3

PERFORMANCE INDICATORS

This chapter looks at a series of performance indicators relating to the maritime transport sector. It provides an update on port activity, with a focus on the liner shipping connectivity index, the time ships spend in ports and data on the operation of container terminals. It also offers insights from the port performance scorecard of the TrainForTrade Port Management Programme of UNCTAD. Finally, the chapter presents novel metrics on greenhouse gas emissions from shipping in terms of flag, vessel type and other parameters.

The port data offer useful information on the determinants of port performance, including infrastructure investments, private sector participation and trade facilitation. The data also show the relevance – and the limits – of economies of scale as they apply to container shipping and port operations. Each of the different data sources is helpful in the analysis of complementary information:

- Section A uses automatic identification system data for the complete world fleet and port calls at the country level, with a high level of detail about the vessels and the time they spent in port in 2018, 2019 and early 2020.[7]
- Section B is devoted to data relating to container ships. It employs data on their shipping schedules and presents statistics on the network of the services and companies from 2006 to early 2020.[8] Unlike the automatic identification system data discussed in section A, the data in section B do not cover other vessel types.
- Section C utilizes data obtained from 10 of the world's largest shipping companies on container ports of call of these companies in 2019. The section provides a detailed analysis of the performance of container terminals for these ports.[9]
- Section D uses data from selected ports that are members of the TrainForTrade Port Management Programme, based on a detailed questionnaire elaborated by UNCTAD.[10]
- Section E makes use of automatic identification system data, coupled with information about vessel types and other ship characteristics, to discuss a key performance indicator for the shipping side of maritime transport, notably carbon-dioxide emissions. By doing so, it is possible to provide statistics on the annual carbon-dioxide emissions of the world fleet.[11]

It is reassuring that the statistics generated by different means from different sources are consistent in their main metrics, for example, as regards the relationships between vessel sizes, their position in the shipping network and economic development on the one hand, and performance indicators on the other.

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[7] Underlying data provided by MarineTraffic.

[8] Underlying data provided by MDS Transmodal.

[9] Underlying data provided by Journal of Commerce–IHS Markit.

[10] Underlying data provided by the ports in annual surveys.

[11] Underlying data provided by Marine Benchmark.

PERFORMANCE INDICATORS

Most connected port pairs

1. **Ningbo–Shanghai, China**
   52 liner shipping companies providing 154 direct services and a total deployed annualized capacity of 50.1 million TEUs
2. **Port Klang, Malaysia–Singapore**
   41 companies
3. **Busan, Republic of Korea–Shanghai, China**
   38 companies
4. **Shanghai–Qingdao, China**
   37 companies

Port calls

in 2019

Recorded arrivals
4,362,737

Median time in port
0.966 day

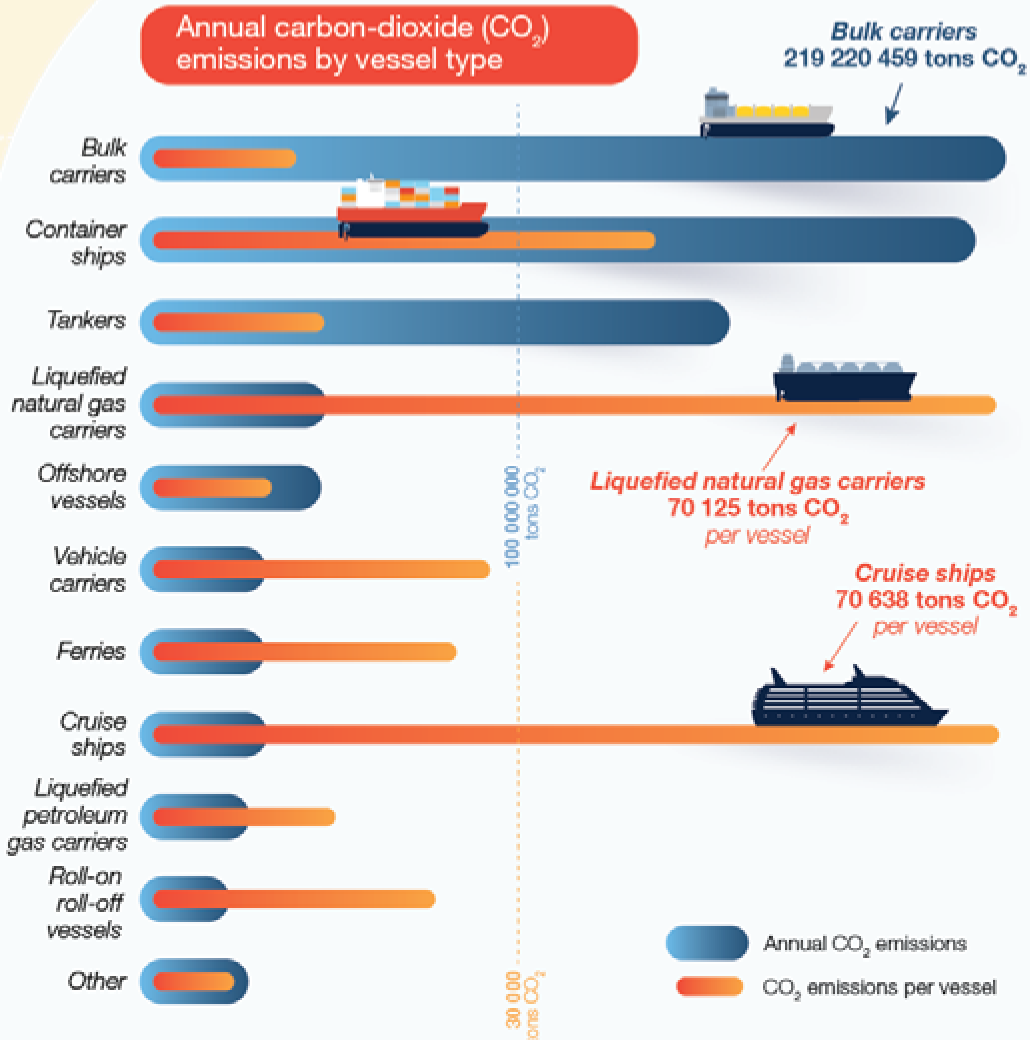
Average age of vessels
18 years

Average size of vessels
14,980 gross tons

Maximum size of vessels
234,006 gross tons

Maximum container carrying capacity of vessels
23,756 TEUs

Annual carbon-dioxide (CO_2) emissions by vessel type



A. PORT CALLS AND TURNAROUND TIMES

1. Port calls increase and turnaround times improve

The global number of recorded commercial shipping port calls of ships of 1,000 gross tons and above rose by 6.07 per cent between 2018 and 2019 (figure 3.1). Ports further improved their overall efficiency, as the median time a ship spent in port decreased slightly by 0.41 per cent (table 3.1), from 0.970 days to 0.966 days.

The performance of seaports is an important determinant of trade costs and connectivity (Sánchez et al., 2003; UNCTAD, 2017a). The longer ships spend in port, the less time they have at sea to carry cargo for international trade. Longer times in port will lead to either higher speeds at sea and thus greater fuel consumption and carbon-dioxide emissions or the use of additional vessels to maintain the same frequency of services. This also results in longer transit times and higher inventory-holding costs. Neither of these outcomes is desirable for carriers or shippers. For ports, too, faster turnaround times are of interest, as they effectively increase their throughput capacity with the same fixed assets. Port efficiency and prompt turnarounds are therefore mutually rewarding.

A shorter time in port is a positive indicator of a port's efficiency and trade competitiveness, although there may also be good reasons for a ship to spend more time in a port, as it may bunker, purchase goods or services, or simply load and unload high volumes of goods for import and export. Benefiting from a data set provided by MarineTraffic, which draws on automatic identification system data emitted by the world's commercial fleet, this section provides an update on the time ships spent in port during calls in 2018 and 2019, including initial trends that can be observed during that period.[12]

In 2019, more than half (55 per cent) of recorded port calls worldwide were passenger ships, followed by tankers and other wet bulk carriers (12 per cent), container ships (11 per cent) and general cargo break bulk ships (10 per cent) (table 3.2). Container ships had the fastest turnaround time, with a median of 0.69 days, an improvement of one per cent over 2018. Dry bulk carriers took the longest to load and unload – more than two days' median time. For all vessel types, 2019 recorded an increase in port calls and a slight decrease in the median turnaround time, as compared with 2018.

[12] UNCTAD calculations are based on data provided by MarineTraffic (www.marinetraffic.com). Aggregated figures are derived from the fusion of automatic identification system data with port-mapping intelligence by MarineTraffic, covering ships of 1,000 gross tons and above. Passenger ships and roll-on roll-off carriers are not included in the computation of turnaround times. Only arrivals have been taken into account to measure the number of port calls. Cases with less than 10 arrivals or 5 different vessels on a country level per commercial market as segmented are not included. The data will be updated every six months on the maritime statistics portal of UNCTAD (http://stats.unctad.org/maritime).

2. Turnaround times vary by vessel type

Container ships

The maximum vessel size of container ships in gross tons went up by 6.87 per cent between 2018 and 2019, while the increase in TEUs was even greater, at more than 10.94 per cent. The largest container ships are now de facto as big as the largest wet bulk carriers and bigger than the largest dry bulk carriers and cruise ships (table 3.2; see also chapter 2 for more details of the world fleet).

The countries with the most container ship port calls in 2019 (table 3.3, figure 3.2), were China (72,583), Japan (39,066) and the Republic of Korea (23,933). Among the top 25 countries in container port calls, only 4 recorded median turnaround times of more than one day, notably Australia, Indonesia, Viet Nam and the United States, while in Japan and Taiwan Province of China, a container ship spent a median time of less than half a day in port (table 3.3).

Section C discusses in more detail the possible determinants of why container ships may spend more time in port in some countries than in others. Most importantly, the time in port is associated with the number of containers that are loaded and unloaded during each port call.

Tankers and other liquid bulk carriers

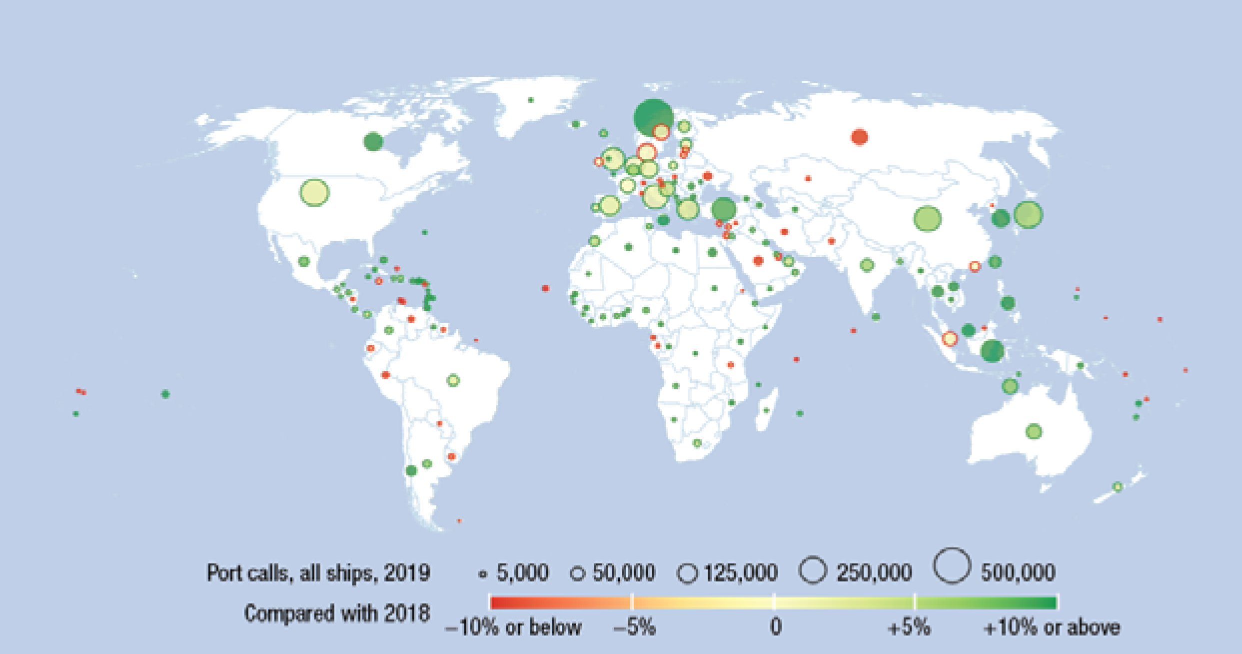
With 44,633 port calls to its name, Japan continued to record the largest number of arrivals of tankers and other liquid bulk carriers in 2019, albeit slightly less (-0.55 per cent) than in 2018. It is followed by the Netherlands (41,042 arrivals), China (40,702) and Singapore (36,187). Together, these four countries account for 30.9 per cent of the world total for this vessel type, while the top 20 countries account for 74.6 per cent.

Japan (7.4 hours) and Germany (8.5 hours) represent the shortest median turnaround times, compared with India and the United States, whose tankers spent the longest time in port. There is a close relationship between vessel sizes and time spent in port, as smaller ships take less time to load or unload. Most countries among the top 20 receive ships of 300 000 dwt and above. The exceptions are Belgium, Hong Kong, China and the Russian Federation, where port depth and infrastructure do not accommodate vessels of this size.

Dry bulk carriers

The largest dry bulk carriers of 404,389 dwt are deployed for the transportation of iron ore from Brazil to China or to a distribution hub in Malaysia. With regard to port calls, China received by far the largest number of dry bulk carriers in 2019 (60,420 arrivals), followed by Japan (30,528 arrivals) and Australia (15,399 arrivals).

Figure 3.1 Port calls, all vessel types, 2019



Source: UNCTAD calculations, based on data provided by MarineTraffic.

Notes: Ships of 1,000 gross tons and above. For data that include all countries, see http://stats.unctad.org/maritime.

Table 3.1 Recorded port calls and time in port, 2018 and 2019

Port calls	2018	2019	Change 2019 over 2018
Number of recorded arrivals	4 112 944	4 362 737	6.07
Median time in port (days)	0.970	0.966	- 0.41
Average age of vessels (years)	18	18	0.00
Average size of vessels (gross tons)	15 066	14 980	- 0.57
Maximum size of vessels (gross tons)	234 006	234 006	0.00
Maximum container-carrying capacity of vessels (20-foot equivalent units)	21 413	23 756	10.94
Total	**7.66**	**1.58**	**0.53**

Source: UNCTAD calculations, based on data provided by MarineTraffic (www.marinetraffic.com).

Roll-on roll-off carriers

Japan leads the world in roll-on roll-off ship arrivals, with 34,995 port calls in 2019. It is followed by the United Kingdom (16,465), the Netherlands (12,494), Spain (11,529) and Italy (9,465). This vessel type mainly includes ferries for coastal and inter-island transport, as well as car carriers. As an island economy and major automobile exporter, Japan is particularly dependent on roll-on roll-off shipping.

Passenger ships

In 2019, Norway accounted for the largest share of port calls (535,649) of passenger ships of 1,000 gross tons, followed by the United States (213,902) and Italy (194,992). The latter two are home ports to many cruise ships that are included in this category. In the Baltic and Mediterranean seas, as well as in countries with large archipelagos, such as Indonesia, Japan, Norway, the Philippines and Turkey, maritime passenger transport often replaces buses and trains as the most economical and environmentally friendly mode of public transport.

Liquefied natural gas carriers

The number of arrivals of liquefied natural gas carriers rose significantly between 2018 and 2019 (more than 15 per cent), in line with the growing demand for this source of energy and the corresponding fleet growth (table 2.1). The countries with the most port calls in this segment were Japan (1,901), Australia (1,179) and Qatar (1,043). Among the top 20 countries, ships spent

Table 3.2 Port calls and time in port by vessel type, 2019

Vessel type	Number of arrivals	Number of arrivals, change over 2018 (percentage)	Median time in port (days)	Median time in port (days), change over 2018 (percentage)	Average size of vessels (gross tons)	Average size of vessels, change over 2018 (percentage)	Average age of vessels	Maximum size of vessels (gross tons)
Container ships	474 553	4.52	0.69	-1.09	38 172	-0.90	13	232 618
Dry break bulk carriers	446 817	3.83	1.10	-0.71	5 476	0.70	20	91 784
Dry bulk carriers	277 872	7.06	2.01	-2.14	32 011	0.22	15	204 014
Liquefied natural gas carriers	12 222	15.12	1.11	-0.15	95 469	1.79	10	168 189
Liquefied petroleum gas carriers	55 227	11.89	1.01	-0.60	10 300	-3.40	14	59 226
Passenger ships	2 378 937	6.80	-		8 859	-0.77	21	228 081
Roll-on roll off carriers	190 907	1.80	-		25 277	-0.36	19	100 430
Wet bulk carriers	526 202	6.49	0.93	-0.56	15 702	1.02	14	234 006
All	**4 362 737**	**6.07**	**0.97**	**-0.41**	**14 980**	**-0.57**	**18**	**234 006**

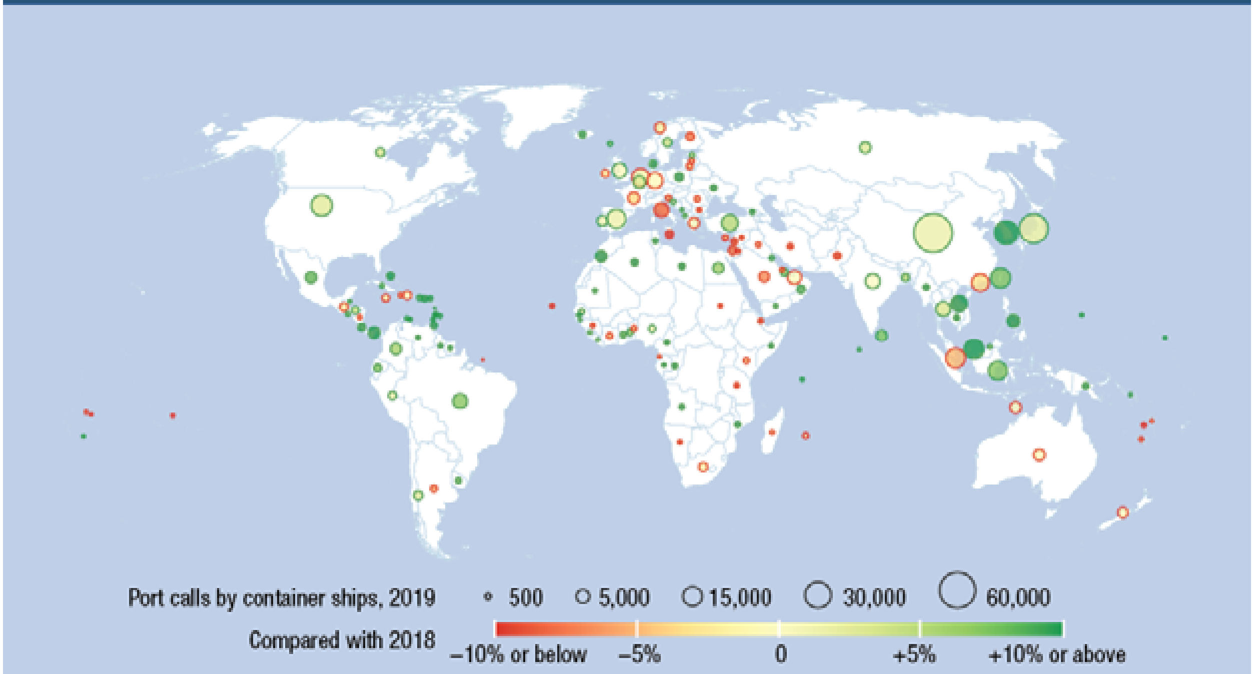
Source: UNCTAD calculations, based on data provided by MarineTraffic (www.marinetraffic.com).
Note: Ships of 1,000 gross tons and above.

