4.546	BELL BAY	163	−0.205
AGADIR	276	1.122	BERBERA	223	0.368
AGUADULCE (COLOMBIA)	45	−2.035	BILBAO	224	0.384
ALEXANDRIA (EGYPT)	234	0.482	BLUFF	257	0.731
ALGECIRAS	10	−3.597	BORUSAN	166	−0.163
ALGIERS	315	2.076	BOSTON (USA)	113	−0.631
ALTAMIRA	145	−0.324	BREMERHAVEN	41	−2.265
AMBARLI	57	−1.783	BRISBANE	246	0.569
ANCONA	193	0.067	BRISTOL	294	1.462
ANTWERP	86	−1.011	BUENAVENTURA	72	−1.353
APRA HARBOR	248	0.610	BUENOS AIRES	320	2.391
AQABA	60	−1.594	BURGAS	117	−0.611
ARICA	207	0.211	BUSAN	52	−1.887
ASHDOD	327	2.797	CAGAYAN DE ORO	122	−0.582
AUCKLAND	123	−0.562	CAI LAN	46	−1.991
BALBOA	114	−0.625	CAI MEP	49	−1.932
BALTIMORE (USA)	138	−0.368	CALDERA (COSTA RICA)	162	−0.206
BANGKOK	271	1.024	CALLAO	231	0.450
BARCELONA	76	−1.224	CAPE TOWN	347	6.528
BARI	201	0.167	CARTAGENA (COLOMBIA)	42	−2.185
BARRANQUILLA	169	−0.137	CARTAGENA (SPAIN)	168	−0.153
BATANGAS	112	−0.663	CASABLANCA	291	1.442
BATUMI	316	2.175	CASTELLON	144	−0.339
BEIRA	268	0.919	CAT LAI	80	−1.149

Port name	Rank	Total score	Port name	Rank	Total score
CATANIA	180	−0.021	DURBAN	349	8.082
CAUCEDO	40	−2.355	DURRES	190	0.057
CEBU	151	−0.275	DUTCH HARBOR	325	2.591
CHARLESTON	95	−0.820	EL DEKHEILA	239	0.509
CHATTOGRAM	306	1.809	ENSENADA	136	−0.378
CHIBA	134	−0.418	FELIXSTOWE	313	2.006
CHIWAN	3	−5.202	FORT-DE-FRANCE	125	−0.543
CHORNOMORSK	230	0.449	FREDERICIA	128	−0.493
CIVITAVECCHIA	175	−0.072	FREEPORT (BAHAMAS)	152	−0.271
COLOMBO	17	−3.209	FREETOWN	220	0.350
COLON	100	−0.752	FREMANTLE	326	2.716
CONAKRY	238	0.505	FUZHOU	23	−2.829
CONSTANTZA	253	0.660	GAVLE	213	0.242
COPENHAGEN	129	−0.471	GDANSK	311	1.944
CORONEL	282	1.203	GDYNIA	90	−0.942
COTONOU	244	0.562	GEMLIK	51	−1.892
CRISTOBAL	170	−0.135	GENERAL SANTOS	278	1.148
DA CHAN BAY TERMINAL ONE	31	−2.588	GENOA	321	2.420
DAKAR	177	−0.031	GIJON	187	0.013
DALIAN	33	−2.506	GIOIA TAURO	142	−0.344
DAMIETTA	250	0.650	GOTHENBURG	341	4.653
DAMMAM	102	−0.737	GRANGEMOUTH	243	0.560
DANANG	84	−1.053	GUANGZHOU	4	−5.162
DAR ES SALAAM	324	2.561	GUAYAQUIL	336	3.647
DAVAO	143	−0.341	GUSTAVIA	126	−0.528
DILISKELESI	54	−1.842	HAIFA	225	0.384
DJIBOUTI	61	−1.590	HAIPHONG	47	−1.953
DOUALA	298	1.510	HAKATA	99	−0.758
DUBLIN	262	0.839	HALIFAX	39	−2.365
DUNKIRK	118	−0.611	HAMAD PORT	36	−2.411

Port name	Rank	Total score	Port name	Rank	Total score
HAMBURG	280	1.176	KRIBI DEEP SEA PORT	303	1.701
HELSINGBORG	164	−0.196	KRISTIANSAND	186	0.008
HERAKLION	178	−0.030	LA GUAIRA	305	1.737
HONG KONG PORT, HONG KONG SAR, CHINA	7	−4.276	LA SPEZIA	241	0.548
			LAE	287	1.314
HOUSTON	266	0.878	LAEM CHABANG	55	−1.807
HUENEME	264	0.862	LAGOS (NIGERIA)	340	4.646
INCHEON	34	−2.422	LARVIK	181	−0.015
IQUIQUE	342	4.766	LATAKIA	171	−0.135
ISKENDERUN	272	1.024	LAZARO CARDENAS	25	−2.798
ITAJAI	308	1.828	LE HAVRE	258	0.746
ITAPOA	69	−1.376	LEIXOES	206	0.201
IZMIR	277	1.136	LIANYUNGANG	37	−2.375
JACKSONVILLE	161	−0.215	LIMASSOL	192	0.063
JAWAHARLAL NEHRU PORT	56	−1.786	LIRQUEN	256	0.708
JEBEL ALI	323	2.482	LIVORNO	251	0.658
JEDDAH	53	−1.862	LOME	288	1.332
JOHOR	110	−0.669	LONDON	82	−1.117
JUBAIL	21	−2.898	LONG BEACH	333	3.175
KALININGRAD	167	−0.159	LOS ANGELES	328	2.899
KAOHSIUNG	5	−4.669	LUANDA	350	8.383
KARACHI	75	−1.292	LYTTELTON	188	0.034
KEELUNG	65	−1.509	MAGDALLA	48	−1.943
KHALIFA BIN SALMAN	140	−0.356	MALABO	263	0.859
KHALIFA PORT	26	−2.795	MALAGA	108	−0.690
KING ABDULLAH PORT	2	−5.684	MANAUS	269	0.967
KINGSTON (JAMAICA)	286	1.283	MANILA	322	2.445
KLAIPEDA	301	1.635	MANZANILLO (MEXICO)	275	1.070
KOBE	19	−3.127	MAPUTO	299	1.533
KOPER	318	2.237	MARIEL	191	0.057
KOTKA	242	0.558	MARSAXLOKK	106	−0.698

Port name	Rank	Total score	Port name	Rank	Total score
MARSEILLE	345	5.696	NOUAKCHOTT	295	1.475
MATADI	209	0.238	NOUMEA	104	−0.721
MAWAN	32	−2.557	NOVOROSSIYSK	300	1.626
MEJILLONES	289	1.381	OAKLAND	332	3.163
MELBOURNE	302	1.676	ODESSA	189	0.046
MERSIN	214	0.275	OITA	185	0.004
MIAMI	200	0.149	OMAEZAKI	109	−0.680
MOBILE	101	−0.745	ONNE	270	0.994
MOGADISCIO	281	1.194	OSAKA	67	−1.440
MOJI	111	−0.663	OSLO	78	−1.192
MOMBASA	331	3.140	OTAGO HARBOUR	314	2.023
MONTEVIDEO	273	1.033	OWENDO	245	0.563
MONTREAL	285	1.231	PAITA	105	−0.705
MUHAMMAD BIN QASIM	296	1.499	PALERMO	172	−0.125
MUNDRA	50	−1.902	PANJANG	247	0.573
MUUGA—PORT OF TALLINN	195	0.092	PAPEETE	157	−0.227
NAGOYA	16	−3.251	PARANAGUA	252	0.659
NAHA	92	−0.883	PECEM	59	−1.647
NANTES−ST NAZAIRE	255	0.693	PENANG	139	−0.367
NAPIER	240	0.513	PHILADELPHIA	83	−1.080
NAPLES	150	−0.280	PHILIPSBURG	194	0.090
NASSAU	173	−0.109	PIPAVAV	38	−2.371
NELSON	210	0.240	PIRAEUS	93	−0.859
NEMRUT BAY	329	2.970	POINT LISAS PORTS	165	−0.182
NEW MANGALORE	232	0.451	POINTE-A-PITRE	147	−0.319
NEW ORLEANS	265	0.865	POINTE-NOIRE	346	5.832
NEW YORK & NEW JERSEY	89	−0.969	PORT AKDENIZ	96	−0.820
NGQURA	351	8.401	PORT BOTANY	337	3.907
NINGBO	24	−2.805	PORT BRONKA	132	−0.454
NORRKOPING	124	−0.553	PORT ELIZABETH	348	7.659