Table 3.3 Port calls and median time spent in port by container ships: Top 25 countries, 2019

Country	Number of arrivals	Median time in port (days)	Average age of vessels (years)	Average size of vessels (gross tons)	Maximum size of vessels (gross tons)	Maximum cargo-carrying capacity of vessels (TEU)
China	72 583	0.60	12	50 062	232 618	23 756
Japan	39 066	0.35	12	17 205	219 688	20 388
Republic of Korea	23 933	0.58	14	30 951	232 618	23 756
United States	19 574	1.03	13	59 336	194 250	19 462
Taiwan Province of China	16 733	0.44	14	29 571	219 775	20 388
Malaysia	16 459	0.75	14	41 499	232 618	23 756
Singapore	16 299	0.77	13	54 612	228 741	21 413
Spain	15 137	0.65	14	35 592	232 618	23 756
Indonesia	14 715	1.05	14	15 475	131 332	11 356
Hong Kong, China	12 355	0.53	14	39 826	228 741	21 413
Netherlands	12 155	0.80	13	32 385	232 618	23 756
Turkey	11 011	0.63	16	34 599	176 490	15 908
Viet Nam	10 041	1.03	16	18 459	175 688	16 000
Germany	9 543	0.74	13	42 018	232 618	23 756
United Kingdom	8 395	0.73	14	36 766	232 618	23 756
India	8 211	0.91	15	46 994	153 666	13 386
Italy	8 171	0.91	15	44 772	194 849	19 462
Thailand	8 130	0.68	17	22 653	154 000	14 220
Brazil	8 050	0.73	9	62 947	119 441	11 923
United Arab Emirates	7 082	0.94	15	47 830	219 277	21 200
Philippines	5 492	0.84	15	19 124	71 786	6 800
Belgium	5 190	1.00	14	52 967	232 618	23 756
France	4 468	0.75	13	56 344	219 277	20 776
Australia	4 400	1.18	12	48 715	109 712	9 971
Panama	4 347	0.63	11	45 162	150 000	14 000
World total	**474 553**	**0.69**	**13**	**38 172**	**232 618**	**23 756**

Source: UNCTAD calculations, based on data provided by MarineTraffic.
Notes: Ships of 1,000 gross tons and above. For data that include all countries, see http://stats.unctad.org/maritime.

Figure 3.2 Port calls by container ships, 2019



Source: UNCTAD calculations, based on data provided by MarineTraffic.

Notes: Ships of 1,000 gross tons and above. For data that include all countries, see http://stats.unctad.org/maritime.

the least time per port call in Norway (eight hours on average), and the longest in Singapore (two days).

Break bulk vessels

Norway (33,564 calls), China (30,007) and the Russian Federation (28,837) are the countries with the most port calls by break bulk general cargo vessels. Among the top 20 countries in this category, Germany and Norway have the shortest median turnaround times at 0.35 and 0.33 days respectively, while in France (1.58 days), Italy (1.98 days) and the Russian Federation (1.61 days), general cargo ships spent the longest time in their ports.[13]

3. Small island economies depend heavily on general cargo ships

Break bulk general cargo ships have a declining share in the world fleet (see also chapter 2). They remain, however, particularly important for small island economies and destinations with little port traffic, where the deployment of more specialized ships may not be justified. For small island economies or countries that are archipelagos, such as Indonesia or the Philippines, break bulk general cargo vessels account for a substantial share of the countries' total port calls.

Some small island economies are among those with the longest port turnaround times for general cargo vessels, as they may lack infrastructure or specialized port equipment. Others have very short turnaround times, owing to the lack of congestion because of low frequencies and the low cargo volumes in loading and unloading (UNCTAD, 2019a). Between 2018 and 2019, the Comoros, Maldives and New Caledonia saw significant improvements both in terms of increased port calls and shorter port turnaround times. Fiji and New Caledonia are served by the youngest and most modern fleet of general cargo ships, while French Polynesia, Maldives and Saint Kitts and Nevis receive vessels that are on average more than 30 years old (table 3.4).

4. A downturn in port calls during the COVID 19 pandemic

The COVID 19 crisis led to fewer port calls for most vessel types during the first half of 2020 (figure 3.3).

Liquefied natural gas and liquefied petroleum gas carriers and tankers (wet bulk carriers) continued to record increases in port calls during the first quarter of 2020. In the second quarter, however, all vessel types experienced a decline in the number of port calls. The hardest hit were roll-on roll-off vessels, which include ferries and other vessels that also carry passengers.

With regard to container ship port calls, the number of arrivals started to fall below 2019 levels about week 12 (mid-March 2020) and began to recover gradually about week 25 (third week of June) (figure 3.4). By mid-June, the average number of container vessels arriving weekly at ports worldwide had sunk to 8,722, an 8.5 per cent year-on-year drop. Since then, the average weekly calls started to recover, rising to 9,265 in early

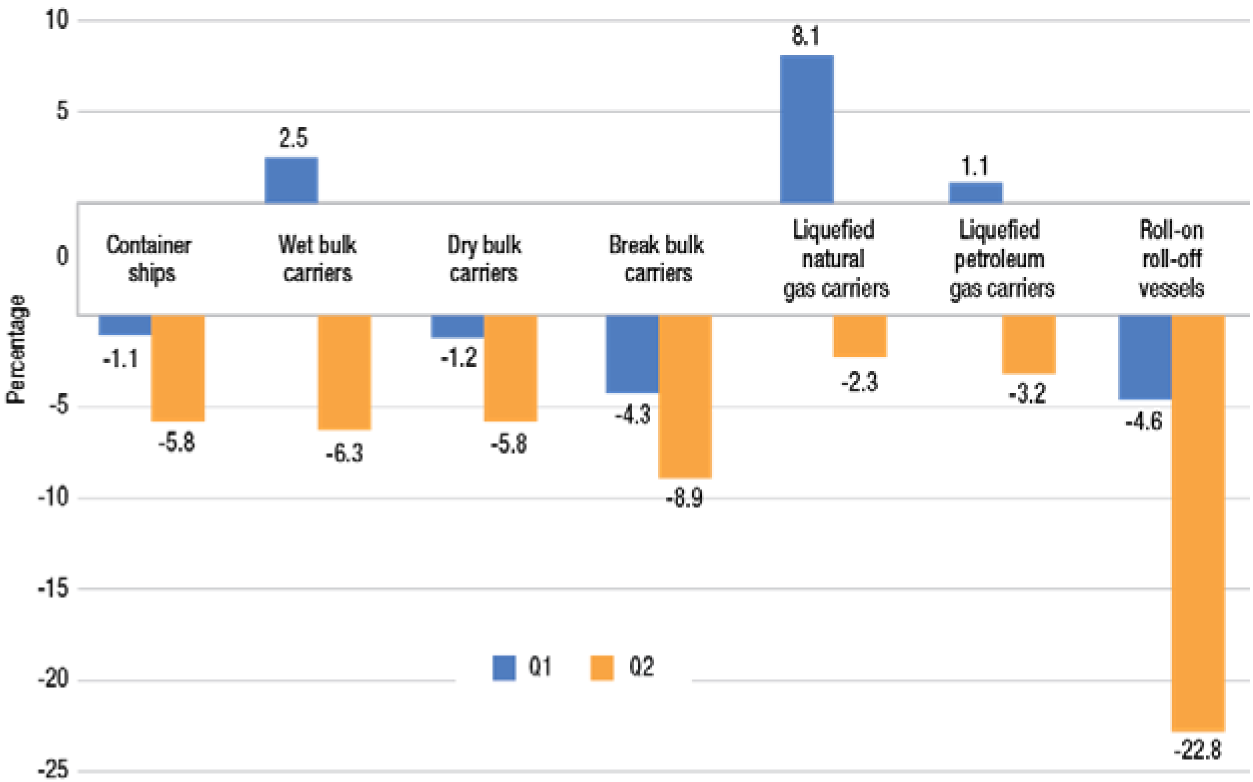
[13] See http://stats.unctad.org/maritime for the complete tables concerning all vessel types.

Table 3.4 Port calls and median time spent in port, general cargo ships, 2019
(Selected small island economies)

Country or territory, break bulk cargo	Number of arrivals 2019	Number of arrivals, change 2019 over 2018 (percentage)	Median time in port, 2019 (days)	Median time in port, change 2019 over 2018, (percentage)	Average age of vessels (years)	Average size of vessels (gross tons)	Maximum size of vessels (gross tons)
American Samoa	57	-6.6	0.63	10.3	16	9 494	18 100
Antigua and Barbuda	193	12.9	0.39	3.4	22	5 797	17 644
Aruba	59	- 51.2	0.73	82.3	19	9 729	28 805
Bahamas	464	-15.3	0.41	28.9	26	4 831	91 784
Barbados	309	-5.8	0.56	4.3	22	6 813	22 698
Cabo Verde	360	36.9	0.63	-10.6	21	5 095	46 295
Cayman Islands	153	-14.0	0.56	3.8	24	7 513	27 818
Christmas Island	50	-35.1	0.43	-10.7	14	5 913	10 021
Comoros	197	32.2	1.03	-25.3	15	6 352	24 960
Curaçao	320	-31.9	0.53	1.9	18	3 285	16 137
Dominican Republic	107	-0.9	0.40	-1.2	16	6 586	14 413
Fiji	457	40.6	0.95	39.7	7	4 914	40 393
French Polynesia	555	-12.9	0.19	20.4	39	3 165	54 529
Grenada	124	-23.5	0.58	43.8	24	7 016	16 639
Guam	67	-25.6	2.11	-2.5	20	8 979	61 185
Guernsey	339	63.0	0.14	13.4	25	1 687	2 601
Haiti	384	-4.5	0.96	1.9	21	4.760	24 140
Jamaica	576	1.4	0.90	-10.6	13	9.099	29 688
Maldives	101	44.3	0.49	-89.1	31	4.041	20 965
Martinique	193	-9.0	0.40	2.5	17	8.628	27 828
Mauritius	133	-10.1	3.48	47.6	21	5 317	21 483
Mayotte	25	-66.2	2.23	-8.1	11	7 219	24 960
Micronesia	73	-24.0	0.35	-53.6	22	4 352	9 924
New Caledonia	549	52.5	1.24	-24.0	8	7 507	29 829
Reunion	53	-11.7	1.30	-13.6	12	8 323	21 483
Samoa	68	-2.9	0.54	41.9	15	9 045	18 100
Seychelles	137	-18.5	5.22	-8.7	24	5 384	16 803
Sint Maarten	179	-39.9	0.38	-25.0	18	6 374	22 698
Solomon Islands	50	-38.3	1.75	2.9	17	10 509	18 468
Saint Kitts and Nevis	207	6.2	0.27	14.3	35	3 274	14 413
Saint Lucia	287	8.7	0.41	-10.6	28	5 892	16 137
Saint Vincent and the Grenadines	116	-38.6	0.38	23.6	16	9 761	16 137
Timor-Leste	164	6.5	0.98	-2.5	16	4 339	9 719
Tonga	82	3.8	0.39	-12.3	15	8 363	18 100
Trinidad and Tobago	584	-14.4	0.91	13.6	16	7 326	30 488
Turks and Caicos Islands	197	-27.0	0.43	-3.6	19	1 749	2 191
Tuvalu	69	-4.2	11.21	-19.9	28	4 047	6 965
Vanuatu	17	-55.3	0.83	21.4	15	15 551	18 100
Word total	**446 817**	**3.8**	**1.10**	**-0.7**	**20**	**5 476**	**91 784**

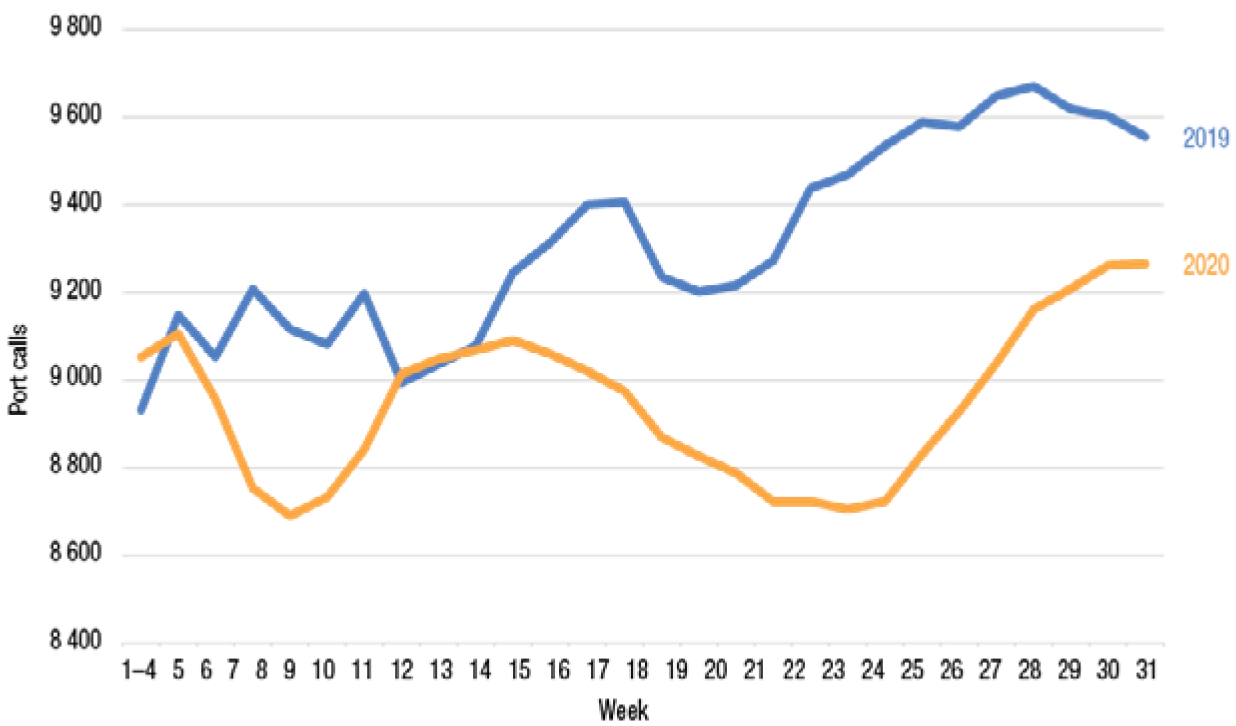
Source: UNCTAD calculations, based on data provided by MarineTraffic.
Note: Ships of 1,000 gross tons and above. For data that include all countries, see http://stats.unctad.org/maritime.

Figure 3.3 Global change in the number of port calls, first and second quarters of 2020 compared with the first and second quarters of 2019, selected vessel types



Source: UNCTAD calculations, based on data provided by MarineTraffic.
Abbreviation: Q, quarter.

Figure 3.4 Number of weekly container ship port calls worldwide, moving four-week average, 2019 and 2020



Source: UNCTAD calculations, based on data provided by MarineTraffic.

August 2020, just 3 per cent below the levels recorded 12 months earlier. For a more detailed analysis by region, see UNCTAD, 2020a (https://unctad.org/en/pages/newsdetails.aspx?OriginalVersionID=2465).

5. Future uses of automatic identification system data to assess port and shipping performance

The automatic identification system was initially developed and introduced as a tool to support navigational safety. Today, the signals transmitted through the system are used to track the movement of vessels, even if the owners of those vessels may prefer otherwise. Without publicly available data, the data and analysis presented above would not be possible. The transmission of signals from automatic identification systems is mandatory and increasingly scrutinized, and the data coverage is continuously improving. Combining automatic identification system-derived statistics with other sources of data and information can help respond to growing demands for optimization of the supply chain, monitoring of emission data and trade forecasts.

Optimizing the supply chain

Already today, initiatives such as port-call optimization benefit from automatic identification system data (UNCTAD, 2020b). Beyond the seaside of the operation, the whole supply chain can benefit from exchanging data, including automatic identification system data on ship movements, but also data on other modes of transport, ports and the goods that are being traded. In this context, digitalization, artificial intelligence, blockchain, the Internet of things and automation are of growing relevance. They help optimize existing processes, create new business opportunities and transform supply chains and the geography of trade (UNCTAD, 2019b).

Notwithstanding the potential opportunities and benefits offered by the automatic identification system, including low-cost global access, its use requires capacity-building and investments in digitalization, especially in developing countries. There is a need for policy design at the national and international levels to ensure that developing countries can benefit from the automatic identification system and the digitalization of maritime transport (UNCTAD, 2019b).

Trade statistics and forecasts

Automatic identification system data do not include information about the cargo the ships carry. However, by combining the data on vessel moves and drafts with information on vessel type, trade flows and countries of departure and destination, automatic identification system data can help obtain an increasingly exact and up-to-date picture of trade flows (Arslanalp et al., 2019; Cerdeiro et al., 2020; United Nations, 2020; World Bank, 2020). Combined with information on the speed of vessels, port departures and idle ships, this can serve to produce nowcasts and forecasts of trade and economic growth. It can also help verify trade statistics by checking published trade data against the vessel moves that would be necessary to actually transport those goods. Such efforts would benefit from further standardization of data.

Reducing emissions

Shipping will have to move away from carbon. Initiatives such as the Getting to Zero Coalition, supported by UNCTAD, aim to reduce carbon-dioxide emissions from shipping to net zero (Global Maritime Forum, 2020). A ship's emissions depend on numerous factors, including vessel size, engine type, fuel used and speed. Automatic identification system data – combined with information on the ship's engine and fuel – can help assign carbon-dioxide emissions to the country of the vessel's flag or the country's waters where the carbon dioxide is being emitted. Section E below provides an example of such use of automatic identification system data.

B. CONTAINER SHIPPING: LINER SHIPPING CONNECTIVITY

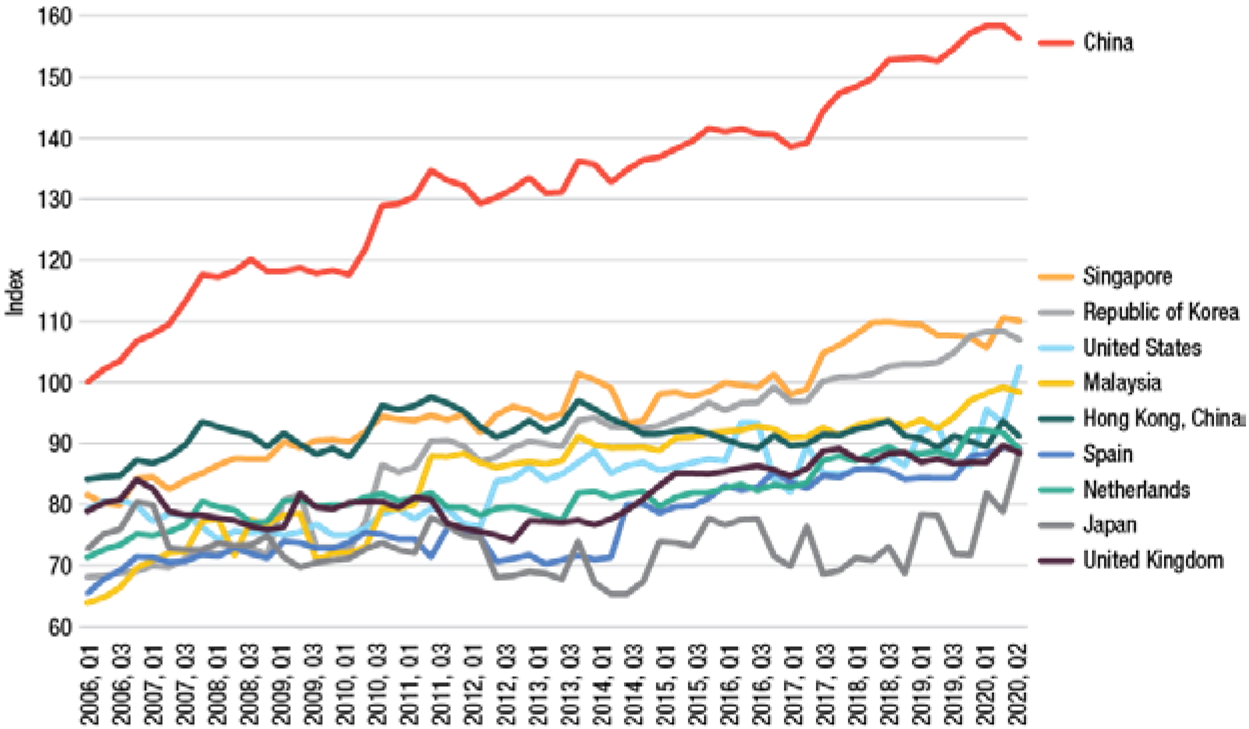
1. Countries' evolving liner shipping connectivity

In 2020, 6 of the 10 most connected economies are in Asia (China; Singapore; the Republic of Korea; Malaysia; Hong Kong, China; and Japan, 3 are in Europe (Spain, the Netherlands, and the United Kingdom), and 1 in North America (the United States) (figure 3.5). The most connected country – China – improved its liner shipping connectivity index by 56 per cent since the baseline year 2006, while the global average liner shipping connectivity index went up by 50 per cent during the same period.

Since 2020, UNCTAD, in collaboration with MDS Transmodal, reports quarterly values for the liner shipping connectivity index, both at the port and country levels.[14] The work is based on empirical

[14] UNCTAD developed the liner shipping connectivity index in 2004. The basic concepts and major trends are presented and discussed in detail in UNCTAD, 2017a and MDS Transmodal, 2020. In collaboration with MDS Transmodal, the liner shipping connectivity index was updated and improved in 2019 to offer additional country coverage, including several small island developing States, and to add a component covering the number of countries that can be reached without the need for trans-shipment. The remaining five components, notably the number of companies that provide services, the number of services, the number of ships that call per month, total annualized deployed container-carrying capacity and ship sizes, have remained unchanged. Applying the same methodology as for the country-level liner shipping

Figure 3.5 Liner shipping connectivity index of top 10 economies, first quarter 2006– second quarter 2020



Source: UNCTAD calculations, based on data provided by MDS Transmodal. For the data set that includes all countries, see http://stats.unctad.org/LSCI.

Abbreviation: Q, quarter.

evidence that a country's competitiveness and access to overseas markets benefit from better liner shipping connectivity, which reflects access to the global container shipping network (UNCTAD, 2017a). This section first analyses trends at the country and port levels, and then goes on to discuss developments regarding the different components from which the index is generated.

connectivity index, UNCTAD has generated a new liner shipping connectivity index for ports.

Each of the six components of the port liner shipping connectivity index captures a key aspect of connectivity:

- A large number of scheduled ship calls allows for a high frequency of servicing imports and exports.
- A large deployed capacity allows shippers to trade sizable volumes of imports and exports.
- A large number of regular services to and from a port is associated with shipping options to reach different overseas markets.
- A large number of liner shipping companies that provide services is an indicator of the level of competition in the market.
- Large ship sizes are associated with economies of scale on the sea leg and possibly lower transport costs.
- A large number of destination ports that can be reached without the need for trans-shipment is an indicator of fast, reliable and direct connections to foreign markets.

Since 2020, the same methodology has been applied to country and port levels on a quarterly basis.

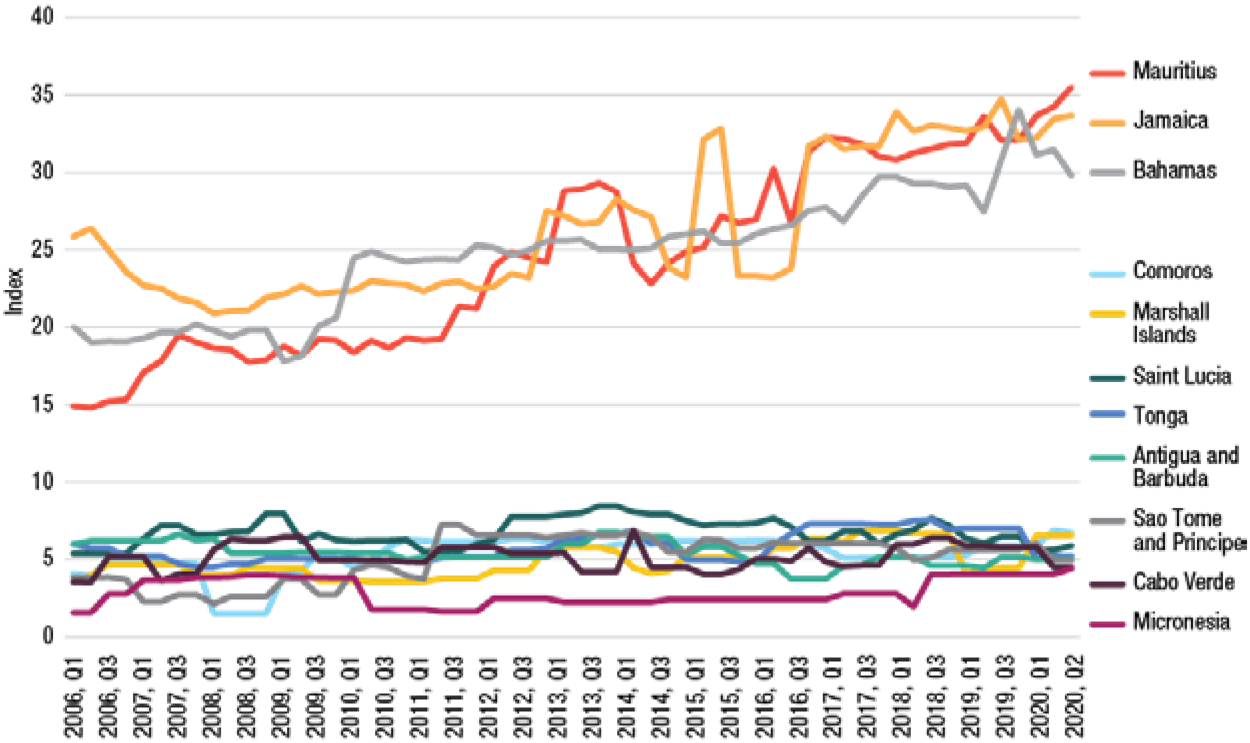
2. Liner shipping connectivity of many small island developing States stagnates

Many small island developing States and other small island economies have poor shipping connectivity. Yet, there is often little they can do to enhance their liner shipping connectivity, which remains limited, given their geographic position, lack of a wider hinterland and low trade volumes. Figure 3.6 depicts the liner shipping connectivity index of selected small island developing States and other small island economies where shipping schedules are reported separately.

A few small island developing States, notably the Bahamas, Jamaica and Mauritius, have been able to position their ports as trans-shipment hubs and increase their attraction as ports of call. Mauritius, for example, has more than doubled its liner shipping connectivity index since 2006. The additional fleet deployment stemming from trans-shipment can also be used for shipments of national importers and exporters. Nonetheless, most small island developing States continue to experience low levels of connectivity, with a lack of improvement over the years.

Among the leading ports in each subregion, Suva, in the Pacific, has the lowest port liner shipping connectivity index (figure 3.8). Among the 50 least connected economies, 37 are small island developing States.

Figure 3.6 Liner shipping connectivity index of selected small island developing States, first quarter 2006–second quarter 2020



Source: UNCTAD calculations, based on data provided by MDS Transmodal. For the data set that includes all countries, see http://stats.unctad.org/LSCI.
Abbreviation: Q, quarter.

Among the 20 least connected economies, all except the Democratic People's Republic of Korea, Moldova and Paraguay are small island developing States, and the latter two are landlocked countries, whose low liner shipping connectivity index is generated from containerized river transport services.

Achieving economies of scale, while ensuring some level of competition and choice for their shippers is a difficult conundrum for many small island developing States and other small economies or remote ports. If better port infrastructure, through the use of dredging and specialized port cranes, for example, makes it possible for larger and more efficient ships to call, these same ships will then require fewer port calls to carry the same monthly volume of foreign trade. This may result in even less choice for shippers and a lower frequency of services. Put differently, it may not be possible, especially for small island developing States, to improve on all components of the liner shipping connectivity index, as illustrated in figure 3.9 (see also chapter 4, which discusses the challenge faced by small island developing States in the Pacific).

3. Developments at the port level

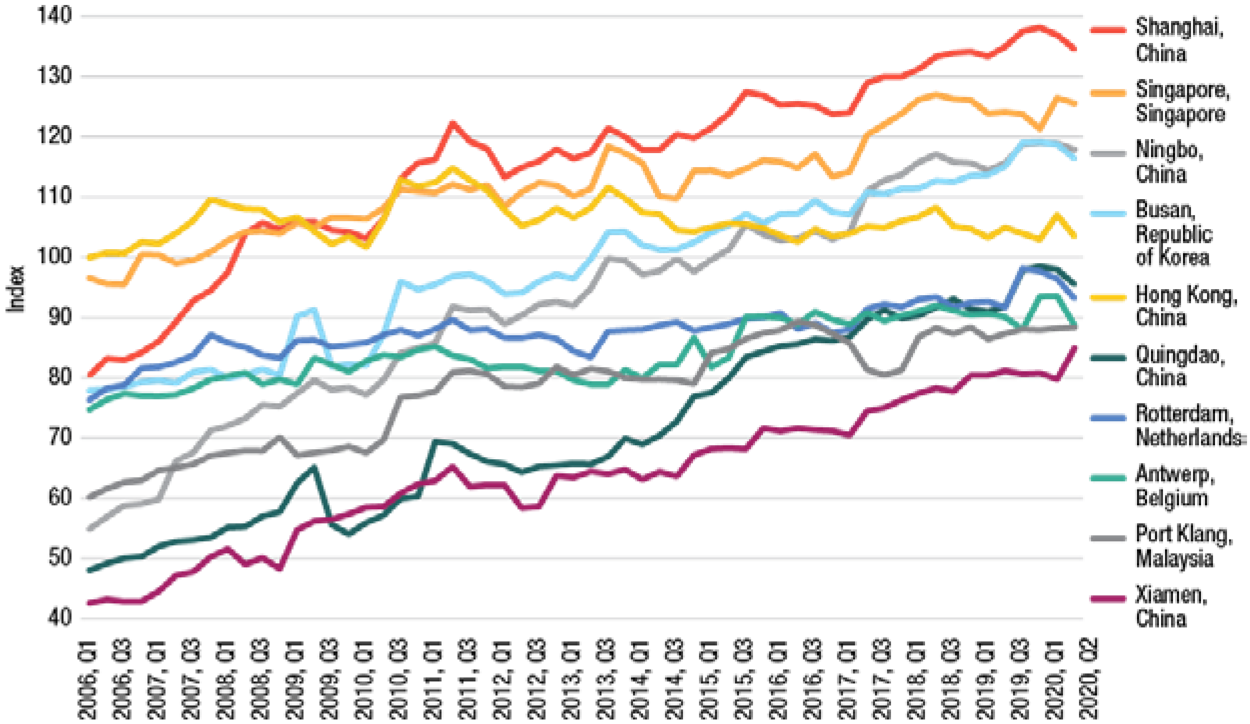
In 2020, five of the top 10 ports are located in China (Shanghai, Ningbo, Hong Kong, Qingdao and Xiamen), three are in other Asian countries (Malaysia, the Republic of Korea and Singapore), and two are in Europe (Belgium and the Netherlands). The liner shipping connectivity index of almost all of the top 10 ports has risen significantly since 2006, except Hong Kong, China, overtaken by four other ports (figure 3.7).

The port-level liner shipping connectivity index is generated for all container ports of the world that receive regular container shipping services.[15] In the second quarter of 2020, the database maintained by MDS Transmodal (www.mdst.co.uk) recorded regular container shipping services in 939 ports worldwide, a 12.6 per cent increase over 2006. This latest port count follows a decline of 3.6 per cent compared with the peak of the first quarter of 2019, when global liner shipping services included 974 ports in their schedules. Most of this recent decline took place during the first two quarters of 2020 and can be largely attributed to capacity management in response to the COVID-19 pandemic.

Figure 3.8 depicts the liner shipping connectivity index of the leading ports in major maritime regions. Several of the regional leaders saw a spike in the index in the second quarter of 2020, as they managed to attract additional services with larger vessels.

15 For the complete data set providing quarterly values of the liner shipping connectivity index of more than 1,200 ports, from the first quarter of 2006 onwards, see http://stats.unctad.org/maritime.