Port name	Rank	Total score	Port name	Rank	Total score
PORT EVERGLADES	208	0.213	ROTTERDAM	116	−0.611
PORT FREEPORT	182	−0.008	SAIGON	137	−0.375
PORT KLANG	14	−3.334	SAINT JOHN	211	0.241
PORT LOUIS	344	5.501	SALALAH	6	−4.531
PORT MORESBY	217	0.307	SALERNO	174	−0.080
PORT OF SPAIN	260	0.775	SALVADOR	43	−2.051
PORT OF VIRGINIA	85	−1.044	SAMSUN	297	1.502
PORT REUNION	334	3.302	SAN ANTONIO	159	−0.218
PORT SAID	58	−1.652	SAN JUAN	148	−0.303
PORT VICTORIA	292	1.457	SAN PEDRO (COTE D'IVOIRE)	319	2.267
POSORJA	77	−1.192	SAN VICENTE	221	0.361
POTI	215	0.278	SANTA CRUZ DE TENERIFE	88	−0.970
PRINCE RUPERT	330	2.979	SANTA MARTA	120	−0.589
PUERTO BARRIOS	103	−0.731	SANTO TOMAS DE CASTILLA	203	0.185
PUERTO BOLIVAR (ECUADOR)	141	−0.347	SANTOS	70	−1.376
PUERTO CABELLO	309	1.829	SAVANNAH	279	1.158
PUERTO CORTES	131	−0.468	SAVONA-VADO	310	1.897
PUERTO LIMON	94	−0.858	SEATTLE	236	0.487
PUERTO PROGRESO	259	0.750	SEPETIBA	73	−1.338
PUERTO QUETZAL	154	−0.269	SHANGHAI	63	−1.532
QINGDAO	8	−3.860	SHANTOU	91	−0.935
QINZHOU	127	−0.523	SHEKOU	9	−3.726
QUY NHON	79	−1.163	SHIBUSHI	135	−0.382
RAUMA	229	0.439	SHIMIZU	12	−3.361
RAVENNA	179	−0.025	SHUAIBA	149	−0.301
RIGA	235	0.482	SHUWAIKH	160	−0.216
RIJEKA	312	1.974	SIAM SEAPORT	115	−0.613
RIO DE JANEIRO	199	0.126	SINES	18	−3.183
RIO GRANDE (BRAZIL)	74	−1.332	SINGAPORE	15	−3.279
RIO HAINA	146	−0.322	SOHAR	71	−1.375

Port name	Rank	Total score	Port name	Rank	Total score
SOKHNA	293	1.459	TUTICORIN	130	−0.469
SOUTHAMPTON	290	1.404	ULSAN	98	−0.811
ST PETERSBURG	304	1.719	UMM QASR	233	0.452
STOCKHOLM	267	0.915	VALENCIA	283	1.211
SUAPE	81	−1.129	VALPARAISO	222	0.365
TACOMA	335	3.628	VANCOUVER (CANADA)	237	0.499
TAICHUNG	97	−0.814	VARNA	196	0.094
TAIPEI, TAIWAN, CHINA	30	−2.681	VENICE	274	1.042
TAKORADI	254	0.683	VERACRUZ	158	−0.219
TAMPA	226	0.411	VIGO	156	−0.233
TANGER MEDITERRANEAN	27	−2.769	VILA DO CONDE	183	0.000
TANJUNG EMAS	133	−0.433	VITORIA	183	0.000
TANJUNG PELEPAS	13	−3.342	VLADIVOSTOK	202	0.182
TANJUNG PERAK	153	−0.269	VOSTOCHNY	204	0.192
TANJUNG PRIOK	64	−1.521	WALVIS BAY	307	1.819
TARRAGONA	121	−0.588	WELLINGTON	176	−0.049
TAURANGA	219	0.333	WILHELMSHAVEN	119	−0.598
TEESPORT	216	0.303	WILMINGTON (NORTH CAROLINA, USA)	155	−0.237
TEMA	261	0.782	XIAMEN	62	−1.541
THESSALONIKI	284	1.229	YANGSHAN	28	−2.733
TIANJIN	218	0.310	YANTIAN	29	−2.724
TIMARU	317	2.225	YARIMCA	68	−1.393
TIN CAN ISLAND	343	4.789	YOKKAICHI	107	−0.692
TOAMASINA	227	0.433	YOKOHAMA	1	−5.995
TOKYO	35	−2.418	YEOSU	22	−2.831
TOMAKOMAI	205	0.194	YUZHNY	198	0.105
TRIESTE	212	0.241	ZEEBRUGGE	87	−0.988
TRIPOLI (LEBANON)	66	−1.497	ZHOUSHAN	20	−2.963