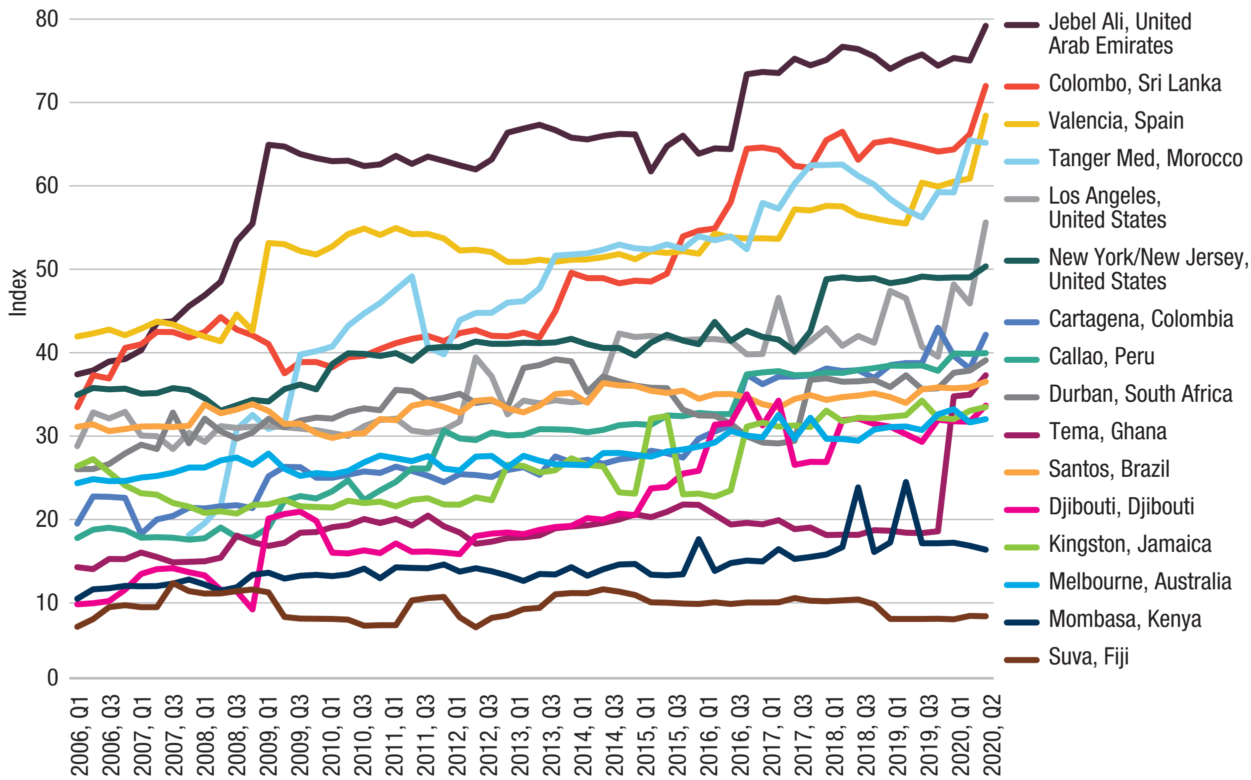
Figure 3.7 Liner shipping connectivity index of top 10 ports, first quarter 2006–second quarter 2020



Source: UNCTAD calculations, based on data provided by MDS Transmodal. For the liner shipping connectivity index of all ports, see http://stats.unctad.org/maritime.

Abbreviation: Q, quarter.

Figure 3.8 Liner shipping connectivity index of leading regional ports, first quarter 2006–second quarter 2020



Source: UNCTAD calculations, based on data provided by MDS Transmodal. For the liner shipping connectivity index of all ports, see http://stats.unctad.org/maritime.

Abbreviation: Q, quarter.

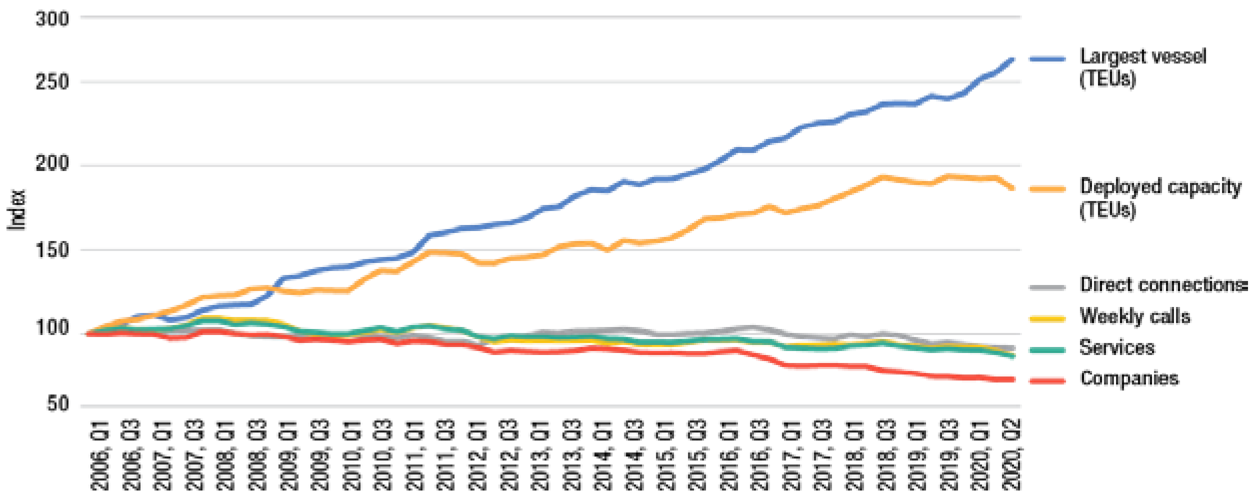
4. Liner shipping connectivity index components: Bigger ships and fewer companies

The liner shipping connectivity index helps to analyse trends among countries and ports. A look at the six components generating the index provides insights into industry developments (figure 3.9). The average fleet deployment per country is a reflection of the long-term trend of consolidation, as vessel sizes and total capacity deployed increase sharply, while the average number of companies that provide services to and from each country continues to decrease. The number of direct connections, number of services and number of weekly calls all follow a similar, slightly downward trend.

5. Fleet deployment during the COVID-19 pandemic

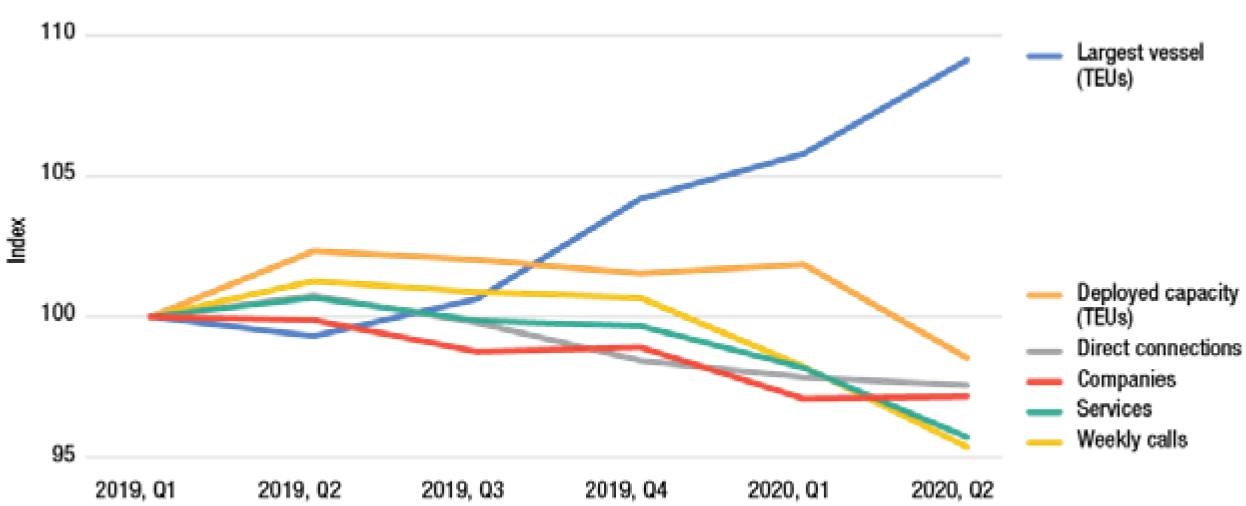
During the first two quarters of 2020, carriers managed their deployed capacity by reducing the frequency of calls and number of services. The average size of the largest container ships deployed continued to grow, in line with the long-term trends analysed in chapter 2. In the first quarter of 2020, scheduled deployed capacity still stood above that of the same quarter of 2019, albeit with a larger number of blank sailings; during the second quarter of 2020, schedules were adjusted further, and total deployed capacity was reduced below 2019 levels (figures 3.9, 3.10 and 3.11).

Figure 3.9 Liner shipping connectivity index components, first quarter 2006–second quarter 2020, index of averages per country
(First quarter 2006 = 100)



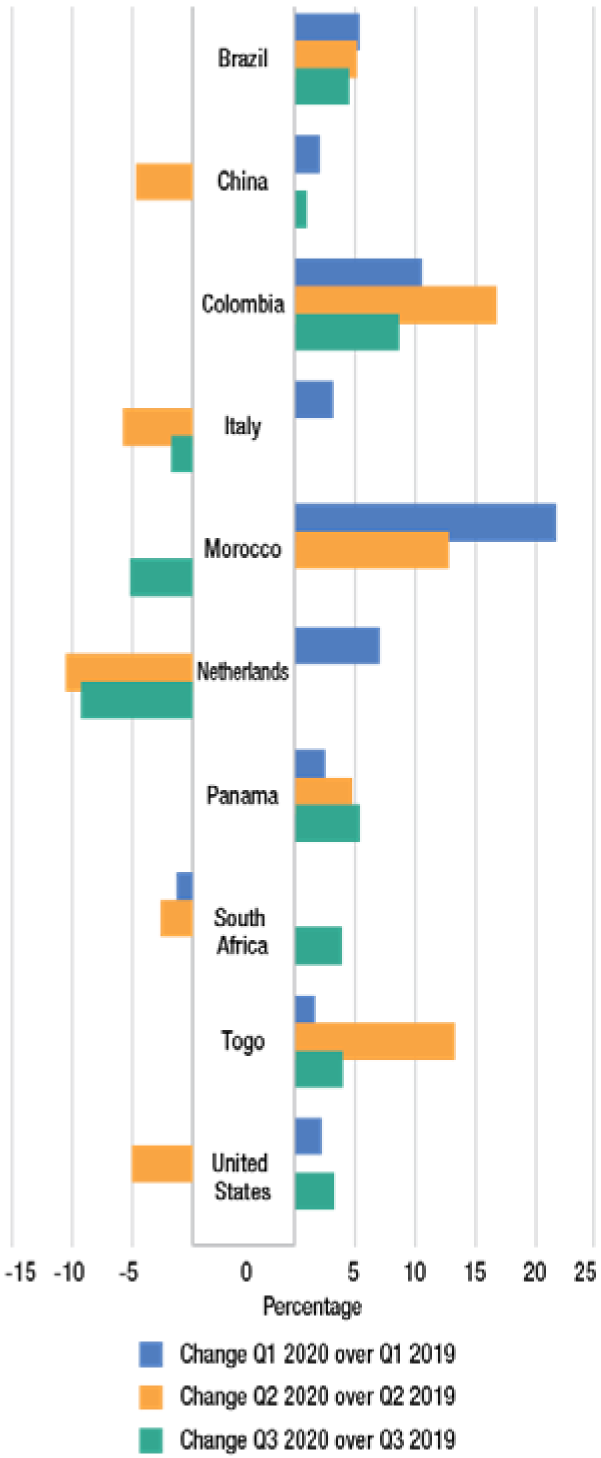
Source: UNCTAD calculations, based on data provided by MDS Transmodal.
Abbreviation: Q, quarter.

Figure 3.10 Quarterly trends in fleet deployment, first quarter 2019–second quarter 2020
(First quarter 2019 = 100)



Source: UNCTAD calculations, based on data provided by MDS Transmodal.
Abbreviation: Q, quarter.

Figure 3.11 Quarterly trends in fleet deployment, selected countries, 2019–2020
(Percentage change)



Source: UNCTAD calculations, based on data provided by MDS Transmodal.

Note: Timeline: first and second quarters of 2020 compared with first and second quarters of 2019.

Abbreviation: Q, quarter.

Container shipping schedules show that total fleet deployment during the first quarter of 2020 was still above that of the first quarter of 2019 in most economies. During the second quarter, carriers started to reduce capacity considerably. Steps taken by the shipping lines to manage capacity helped them sustain positive earnings during the first semester of 2020, in spite of less traffic (see also chapter 2).

China started 2020 with an increase of 2.1 per cent over the first quarter of 2019, recording a negative year-on-year growth of minus 4.7 in the second quarter. Growth then rebounded to more than 1 per cent in the third quarter. Most European countries underwent a steeper decline. For example, the Netherlands went from plus 7.0 per cent in the first quarter to minus 10.5 per cent in the second quarter and minus 9.3 per cent in the third quarter. Morocco experienced positive growth in in the first two quarters, but lost ground in the third quarter. Togo stands out as gaining deployed capacity, as the port of Lomé is becoming a regional hub for West African trade, especially for Nigeria, where most of the ports are draft restricted.

6. Better connectivity stimulates port traffic

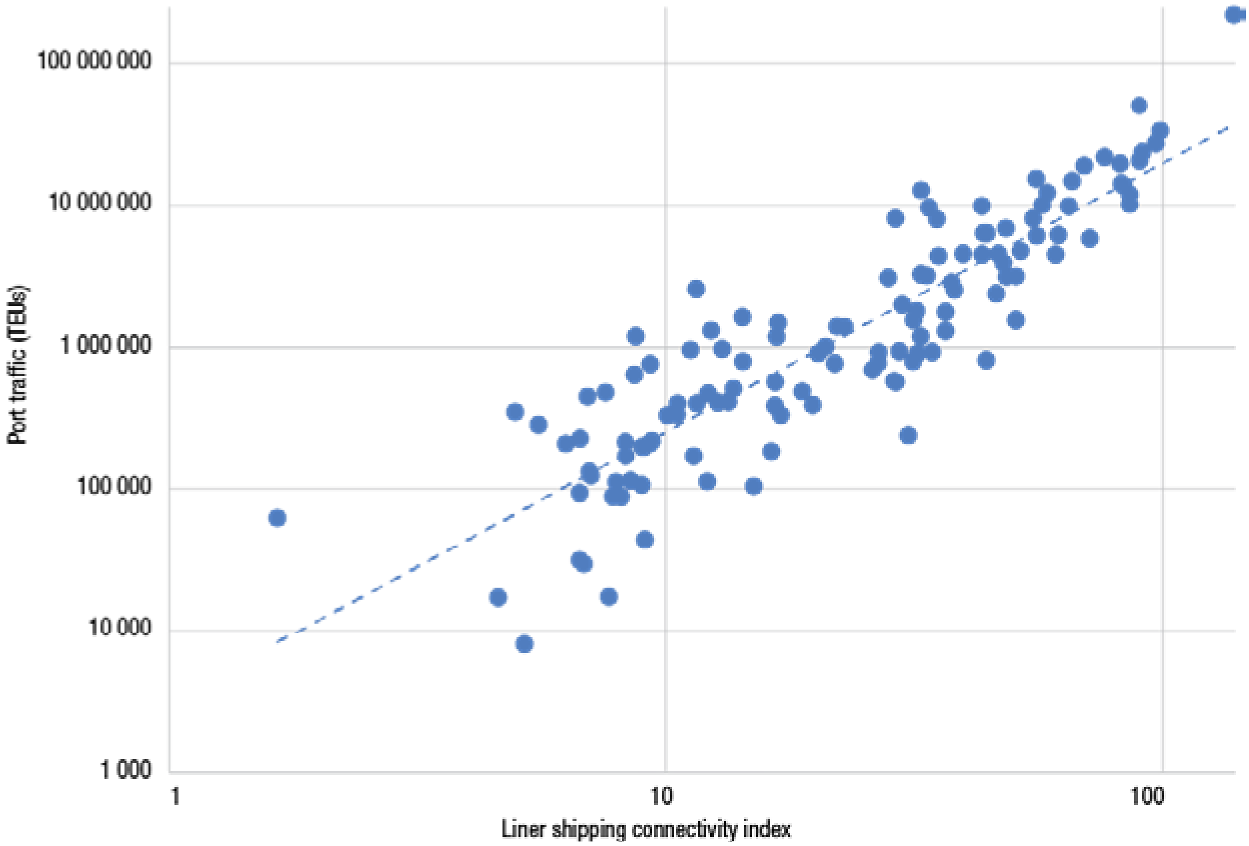
The liner shipping connectivity index is an indicator of the deployment of the world's container ship fleet. It is highly correlated with a country's port traffic. If there is more demand for the shipping of containerized cargo, liner companies will deploy more and larger ships, to achieve a higher level of total fleet deployment. They are also likely to provide more services to better connect the country directly to more countries. As the demand goes up, additional companies will enter this market. These components of fleet deployment are the six components from which the liner shipping connectivity index is generated.

It is interesting to analyse the correlation between these six components, as well as the liner shipping connectivity index, and each country's port container traffic patterns. UNCTAD has been systematically gathering port traffic statistics since 2010 (http://stats.unctad.org/TEU) (see also chapter 1). Figure 3.12 depicts the correlation between the liner shipping connectivity index and the port traffic of countries in 2017, the year for which the most complete statistics are available.

Interestingly, the correlation is not linear. Each additional 1 per cent increase in the liner shipping connectivity index is associated with a 1.896 per cent increase in port traffic. In other words, as more ships and services are provided, port traffic grows exponentially. This statistical finding is in line with the data, port performance and economies of scale recorded by the shipping companies (see section C below).

Similar correlations are observed for the individual components of the index with port traffic (table 3.5). For each component, there is a high and non-linear correlation with a country's port traffic. The highest correlation and the lowest exponential growth are recorded for the total deployed container-carrying

Figure 3.12 Liner shipping connectivity index and port traffic, 2017
(20-foot equivalent units)



Source: UNCTAD calculations, based on UNCTAD port traffic statistics and the liner shipping connectivity index generated with data from MDS Transmodal. Values are given for the first quarter of the 2017 liner shipping connectivity index and 2017 annual port traffic volumes in TEUs.

Note: $R^2 = 0.7851$; $y = 3209.1x^{1.896}$.

Table 3.5 Correlation between components of the liner shipping connectivity index and port traffic

Liner shipping connectivity index component	Coefficient of determination (R^2)	Elasticity
Liner shipping connectivity index	0.79	1.90
Total deployed container-carrying capacity (20-foot equivalent units)	0.90	1.13
Services (number of)	0.87	1.50
Frequency of port calls (number per week)	0.86	1.43
Companies (number of)	0.82	1.90
Size of largest ships (20-foot equivalent units)	0.61	1.53
Direct connections (number of, countries)	0,56	1.96

Source: UNCTAD calculations, based on UNCTAD port traffic statistics and the liner shipping connectivity index generated with data from MDS Transmodal. Correlation and elasticity are based on a power equation (see figure 3.12). Underlying values relate to the first quarter of the 2017 liner shipping connectivity index and 2017 annual port traffic volumes in TEUs.

capacity, as the two variables should largely grow in parallel. As regards additional companies and direct connections to additional markets, exponential growth is much stronger; increasing the number of direct connections by 1 per cent is associated with an increase in the port traffic by almost 2 per cent. In other words, for a port authority that aims to boost its port traffic, it would make good sense to focus especially on attracting additional carriers that provide direct services to a large number of trading partners.

7. Connecting trading partners through the container shipping network

In the second quarter of 2020, there were 939 seaports that were connected to the global liner shipping network through regular container shipping services (figure 3.13). If all ports had direct connections with each other, there would be 440,391 port-to-port liner shipping services. In reality, only 12,748 port pairs had such direct services, that is to say, 2.9 per cent of the theoretical total. For trade between 97.1 per cent of port pairs, containers need to be trans-shipped in one or more other ports. The necessary number of trans-shipments is one or two for most port pairs. The least connected port pairs require up to six trans-shipments. For example, 7 shipping services and 14 port moves would be necessary to export a container from some Pacific island ports to some Atlantic island ports for one trade transaction.

The structure of the liner shipping network is further illustrated in figure 3.14. Through an algorithm, the illustration visualizes ports that are well connected by locating them in close proximity to each other. Ports that have more direct connections in total are represented by larger points. The more distant ports are from each other, the more trans-shipments would be required to transport a container between them. An example of low connectivity depicted in figure 3.14 would be that of connectivity between Coatzacoalcos, Mexico with Basra, Iraq or with Malacca, Malaysia or with Rarotonga, the Cook Islands. Colour schemes reflect the geographical location of the port, and as expected, ports that are geographically closer to each other tend to be better connected with each other through the container shipping network.

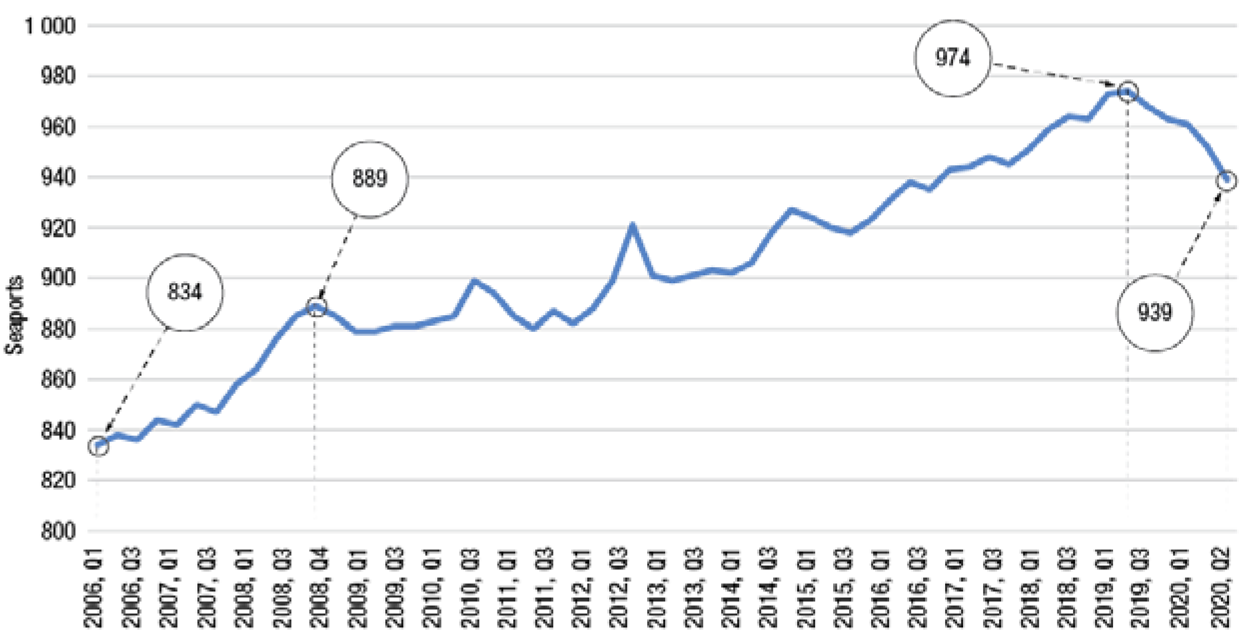
The port pair that is most connected through direct services is Ningbo–Shanghai, China, with 52 liner shipping companies providing 154 direct services and a total deployed annualized capacity of 50.1 million TEUs between the two ports. It is followed by Port Klang, Malaysia–Singapore, with 41 companies; Busan, the Republic of Korea–Shanghai, China, with 38 companies; and Shanghai–Qingdao, China, with 37 companies.

All the top 50 most connected port pairs are on intraregional routes, almost exclusively within Asia, except for two connections within Europe: Antwerp, Belgium-Rotterdam, the Netherlands, with 24 companies and Hamburg, Germany–Rotterdam, the Netherlands, with 23 companies.

In other regions, too, neighbouring ports are generally the most connected with each other. These intraregional connections do not necessarily carry trade between neighbouring ports, but the high connectivity is the result of being connected to the same overseas routes, in combination with feedering and trans-shipment services.

In Africa, for example, Durban and Cape Town, South Africa are connected with each other by services provided by 12 companies. In Angola, Luanda is most connected with Cape Town, South Africa with seven companies, and Mombasa, Kenya is most connected with Dar-es-Salam, the United Republic of Tanzania through direct services by 10 companies. By comparison, there are only six companies that connect Mombasa, Kenya with Ningbo, China. The connectivity

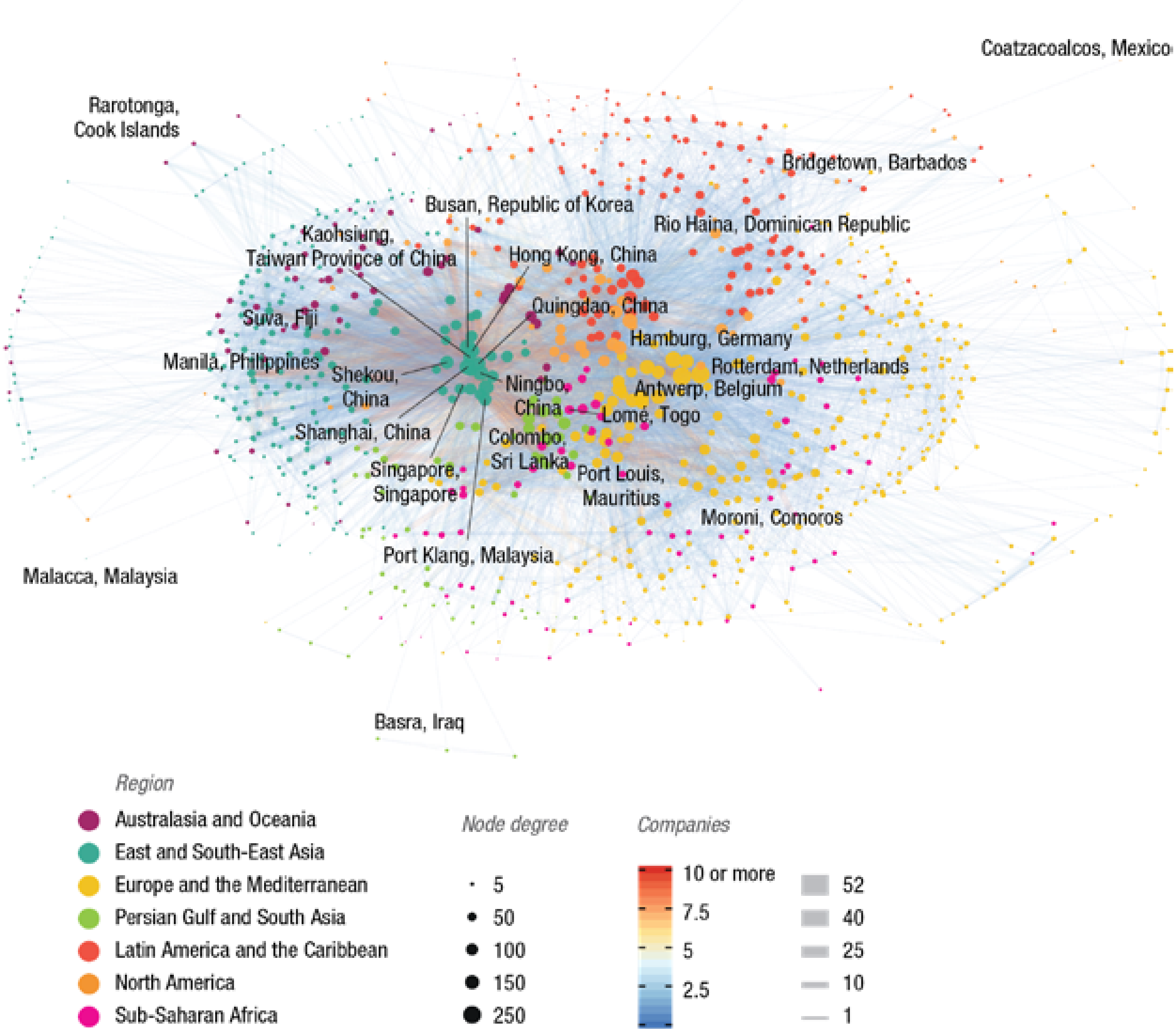
Figure 3.13 Number of seaports with regular container vessel calls, first quarter 2006–second quarter 2020



Source: UNCTAD calculations, based on data provided by MDS Transmodal.

Abbreviation: Q, quarter.

Figure 3.14 Global liner shipping network, second quarter 2020



Source: UNCTAD calculations, based on data provided by MDS Transmodal; visualization by Julian Hoffmann.
Notes: Layout = stress; links = number of companies providing a direction connection.

level of Tanger Med, Morocco is highest with Algeciras and Valencia, Spain, through services provided by nine liner companies.

In South America, Buenos Aires, Argentina is most connected with Montevideo, Uruguay (13 companies) and in Brazil, 14 companies provide direct services between Paranaguá, Rio de Janeiro and Santos. There are 10 companies that connect San Antonio, Chile with Callao, Peru; 15 companies that connect Callao, Peru with Guayaquil, Ecuador and 12 companies that provide direct services between Cartagena, Colombia and Manzanillo, Panama.

In the Pacific, two ports in Fiji (Lautoka and Suva) are connected through services by seven liner companies, while Betio, Kiribati is connected with Lautoka and Suva, Fiji through services by two carriers. Also, Kosrae and Pohnpei, Micronesia have direct services with Majuro, the Marshall Islands that are provided by two companies, while only one company connects these ports with Yokohama, Japan and other ports in Asia. Honiara, Solomon Islands and Port Vila, Vanuatu are most connected with ports in Fiji (four companies) and with Yokohama, Japan and other ports in Asia (3 companies).[16]

C. CONTAINER SHIPPING: PORT PERFORMANCE

1. Container terminal performance

On average, 75–85 per cent of the port call time of container ships is taken up by container operations, that is to say, the time between the first and last container lifts, while the remaining time may be due to pilotage, mooring,

[16] Data relate to the second quarter of 2020. These are UNCTAD calculations based on data provided by MDS Transmodal. The liner shipping bilateral connectivity index for all port and country pairs is available at http://stats.unctad.org/maritime.

customs formalities and other operational or procedural requirements. The efficiency of the container operation segment is influenced by the combination of crane speed multiplied by the quantity of cranes deployed (crane intensity). Although constrained occasionally by stowage plans, a ship's overall length or available cranes, crane intensity is also largely influenced by the call size.

There are large variations in average port times, and this should be seen as an opportunity for improvement. The gaps are too large to be closed with a single giant step, so a succession of smaller but progressive steps is required in all countries located towards the bottom of table 3.6.

The lead metric for the 2019 port turnaround times is the average of total port hours per port call. For this, port hours are counted from the time a ship reaches the port limits (pilot station or anchorage) until it departs from the berth after operations are completed. It therefore incorporates waiting/idle time, steaming-in time and berth time. The time taken to steam out of the port limits is not included because first, it is very homogeneous, and second, it is not influenced by port effectiveness. Any delays in departure due to channel congestion; absence of pilots, tugs or other resources; and ship readiness are all incurred before a ship departs from the berth and the last line is released. Ships may also sit idle on departure for bunkering or repair or simply in safe waters if the next port cannot accommodate berthing on arrival.

The data used in this section are provided by IHS Markit from its extensive, proprietary Port Productivity Programme. It comprises close to 200,000 container ship port calls per year, approximately 42 per cent of the total. It combines data on the vessel calls and time in port with detailed information about the containers loaded and unloaded at each call, totalling more than 300 million TEUs, at more than 430 ports in 138 countries. The underlying data are provided by 10 of the world's largest shipping lines and are enhanced with matched port arrival times from the IHS Markit automatic identification system database.

The time ships spent in port in 2019 is reported in section A (table 3.3). It is measured in absolute numbers, without considering the number of containers loaded or unloaded during this period. For the selected ports and carriers analysed in this section, the Journal of Commerce–IHS Markit database makes it possible to adjust the port turnaround time for loading and unloading operations during this period.

For an objective overview of container ship in-port time, different factors need to be considered, including the call size and quantity of container moves per ship call. For objective benchmarking, the actual port call hours are weighted by the quantity of containers exchanged per call. The formula used to achieve this for each country is as follows:

> *Actual port hours/actual call size x actual call size of full benchmark group*

For example, if a country takes 12 hours to handle a ship with 1,200 containers loaded and unloaded, and the average of the benchmark group is 1,500 moves per call, it is then assumed that it will take the subject port 15 hours to handle that same quantity (*12/1,200 x 1,500*). In sum, the resulting weighted port hours represent the time a ship spends in port per container loaded and unloaded, multiplied by the global average number of containers of the benchmark group.

2. Most of the countries with the best port performance are in Asia

A shorter time in port is a positive indicator of a port's efficiency and trade competitiveness. Based on the criteria explained above, container ships spent an average time of 23.2 hours (0.97 days) in port per call in 2019.

Table 3.6 lists the world's leading 25 economies in terms of total container ship port calls (as per table 3.3) and provides their average in-port time, weighted by call size. The average port-call time across these 25 economies in 2019 was 21.7 hours (0.91 days), slightly less than the global average.

Among the leading 25 countries in terms of container ship port calls, the United Arab Emirates hold the record for the shortest in-port time (14.1 hours of weighted port time), followed by China (15.5 hours), Singapore (17.4 hours) and the Republic of Korea (17.8 hours). Of the nine countries performing better than the average of the entire group, only two (Belgium and the Netherlands) are outside Asia. The lowest levels of performance are represented by France (41.8 hours), Italy (36.5 hours), Australia (34.6 hours) and Brazil (33.6 hours).

Table 3.7 lists the top and bottom 10 countries in terms of their weighted average port hours, as well as the average vessel size in terms of container-carrying capacity (TEUs). Four Middle Eastern countries were among the top 10 in 2019. Along with the Republic of Korea, Singapore and Sri Lanka, the ports of these countries handle predominantly trans-shipment containers. They generally have high crane densities on the quay walls, enabling high crane intensities. The ratio of yard to quay equipment is similar to that of most contemporary container terminals but a trans-shipment container has only one yard move per quay move, whereas that number is doubled in gateway ports.

Trans-shipment ports have some fundamental advantages, such as limited gateway cargo, with fewer outside trucks causing congestion in the yards, and potentially planned days ahead, with cargo arriving and departing in large batches. Last, but not least, most ports are operated by global terminal operators, and many are set up as cost centres or joint ventures with the ship operators.

Hub ports face other challenges, such as tight connections, fragmented discharge and roll-overs with an impact on yard integrity; in addition, the last port

Table 3.6 Weighted average port call hours in top 25 economies, 2019

Country	Number of weighted average port hours
United Arab Emirates	14.1
China	15.5
Singapore	17.4
Republic of Korea	17.8
India	18.2
Thailand	20.0
Netherlands	20.3
Malaysia	20.5
Belgium	20.7
Hong Kong, China	22.5
Germany	23.0
Viet Nam	23.0
United States	24.7
Taiwan Province of China	25.8
United Kingdom	26.5
Spain	26.8
Indonesia	27.2
Japan	28.2
Philippines	31.7
Panama	32.3
Turkey	32.5
Brazil	33.6
Australia	34.6
Italy	36.5
France	41.8
Top 25 economies	**21.7**

Source: Journal of Commerce–IHS Markit Port Productivity Programme.

Note: The top 25 countries are derived from the total number of container ship port calls shown in table 3.3.

Table 3.7 Weighted average port call hours, top and bottom 10 countries or territories

Economy	Weighted average port hours	Average vessel size
Oman	12.5	9 002
United Arab Emirates	13.8	7 619
China	15.1	8 483
Poland	16.6	6 357
Saudi Arabia	16.8	8 351
Singapore	17.0	6 183
Republic of Korea	17.4	7 425
Qatar	17.7	7 081
India	17.8	7 463
Sri Lanka	18.5	5 749
Top 10	**15.9**	**7 769**
Canary Islands	61.7	984
Mozambique	62.6	2 533
Norway	62.9	1 259
Cameroon	63.7	2 541
Bulgaria	64.1	1 162
El Salvador	64.2	2 203
Nigeria	65.0	4 379
Gabon	65.9	1 559
Namibia	71.8	3 561
Trinidad and Tobago	72.1	1 490
Bottom 10	**65.1**	**2 530**

Source: Journal of Commerce–IHS Markit Port Productivity Programme.

before a head-haul must often contend with scattered load stowage in high-profile stacks.

Five of the lowest-ranking countries in table 3.7 are in Africa, which is still catching up in terms of building sufficient infrastructure and implementing the necessary port and trade facilitation reforms to be able to handle ever-growing demand effectively. Much additional investment is required, and the performance indicators presented above suggest that this could well come from private sector operators.