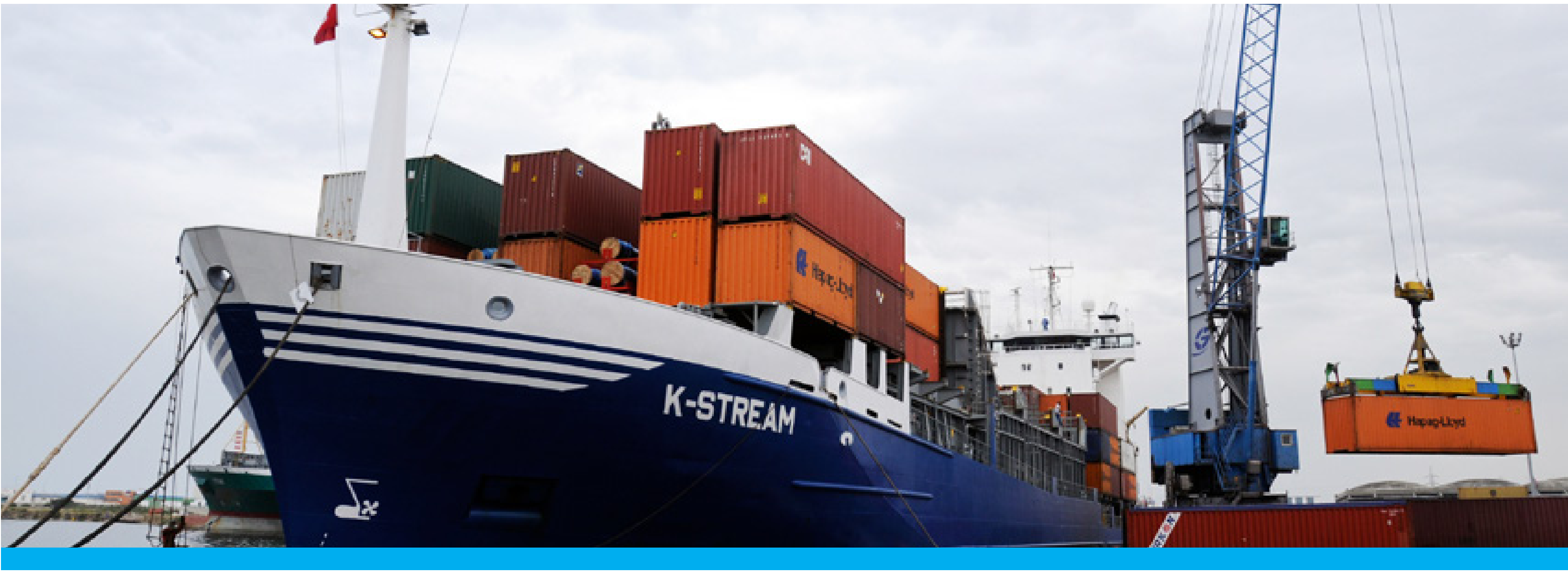
Source: Original calculations for this publication, based on CPPI 2020 data.