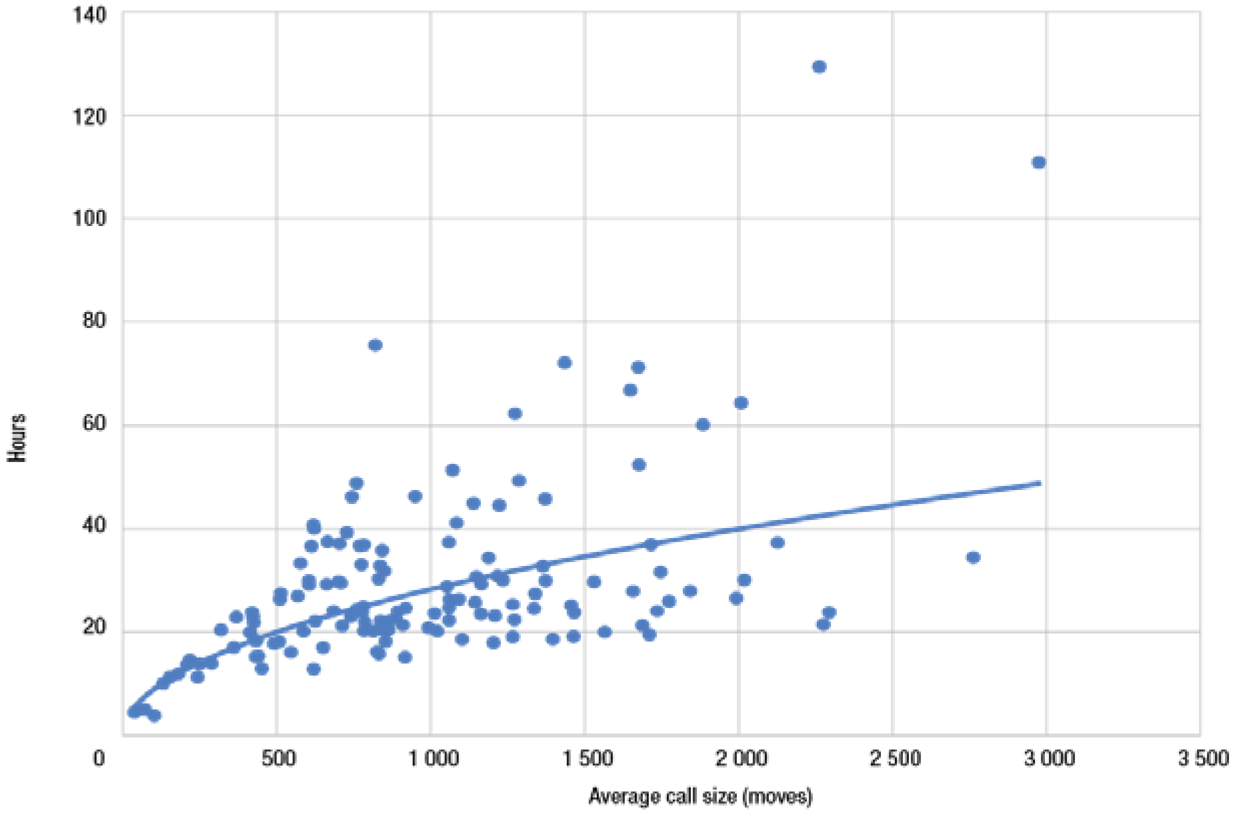
3. Economies of scale in port performance

The larger container ships appear to benefit from economies of scale. As a general rule of thumb, higher move counts (call size) on the larger ships allow terminals to deploy a higher quantity of cranes (crane intensity), and therefore handle more containers per ship hour than countries with smaller average vessel calls. Larger vessels also tend to be assigned a higher priority when scarce resources within a terminal or port are being shared among multiple ships. The larger vessels tend to be deployed to modern and efficient ports where the handling efficiency is significantly more refined than ports and terminals in secondary or tertiary ports of call.

As shown in figure 3.15, the more containers loaded and unloaded per port call (call size), the longer a ship needs to stay in port (average port hours). However, thanks to economies of scale, this relationship is not linear; as the call size goes up by 1 per cent, the time spent in port increases only by 0.5 per cent. The regressions illustrated in figures 3.15 and 3.16 statistically explain 47 per cent of the variance of the time a ship spends in port (R^2 = 0.47), while the remainder of the differences between countries need to be explained by factors such as trans-shipment incidence, port infrastructure, management and trade facilitation, as well as other parameters often associated with economic and institutional development.

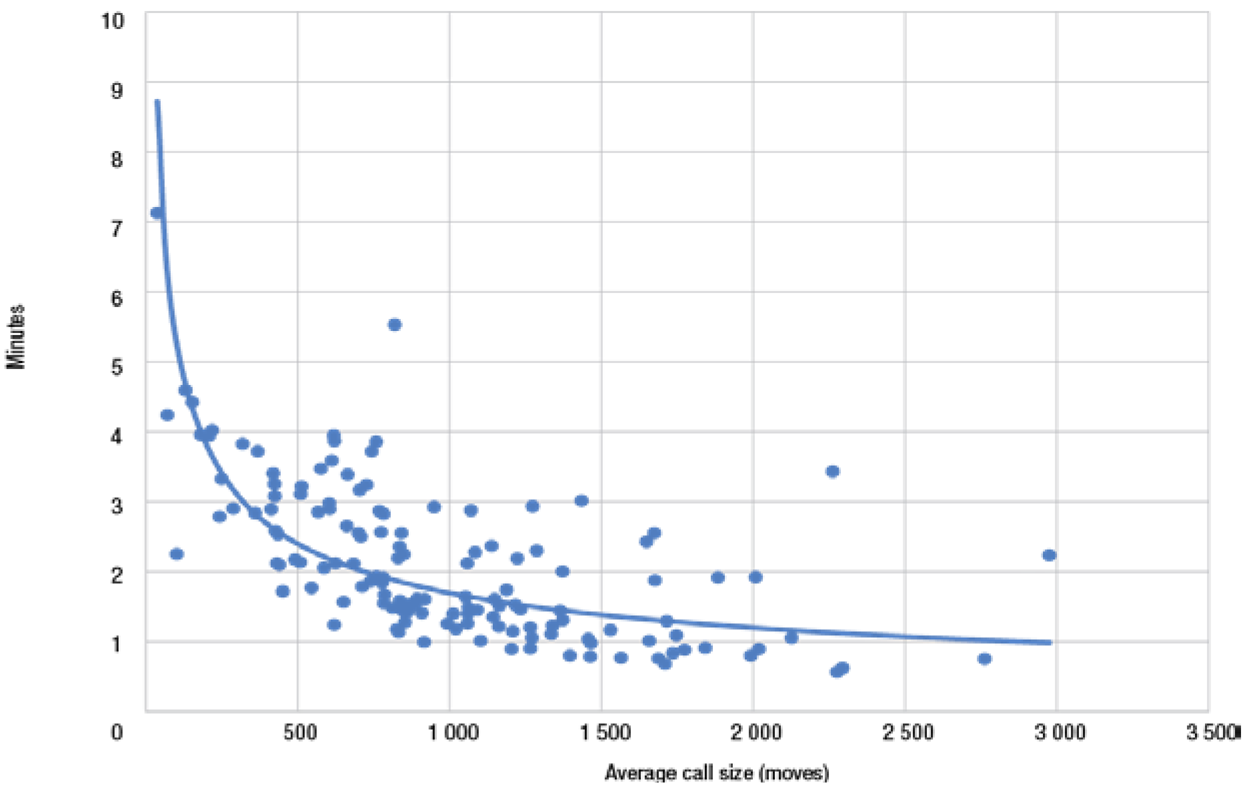
As shown in figure 3.15, the longest average port call durations are those of the Sudan and Yemen. Although both had few port calls in 2019, those port calls involved

Figure 3.15 Country averages of port time per ship and call size, 2019
(Hours in port and moves per port call)



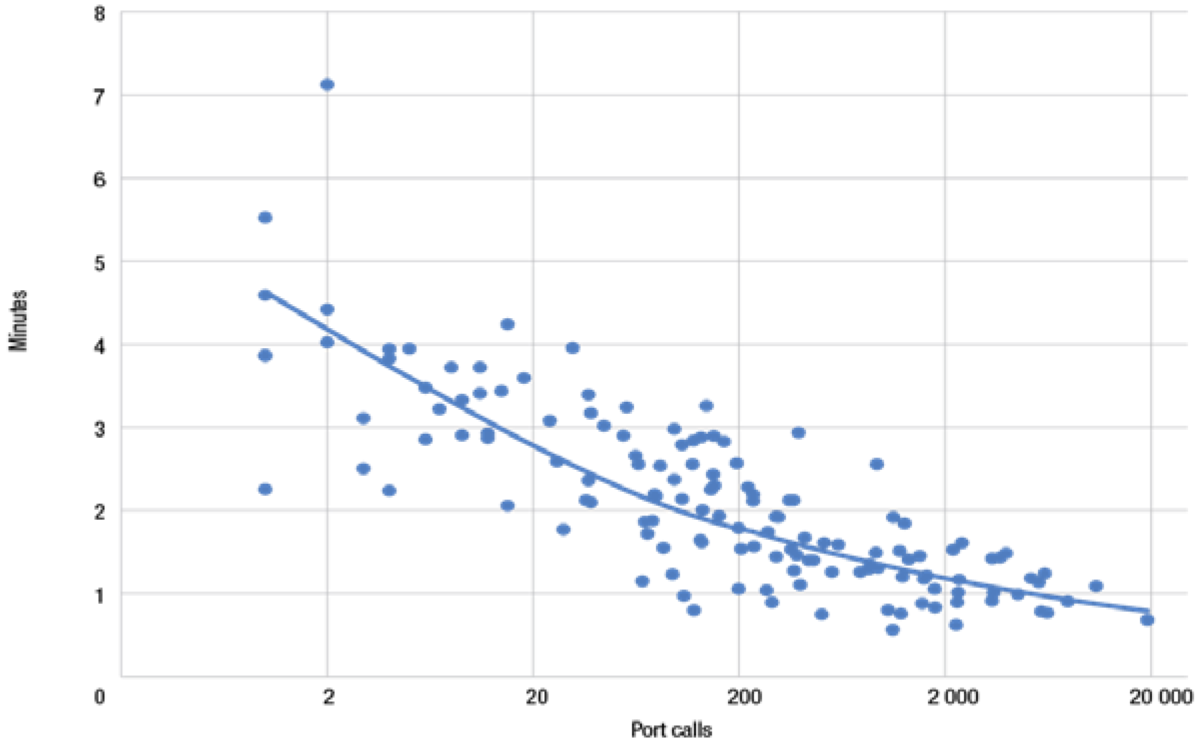
Source: UNCTAD calculations, based on data provided by the Journal of Commerce–IHS Markit Port Productivity Programme.
Note: $R^2 = 0.47$; $y = 0.90\ x^{0.50}$.

Figure 3.16 Minutes in port per container move and average call size, 2019



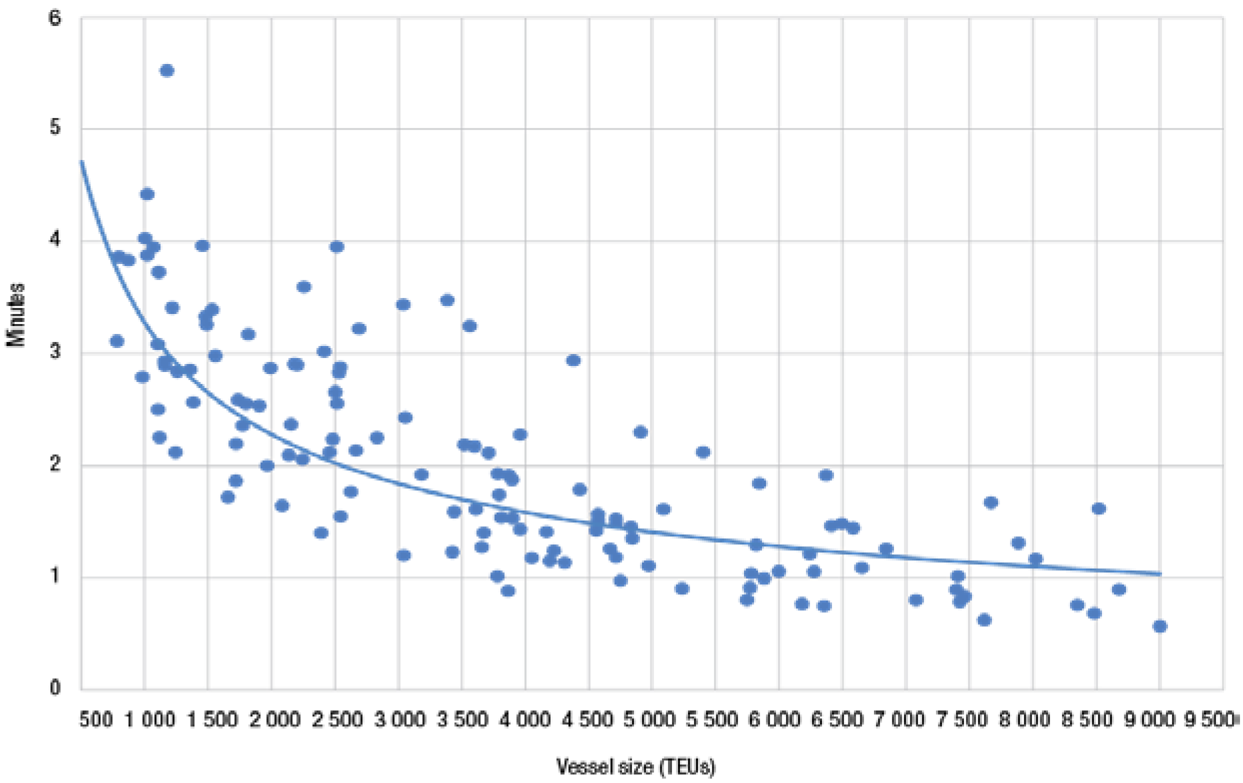
Source: UNCTAD calculations, based on data provided by the Journal of Commerce–IHS Markit Port Productivity Programme.
Note: $R^2 = 0.47$; $y = 53.83\ x^{-0.50}$.

Figure 3.17 Minutes in port per container move and number of port calls per country, 2019



Source: UNCTAD calculations, based on data provided by Journal of Commerce–IHS Markit Port Productivity Programme.
Note: $R^2 = 0.65$; $y = 4.63\ x^{-0.18}$.

Figure 3.18 Minutes in port per container move and average vessel size, 2019



Source: UNCTAD calculations, based on data provided by Journal of Commerce–IHS Markit Port Productivity Programme.
Note: $R^2 = 0.64$; $y = 123.04\ x^{-0.52}$.
Abbreviation: TEU, 20-foot equivalent unit.

a large number of loaded and unloaded import and export containers, for which the ships spent an average of more than 100 hours in port. The three countries with the highest average call size below the trend line (that is to say, they are more efficient) are Oman, Poland and the United Arab Emirates, which have a large share of trans-shipment cargo and whose main terminals are operated by international private terminal operators.

To shed further light on port performance and economies of scale, it is worth considering the time spent in port per container loaded and unloaded.

Economies of scale and efficiencies are mutually beneficial. The faster a ship can load and unload containers (the fewer minutes it needs per container in port), the more ships ports can accommodate with a given number of piers and infrastructure (figure 3.17). Increasing the number of calls by 1 per cent is associated with a decrease of the time in port per container by 0.18 per cent.

A similar picture emerges when the time in port is correlated with average ship sizes (figure 3.18). Larger ships will bring more containers and be assigned more resources (cranes, piers on arrival, yard equipment), and they will thus also spend less time in port for each container loaded and unloaded. At the same time, carriers will assign their largest and most expensive ships, preferably to those ports that can handle them in the shortest time. On average, increasing the average vessel size by one per cent is associated with an improvement in the time spent per container by 0.52 per cent. Among the five countries with the largest average vessel sizes, four are below the trend line, meaning they are more efficient. These are China, the Netherlands, Oman and Saudi Arabia. One is above the trend line: Croatia.

The economies of scale illustrated above are in line with the analysis of other data sets discussed in this chapter, in particular those relating to port traffic and fleet deployment (figure 3.12) and to the time spent in port (table 3.3). The importance of economies of scale does not bode well for small island economies (figure 3.6), which have fewer possibilities to attract more cargo, services or larger ships.

The following section will further explore the issue of port performance from the perspective of ports.

D. PORT PERFORMANCE: LESSONS LEARNED FROM THE TRAINFORTRADE PORT MANAGEMENT PROGRAMME OF UNCTAD

1. TrainForTrade port performance scorecard

Within the framework of the port network of the TrainForTrade Port Management Programme, over 3,600 port managers have been trained in the last two decades in 60 countries in Africa, Asia, Europe, Latin America and the Caribbean.[17]

This section reports on the latest developments regarding the port performance component of the TrainForTrade Port Management Programme. The initiative started in 2012 with a series of international conferences held in cities belonging to the TrainForTrade network (Belfast, Northern Ireland; Ciawi, Indonesia; Geneva, Switzerland; Manila, the Philippines; and Valencia, Spain). Thereafter, the port performance scorecard has gone through enhancements and upgrades to respond to four main technical requests from port members. The new pps.unctad.org website now features a more user-friendly interface, incorporated data-consistency checks, an automated past-entry function and advanced analysis tools by regions and categories with automated graphics and filters. The process captures data through annual surveys (starting with the year 2010) sent to focal points in each port entity around April, to report for the previous calendar year.

In 2020, 24 port entities (out of the 50 ports which reported data since the inception of the port performance scorecard) completed the 2019 survey, reporting a total of 2,509 data points with an average of 72 data points for the five-year rolling back average of the global results. The data were collected through a series of questions (82) from which the port performance scorecard derives 26 agreed indicators under the following six categories: finance, human resources, gender, vessel operations, cargo operations, and environment (table 3.8). This approach has been used since the inception of the port performance scorecard to ensure consistency and comparability of measures over time.