Table A.3. The Ports Omitted from CPPI 2020

Port name	Port name	Port name
TARTOUS	CHENNAI	BRIDGETOWN
TEKIRDAG	LAS PALMAS	PORTSMOUTH (UNITED KINGDOM)
HOSOSHIMA	GEORGETOWN (GUYANA)	YANGON
KAWASAKI	MAMONAL	ST GEORGE'S (GRENADA)
MELILLA	CADIZ	PARAMARIBO
COCHIN	APIA	ZHANJIANG
SAN CARLOS (PHILIPPINES)	BAR	QASR AHMED
VISAKHAPATNAM	PRACHUAP PORT	CASTRIES
BARCADERA	CORK	BORDEAUX
MANTA	PORT-AU-PRINCE	RADES
POZZALLO	MAZATLAN	DIEGO SUAREZ
KAMARAJAR	PLOCE	WILLEMSTAD
HELSINKI	LA ROCHELLE-PALLICE	SKIKDA
KATTUPALLI	HONOLULU	GREENOCK
KRISHNAPATNAM	ALICANTE	TURBO
SHARJAH	CHU LAI	MONROVIA
TRAPANI	NGHI SON	TRABZON
KOMPONG SOM	ANTOFAGASTA	BENGHAZI
PUERTO BOLIVAR (COLOMBIA)	LISBON	FORTALEZA
SUBIC BAY	LIVERPOOL (UNITED KINGDOM)	ESMERALDAS
KUANTAN	KING FAHD INDUSTRIAL PORT (YANBU)	VLISSINGEN
UST–LUGA	BREST	PAGO-PAGO
WILMINGTON (DELAWARE, USA)	VENTERMINALES	DR SYAMA PRASAD MOOKERJEE
CHONGMING	TOWNSVILLE	MAYOTTE
MARIN (SPAIN)	CORINTO	ADEN

Source: IHS Markit, based on CPPI 2020 data.

Appendix B: Constructing the CPPI with Factor Analysis



Structure of the data

103. ***Before discussing the methodology employed in constructing the CPPI with factor analysis (FA), it is helpful to first summarize the structure of available data.*** The dataset contains following five categories of ship size:

a. Feeders: <1,500 TEU
b. Intraregional: 1,500–5,000 TEU
c. Intermediate: 5,000–8,500 TEU
d. Neo-Panamax: 8,500–13,500 TEU
e. Ultra-large container carriers: >13,500 TEU

104. ***For each category, there are ten 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). Thus, ideally, the total variables = 5 × 10 × 2. Of course, many of them have missing values. The objective is to build a factor model to summarize these variables and then construct a port productivity index for all ports under consideration. The data structure for a particular category *k* (k = 1, 2, 3, 4, 5) can be summarized as shown in table B.1. In the following, we use *j* = 1, 2, . . . to denote various bands of call size and *i* = 1, 2, . . . to denote different ports under consideration.

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	Port-to-berth	Berth		Port-to-berth	Berth
1							
2							
3							
. . .							

Imputation of missing values

105. ***A major practical problem is that most idle hour variables have a significant number of missing values.*** For instance, the port performance dataset includes very limited observations for large call size bands when ship capacity is low. Those columns with no data can be just deleted, as they convey no information. One way to deal with missing data in variables is to use only complete cases when extracting factors. This, however, will dramatically reduce the sample size and cause information loss.

106. ***A more sophisticated approach is to use likelihood-based method to impute those missing values.*** For the current dataset, 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 dataset, 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. FA can then be based on the resultant complete dataset, instead of the original one filled with missing values. A subtle point to note: The EM algorithm could produce a negative value for some missing data, which makes little sense as idle hours cannot be less than zero. If a negative value occurs, the value should be set to zero.

107. ***The proposed imputation method relies on some randomness, specifically, the missing values are filled by drawing randomly from a normal distribution.*** This causes a lot of uncertainty, as an extreme value can be drawn by chance. Despite a very low probability, it could happen if drawn only once from the dataset. Thus, the results based on this kind of imputation could be quite unstable. The following can be done to overcome this problem:

1. Impute the missing data, say, 1,000 times (each time will produce a different "complete dataset" due to the randomness);
2. Take the average over those 1,000 complete datasets to obtain final imputation; and
3. Run the FA using this dataset and obtain the final rankings.

108. ***Using this approach, we find the scores produced are much more stable and closer to the prior expectation.*** After thorough testing, 1,000 replications proved sufficient to provide a satisfactory result in all cases. It could be posited that, as the algorithm involves randomness, different results could be produced every time. (The missing value is dealt with by the "norm" package in the statistical software used (R,) which employs an EM imputation algorithm). That would not be a problem, however, as the so-called "random seed" can be set exogenously, which allows "control" of the random sequence generated by the computer. Intuitively, if the same seed—which is nothing more than a positive integer—is used, then the same conclusion should be reached.