With the newest development of the port performance scorecard platform and the digital strengthening of the backbone information technology architecture, UNCTAD expects to increase the participation of port entities beyond the scope of the TrainForTrade network to provide more and more accurate and relevant data and analysis over time. Simultaneously, UNCTAD pursues efforts to include more port entities and countries from the TrainForTrade network that are not yet reporting

[17] See also TrainForTrade Port Management Series (volumes 1 to 7) featuring best case studies and actionable recommendations in line with the Sustainable Development Goals (https://tft.unctad.org/tft_documents/publications/port-management-series). The impact of the programme is measured regularly using two indicators from the TrainForTrade methodology: the performance rate (75 per cent global average) and the satisfaction rate (88 per cent global average) collected over time and for each activity conducted in the TrainForTrade network. Given the long-standing success of the Port Management Programme, which capitalizes on training and capacity-building for port managers and strengthening port institutions equally through the implementation of good governance mechanisms and best practices, it is now time for a deeper analysis of its long-term impact. Based on this assumption and with the support of member ports in the TrainForTrade network, Irish Aid and port partners (France, Ireland, Portugal, Spain and the United Kingdom), steps were taken at the operational level in 2012 to identify the necessary metrics for such an analysis.

Table 3.8 Port performance scorecard indicators, 2015–2019

Category	Indicator number	Description	Mean	Number of values
Finance	1	EBITDA/revenue (operating margin)	38.8%	85
	2	Labour/revenue	22.3%	89
	3	Vessel dues/revenue	15.7%	90
	4	Cargo dues/revenue	34.9%	90
	5	Concession fees/revenue	14.7%	83
	6	Rents/revenue	6.4%	84
Human resources	7	Tons per employee	62 649	94
	8	Revenue per employee	$202 476	88
	9	EBITDA per employee	$104 812	80
	10	Labour cost per employee	$35 760	82
	11	Training cost/wages	1.6%	82
Gender	12	Female participation rate (global)	17.6%	96
	12.1	Female participation rate (management)	38.0%	95
	12.2	Female participation rate (operations)	13.2%	84
	12.3	Female participation rate (cargo handling)	5.5%	60
	12.4	Female participation rate (other employees)	29.4%	27
Vessel operations	13	Average waiting time (hours)	13	83
	14	Average gross tonnage per vessel	18 185	94
	15.1	Average oil tanker arrivals	10.4%	80
	15.2	Average bulk carrier arrivals	10.9%	81
	15.3	Average container ship arrivals	31.8%	79
	15.4	Average cruise ship arrivals	1.4%	78
	15.5	Average general cargo ship arrivals	23.6%	82
	15.6	Average other ship arrivals	24.2%	80
Cargo operations	16	Average tonnage per arrival (all)	7 865	103
	17	Tons per working hour, dry or solid bulk	416	60
	18	Tons per hour, liquid bulk	428	40
	19	Boxes per ship hour at berth	27	44
	20	20-foot equivalent unit dwell time (days)	7	54
	21	Tons per hectare (all)	140 408	91
	22	Tons per berth metre (all)	10 091	102
	23	Total passengers on ferries	1 458 596	57
	24	Total passengers on cruise ships	126 976	61
Environment	25	Investment in environmental projects/total CAPEX	7.2%	35
	26	Environmental expenditures/revenue	2.3%	50

Source: UNCTAD calculations, based on data provided by selected member ports of the TrainForTrade network.
Abbreviations: CAPEX, capital expenditure; EBITDA, earnings before interest, taxes, depreciation and amortization.

in the port performance scorecard component. Major advances in the port performance scorecard tools, enhanced in terms of how the data are validated, as well as comparisons with external data, essentially on gross tonnage and total time in port, add considerable value.

The number of participating ports across the regions has varied over the 10 years of reporting now held in the data set.[18] There are 23–26 ports that report comprehensively every year. This provides a basis for comparative financial and operational benchmarks. These reports can be applied by member ports in a range of planning and performance-based analyses. Table 3.9 provides a summary for the five-year period from 2015 to 2019 of the average port by region and size in each category using the traditional throughput performance measure.

The key elements of the data set are as follows:

- In 2019, port sizes ranged from 1.5 million tons to 80.7 million tons.
- The average port has handled 19.2 million tons per annum since 2015.
- The median value for the same period is 8 million tons.
- Twenty-five per cent of ports averaged less than 3.3 million tons over the 2015–2019 period.

[18] A partnership with MarineTraffic has been established to share data concerning the port entities participating in the port performance scorecard to ensure consistency of data provided by ports.

Table 3.9 Average annual throughput volume, 2015–2019
(Million tons)

Region	Category				
	Small <5m	Medium <10m	Large <20m	Very large <20m	Average
Africa	4.4	8.7	14.2	22.7	11.9
Asia	3.3	7.2		61.5	11.1
Europe	1.5			47.1	41.4
Latin America and the Caribbean	2.2	8.7	14.4	31.9	14.3
Average	**3.0**	**8.5**	**14.3**	**43.4**	**19.2**

Source: UNCTAD calculations, based on data provided by selected member ports of the TrainForTrade network.

2. Financial sustainability

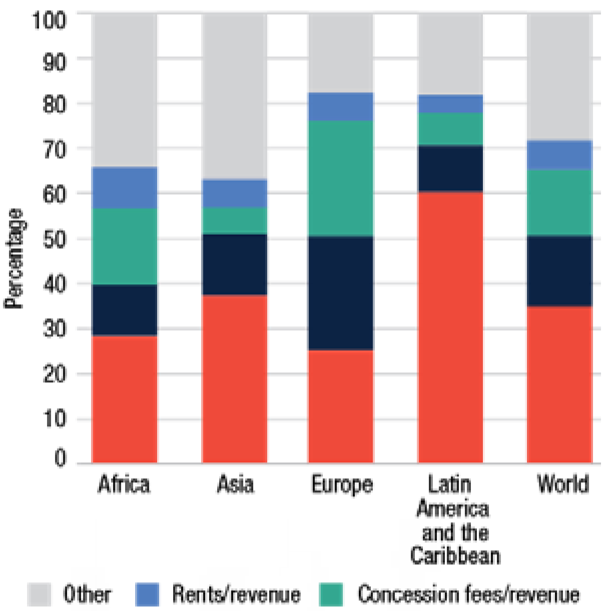
The financial analysis presented on the port performance scorecard platform shows the range of values for ports between 2015 and 2019. Over that period, the average of the annual total revenues of all participating ports was $1.97 billion or 417 million tons. The average revenue per ton varies widely, depending on a port's financial profile, including port dues, port estate, concessions and other services or investment income. Figure 3.19 shows the income categories of interest used in the data (indicators 3–6). The analysis of port revenue by region shows the expected dominance of cargo-related income for port entities, especially when compared with vessel-related income. Thus, ports generate a higher return on working quays for cargo and relatively less on marine assets such as dredged berths and channels.

The ports that show higher values in the concessions category tend to be larger ports with container terminals. Europe has the largest proportion of revenue for this income category.

Figure 3.20 represents the mean values for earnings before interest, taxes, depreciation and amortization as a proportion of revenue (indicator 1), while figure 3.21 shows labour costs as a proportion of revenue (indicator 2). Profit levels, represented here by indicator 1, were reported each year in a consistent range of 36–40 per cent as a global average; it appears reasonable to suggest that this average is a baseline required for a sustainable modern port.

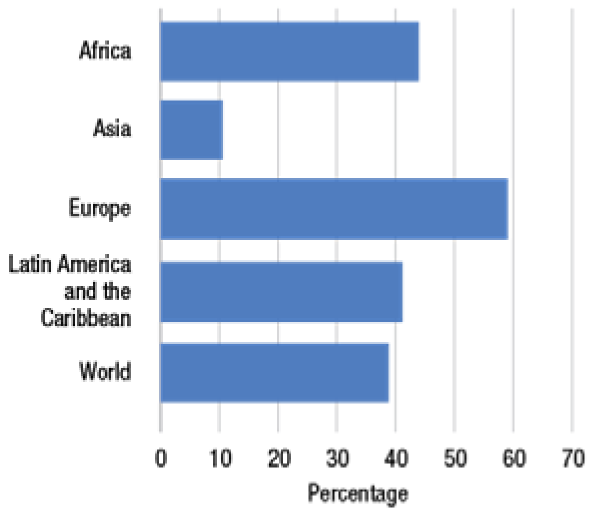
Between 2015 and 2019, the average revenue per port was $88.9 million; 50 per cent of ports brought in less than $49 million in revenue. The ports in quartile 1 (25 per cent of sample) averaged $13.3 million, whereas the large ports in quartile 3 (25 per cent of sample) averaged above $80 million per annum. It is not possible to share the results per individual port, but UNCTAD analysis finds evidence of average rates being closely aligned when similar ports in the same regional group are compared. For example, publicly available data for Irish ports shows this when gross revenue per ton is compared across Ireland. The financial indicators are useful benchmarks by region and by size when forecasting revenue for development projects.

Figure 3.19 Revenue mix of ports by region, 2015–2019



Source: UNCTAD calculations, based on data provided by selected member ports of the TrainForTrade network.

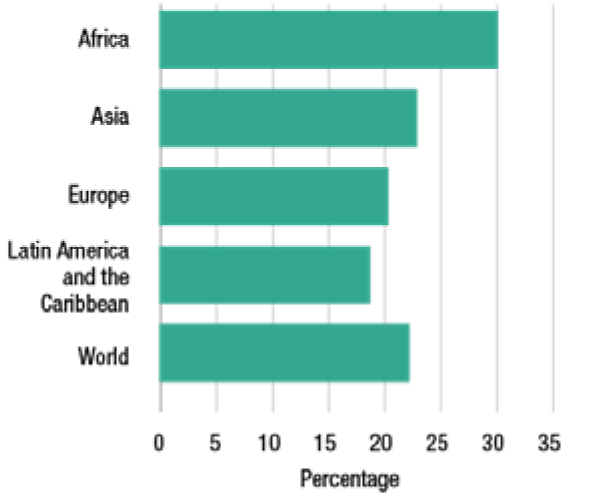
Figure 3.20 Earnings before interest, taxes, depreciation and amortization as a proportion of revenue, 2015–2019
(Percentage)



Source: UNCTAD calculations, based on data provided by selected member ports of the TrainForTrade network

Abbreviation: Earnings before interest, taxes, depreciation and amortization.

Figure 3.21 Labour costs as a proportion of revenue, 2015–2019



Source: UNCTAD calculations, based on data provided by selected member ports of the TrainForTrade network.

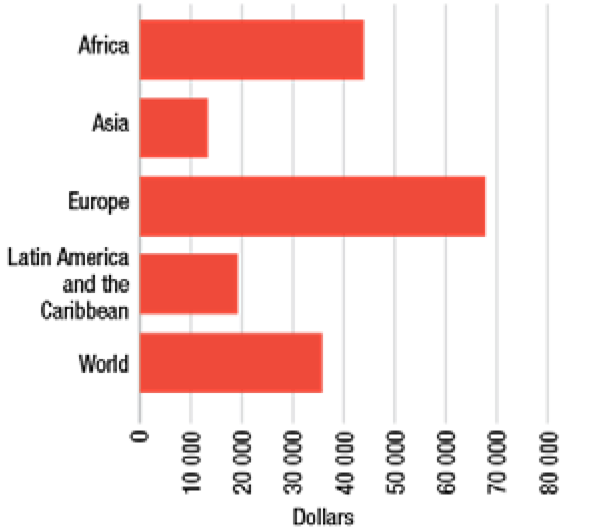
Labour costs have recorded a stable average over the 10 years covered by the port performance scorecard. Values have settled at around 20 to 22 per cent as a proportion of gross revenue (indicator 2). When analysed by region (figure 3.21) and as a proportion of the number of employees, there is a significant range across mean values. For Africa, the value is relatively high and for Latin America and the Caribbean, it is low. It is not clear at this level of data abstraction if this is attributable to rates of pay or employee numbers, which in turn may reflect levels of private supply to port entities as contractors. In the case of Latin America and the Caribbean, the average rate is lower than the global mean, suggesting that ports have relatively high staffing levels (figure 3.22, indicator 10). However, the analysis is less clear with regard to Africa, where labour rates are at the higher end of the spectrum. Europe shows the highest rate per employee – $67,705 per annum.

The average proportion of total capital expenditure on investment in environmental projects (indicator 25) is 7.2 per cent, with 2.3 per cent of operating expenditures reported being devoted to environmental requirements (indicator 26). This is a difficult number to isolate, and therefore the reported benchmarks come with a note of caution. However, throughout the data-collection period, the recorded numbers have been consistent. This suggests a relatively low proportion of total spending, and it will be useful to note any upward trend, should new regulatory requirements be implemented as the effects of climate change increase.

3. Gender participation

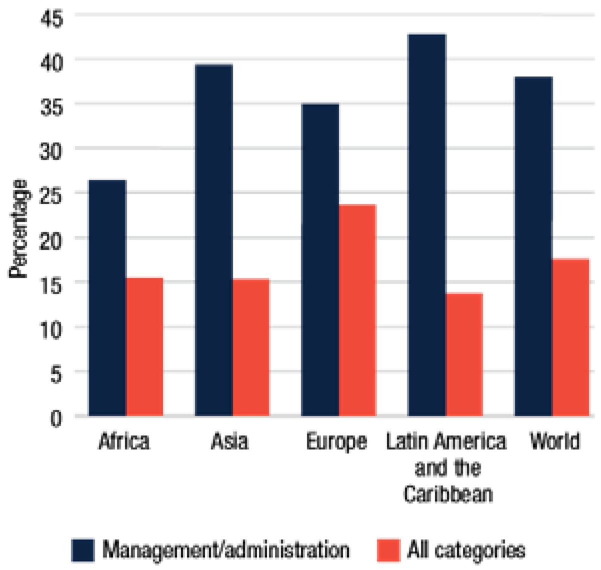
The gender profile remains low in terms of female participation in the port workforce (figure 3.23, indicators 12–12.4). The category that is not very far from a gender-balanced distribution is management

Figure 3.22 Average wages per employee, 2015–2019
(Dollars)



Source: UNCTAD calculations, based on data provided by selected member ports of the TrainForTrade network.

Figure 3.23 Female participation rate in the port workforce, 2015–2019



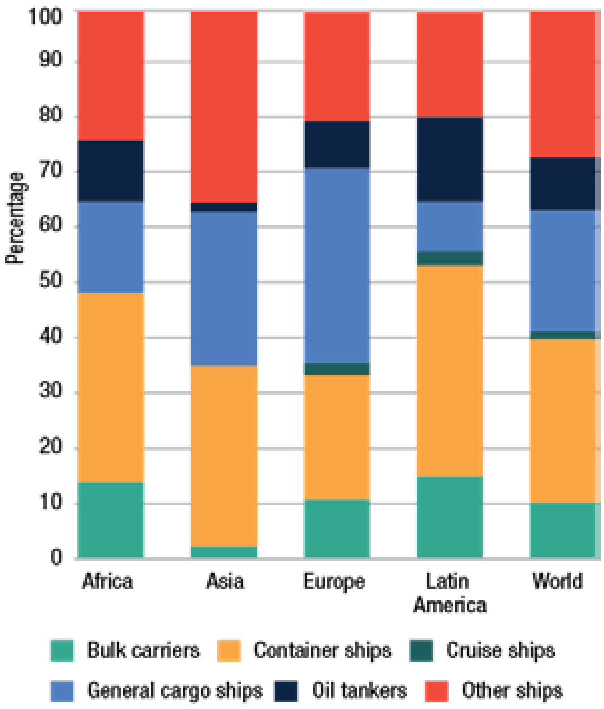
Source: UNCTAD calculations, based on data provided by selected member ports of the TrainForTrade network.

and administration. However, much remains to be done across the participating ports to achieve greater female participation.

4. Vessel and cargo operations

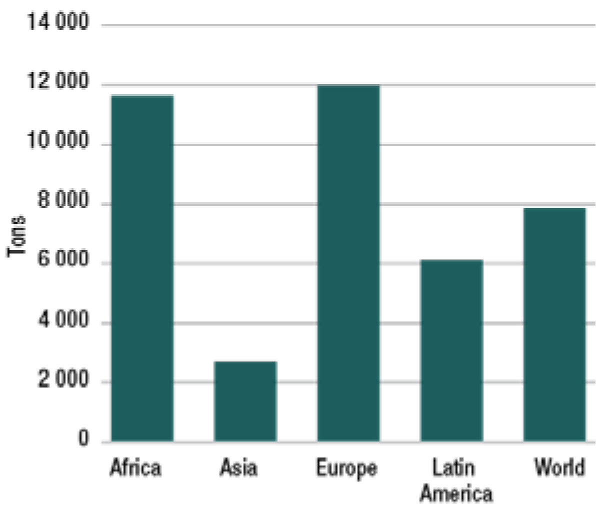
Figures 3.24 and 3.25 illustrate the profile of participating ports in terms of vessel type (indicators 15.1–15.6) and cargo volumes handled (indicator 16). The graphics show once again that there are no two ports with the same vessel and cargo mix. Both Africa and Europe have

Figure 3.24 Share of vessel arrivals, 2015–2019



Source: UNCTAD calculations, based on data provided by selected member ports of the TrainForTrade network.

Figure 3.25 Average cargo per arrival or departure, 2015–2019
(Tons)



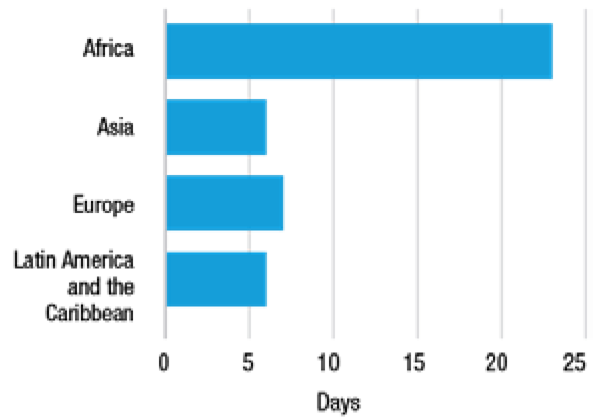
Source: UNCTAD calculations, based on data provided by selected member ports of the TrainForTrade network.

the largest average cargo tons per arrival or departure but arguably for different reasons, given their different vessel mix.