Why is factor analysis useful?

109. ***Essentially, for each port, quite a few variables contain information about its efficiency.*** These include average time cost under various categories: (i) different call size bands, and (ii) berth/port-to-berth. The reason FA can be helpful is 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. Usually, it means just two or three 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

110. ***As observed in table B.2, costs 2, 3, and 4 are simply multiples of cost 1.*** Although each port has four variables, one variable alone is enough to rank the efficiency of these three ports (A > B > C). Of course, this example represents an extreme case, the idea can be generalized if these variables are correlated to a less extreme extent. In that case, the factors are computed as a linear combination of costs 1 through 4. However, if costs 1 through 4 are completely independent of each other, this method makes no sense. Fortunately, this is not the case for the CPPI dataset. Thus, for each port, we can compute its score on all factors and then combine those scores together to reach a final efficiency score.

111. ***Note that for FA, we do not calculate scores for each call size range.*** On the contrary, the whole dataset is used simultaneously to obtain latent factors. This contrasts sharply with the administrative methodology. The approach using FA utilizes all correlations among hours for various call size bands, which from a statistical viewpoint is more efficient. One downside is that FA does not consider that some observations are more reliable than others as they are based on more calls. Therefore, the result could be seriously distorted in the presence of large outliers. This is an area necessitating further investigation in future iterations of the CPPI.

Statistical methodology

112. ***The final index is a weighted average of five subindices.*** Specifically, for a particular port *i*, it is defined as:

$$CPPI(i) = \sum_{k=1}^{5} w_k \cdot I_{k,i}$$

113. ***Where $I_{k,i}$ denote the index for five ship size categories under consideration.*** The weights w_k should be chosen according to the relative importance of these five cases and intuitively it should satisfy $w_1<w_2<w_3<w_4<w_5$. When implementing FA, these weights were selected using the same assumptions in the administrative approach. Note that when aggregating across various ship size group, missing observations should be dealt with as well. In this regard, if the data for a port is unavailable within a ship size group, the assumed imputation is zero. By the construction of factor analysis, zero is always the group average score of observed ports. Thus, assigning zero to unobserved ports seems plausible. The total score for a particular ship size range, $I_{k,i}$, is computed as the average of scores on a set of *m* unobserved factors. Specifically:

$$I_{k,i} = \sum_{d=1}^{m} w_d \cdot f_{k,i,d}$$

114. Here, the weight w_d is proportional to the contribution of d^{th} factor in total variance. Those factors can be collected in a vector, $\boldsymbol{F}_{k,i} = (f_{k,i,1}, \dots, f_{k,i,m})'$, and they are obtained based on the following model:

$$X_{k,j,i} = \Lambda'_{k,j} \cdot F_{k,i} + e_{k,j,i}$$

115. Where $X_{k,j,i}$ represents port-to-berth and berth idle hours for port *i*, ship size category *k* and call size band *j*. $\Lambda_{k,j} = (\lambda_{k,j,1} \dots \lambda_{k,j,m})'$ denotes vectors of factor loadings and $e_{k,j,i}$ represents idiosyncratic errors.

116. ***Each factor characterizes one aspect of port inefficiency. Before calculating the factor score, first the number of latent factors must be determined.*** For the imputed complete dataset, the preliminary analysis shows the number of factors should be three (that is, m = 3). Indeed, by checking the scree plot, it is clear the first three principal components account for more than 80 percent of total variance. Hence, these variables can be adequately captured by three latent factors. Therefore, the final score would be weighted average of three factor scores. Loosely speaking, the factors extracted correspond to the inefficiency on handling small, medium, and large calls. The scores are standardized and a negative score on a factor implies an above-average performance in that aspect.

117. ***Another challenge when applying factor analysis is the need to deal with the so-called "rotation indeterminacy," which means factor loadings cannot be identified without additional restrictions.*** To this end, the "varimax rotation" method is employed, which makes the factors extracted easier to interpret. Also, the method to compute the factor scores must be selected. Various approaches exist in the literature and for this purpose, Anderson-Rubin method has been selected. This method yields approximately standardized factor score estimates with some nice properties. Given complete data, the above procedure is implemented using a standard software package. The result ranks the ports in descending order, with a large value of $I_{k,i}$ indicating a particular port is less efficient.

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