Relating the average time in port to the varied cargo size per vessel can be a useful comparison. There is a tight range of 1.5–2 days in port, on average. Therefore, the larger cargo lots are handled by higher labour and equipment output. With container vessels taking, on average, less time in port (1.2 days), there are higher averages in dry and wet bulk carriers. Dry bulk carriers stay in port 3.5 days on average. Overall, data from the TrainForTrade network show values similar to the global statistics recorded through automatic identification system data (see section A of this chapter).

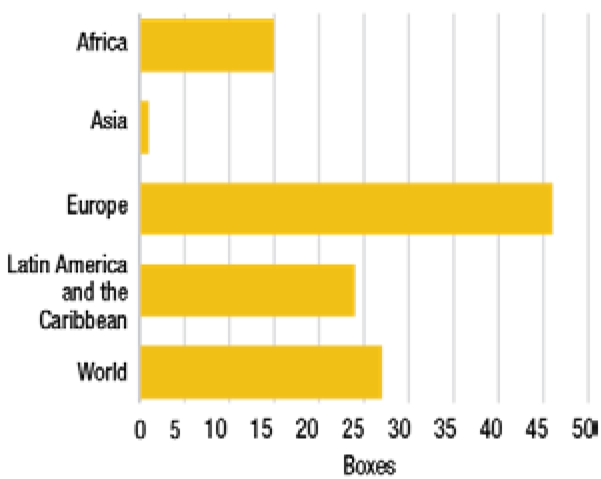
The online port performance scorecard shows little change in waiting times. Figures 3.26 and 3.27 provide some insights into the efficiency of container-handling operations. There are a wide range of values across the standard performance metrics of dwell time and crane lifting rates, and the overall results are in line with the data presented in section 3.C above. Europe has particularly

Figure 3.26 Maximum 20-foot equivalent unit dwell time, 2015–2019
(Days)



Source: UNCTAD calculations, based on data provided by selected member ports of the TrainForTrade network.

Figure 3.27 Average box-handling rate, 2015–2019
(Boxes per ship-hour)



Source: UNCTAD calculations, based on data provided by selected member ports of the TrainForTrade network.

higher lifting rates that perhaps reflect equipment capacity rather than labour efficiency (figure 3.27; indicator 19). Figure 3.26 shows the highest dwell time in days for each region (indicator 20). This topic requires sophisticated analysis to identify the reasons for slow processing, for example, customs procedures, storage agreements, port-container stripping, multiple-user facilities and congestion in road network at or near the port.

E. SHIPPING: EMISSIONS OF THE WORLD FLEET

1. Initiatives to reduce carbon emissions from shipping

Member States of IMO agreed in 2018 "to reduce the total annual greenhouse gas emissions by at least 50 per cent by 2050 compared with 2008" as part of the Initial IMO Strategy on reduction of greenhouse gas emissions from ships (IMO, 2018; UNCTAD, 2020c; UNCTAD, 2020d) (see also chapter 5.B. for additional background information).

To help achieve this objective, the International Chamber of Shipping and other maritime industry associations propose the establishment of a research and development fund to help cut emissions (BIMCO et al., 2019). For heavy fuel oil, this would correspond to a carbon price of $0.63 per ton of carbon dioxide. The project would raise about $5 billion over 10 years. This fund is to be financed by a contribution of $2 per ton of marine fuel oil purchased for consumption. The private sector-led Getting to Zero Coalition suggests that "[S]hipping's decarbonization can be the engine that drives green development across the world" (Global Maritime Forum, 2020).

The falling costs of net zero-carbon energy technologies make the production of sustainable alternative fuels increasingly competitive. Determined collective action in shipping can increase confidence among suppliers of future fuels that the sector is moving in this direction. UNCTAD supports the Getting to Zero Coalition and promotes efforts to achieve sustainability, helping developing countries adapt and build resilience in the light of the climate emergency.

According to Parry et al., 2018, "[T]he environmental case for a maritime carbon tax is increasingly recognized". According to the Environmental Defence Fund (2020), "meeting the IMO's 2050 target represents $50 billion to $70 billion per year for 20 years' spending, but this is also a revenue opportunity". Englert and Losos, 2020 (from the World Bank), also a supporter of the Getting to Zero Coalition, state that a large share of this investment opportunity could lie in developing countries. A sizable part of these investments will have to be made ashore, including in energy infrastructure and in seaports. Shipowners will have to invest in the renewal of the fleet and new technologies (UNCTAD, 2020e).

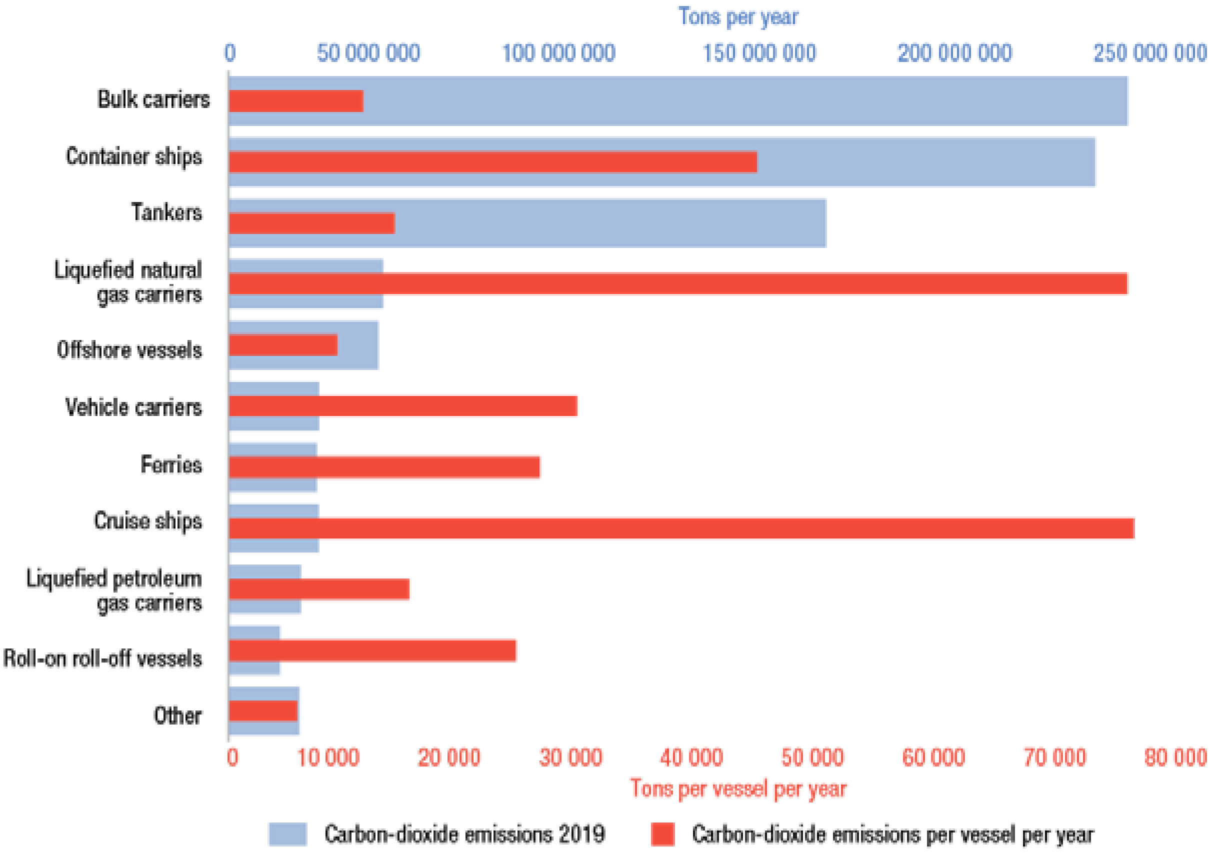
Engine power limit is a short-term measure proposed by Japan that would enable shipowners to meet requirements relating to the energy efficiency index for existing ships and to reach the IMO target in 2030. Engine power limit decreases vessel speed with minimal changes in ship performance, thus reducing fuel use and emissions based on the cube law (relationship between engine load and vessel speed). In a recent study, the systematic assessment of vehicle emissions model of the International Council on Clean Transportation is used to evaluate different scenarios of engine power limit focusing on container ships, bulk carriers and oil tankers, with 2018 automatic identification system data being utilized as a baseline. The study argues that carbon-dioxide "reductions will not be proportional to engine power limit because ship engines are already operating far below their maximum power" (Rutherford et al., 2020). This model shows the negligible effect of engine power limit of less than 20 per cent on a ship's carbon-dioxide emissions. As for an engine power limit ranging between 30 and 40 per cent, emissions reduction is between 2 and 6 per cent. However, the study shows a significant reduction of carbon-dioxide emissions (by 8–19 per cent) for a larger engine power limit of 50 per cent or more.

2. Emissions by vessel type and other determinants

A wide range of parameters influences the amount of carbon dioxide a ship emits per ton-mile. These include vessel type, speed, size, hull design, ballast, technologies and types of fuel used. A larger ship will naturally emit more carbon dioxide per mile, but thanks to economies of scale, it will emit less carbon dioxide per ton-mile; the smallest container ships of up to 999 TEUs emit about twice as much carbon dioxide per container carried as the largest container ships. Container ships tend to transit at higher speeds than dry bulk carriers, thus – all other things being equal – emitting more carbon dioxide per ton-mile than the latter. Liquefied natural gas and cruise ships are on average far larger than offshore or service vessels, such as tugs, and will thus emit more carbon dioxide per ship than the smaller vessels (see figure 3.28).

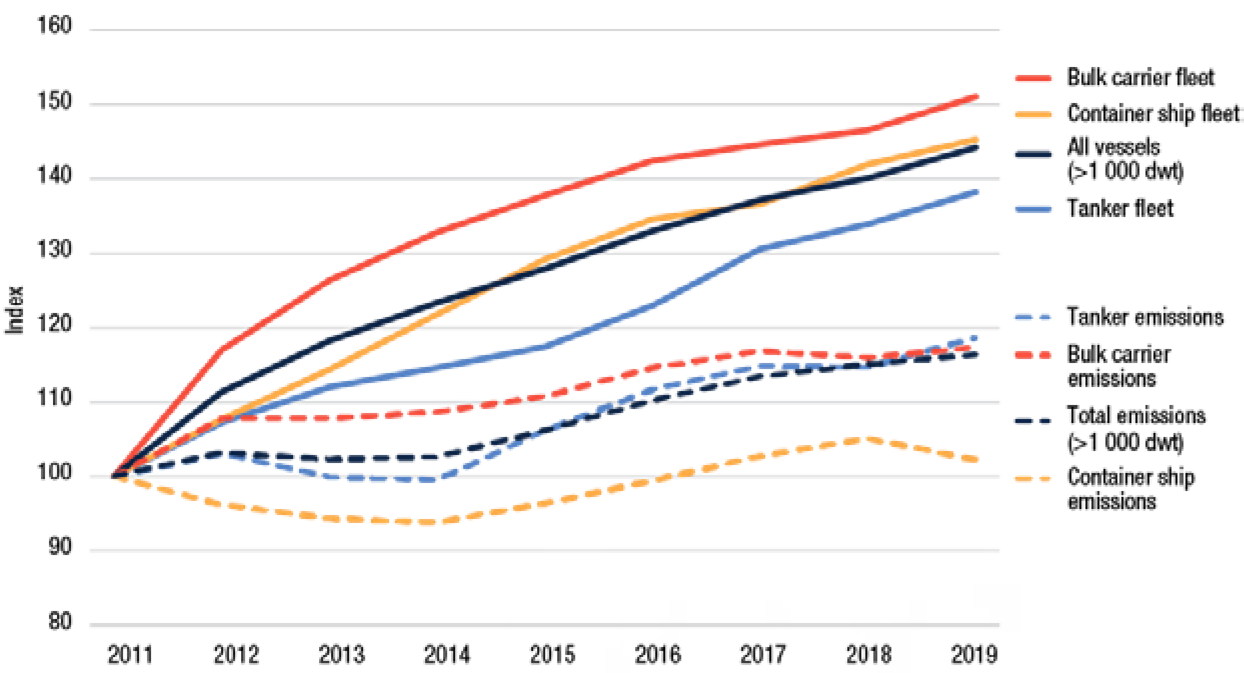
The shift toward larger tankers, bulk carriers and container vessels over the past decade, combined with multiple efficiency gains and the scrapping of less efficient vessels, has meant that carbon-dioxide emissions growth has trailed behind the increase in fleet dead weight. This has been most noticeable for container ships, where modest speed reductions have materially lowered fuel consumption and associated emissions. Whereas container fleet capacity rose by 45 per cent between 2011 and 2019, carbon-dioxide emissions are only 2 per cent higher. Over the same period, carbon-dioxide emissions from tankers and bulk carriers increased by 19 per cent and 17 per cent, respectively, well below the 38 per cent and 51 per cent growth in respective fleet capacity (see figures 3.29 and 3.30).

Figure 3.28 Annual carbon-dioxide emissions per vessel by vessel type, 2019



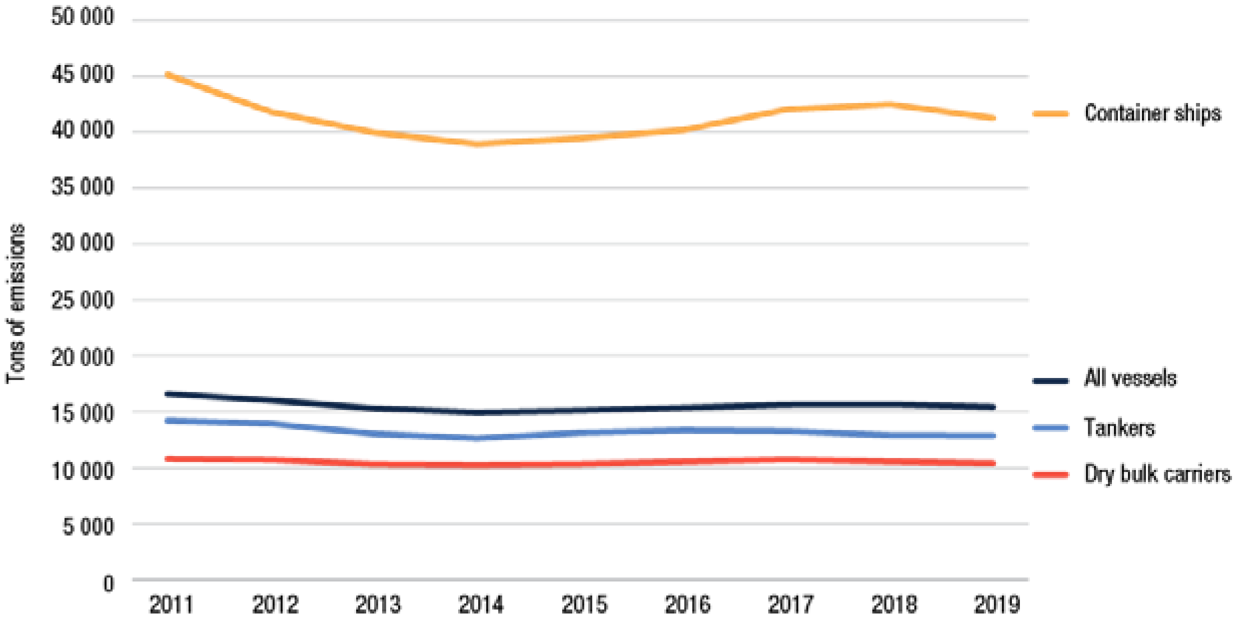
Source: UNCTAD calculations, based on data provided by Marine Benchmark.

Figure 3.29 Comparison of dead-weight tonnage of respective fleet and carbon-dioxide emissions from bulk carriers, container ships and tankers, 2011–2019
(2011 = 100)



Source: UNCTAD calculations, based on data provided by Marine Benchmark.

Figure 3.30 Annual carbon-dioxide emissions per vessel by vessel type, 2011–2019



Source: UNCTAD calculations, based on data provided by Marine Benchmark.

Despite larger average vessel sizes, carbon-dioxide emissions per vessel have declined slightly over the past decade. While further gains can reasonably be expected over the next decade, as modern eco-designs continue to replace older, less efficient designs, and with some further increases in average vessel size likely, these will not be enough to meaningfully reduce overall carbon-dioxide emissions in line with the 2050 targets of IMO. Achieving these targets will require radical engine and fuel technology changes.

According to Shell International (2020), more than 90 per cent of interviewees of a survey on the industrial perspectives of shipping decarbonization stated that such a policy was a main priority of their organization. They also considered the economic disruption induced by the COVID-19 pandemic as an opportunity to accelerate the decarbonization progress. Eighty per cent of the persons interviewed stated that the lack of technology alignment (especially alternative fuels) was a major barrier to decarbonization. Hydrogen and ammonia were considered the most promising long-term fuel alternative, despite its present unviability, due to its significantly lower energy density as compared with heavy fuel oil, challenges relating to its storage and the immaturity of fuel cell technology.

Some shipowners are turning towards liquefied natural gas as an alternative to meet IMO targets for 2030, as liquefied natural gas is 20–25 per cent less carbon-intensive than heavy fuel oil. However, other interviewees are more reserved about the long-term perspectives of liquefied natural gas. Owing to methane slip and other challenges arising during extraction and transport, there is no life-cycle greenhouse gas emission benefit to be derived from liquefied natural gas for any engine technology (Pavlenko et al., 2020).

3. Emissions by flag of registration

Flag States have an important role to play in enforcing IMO rules. They exercise regulatory control over the world fleet, applying the law and imposing penalties in case of non-compliance, on diverse issues. These range from ensuring safety of life at sea to protection of the marine environment and the provision of decent working and living conditions for seafarers.

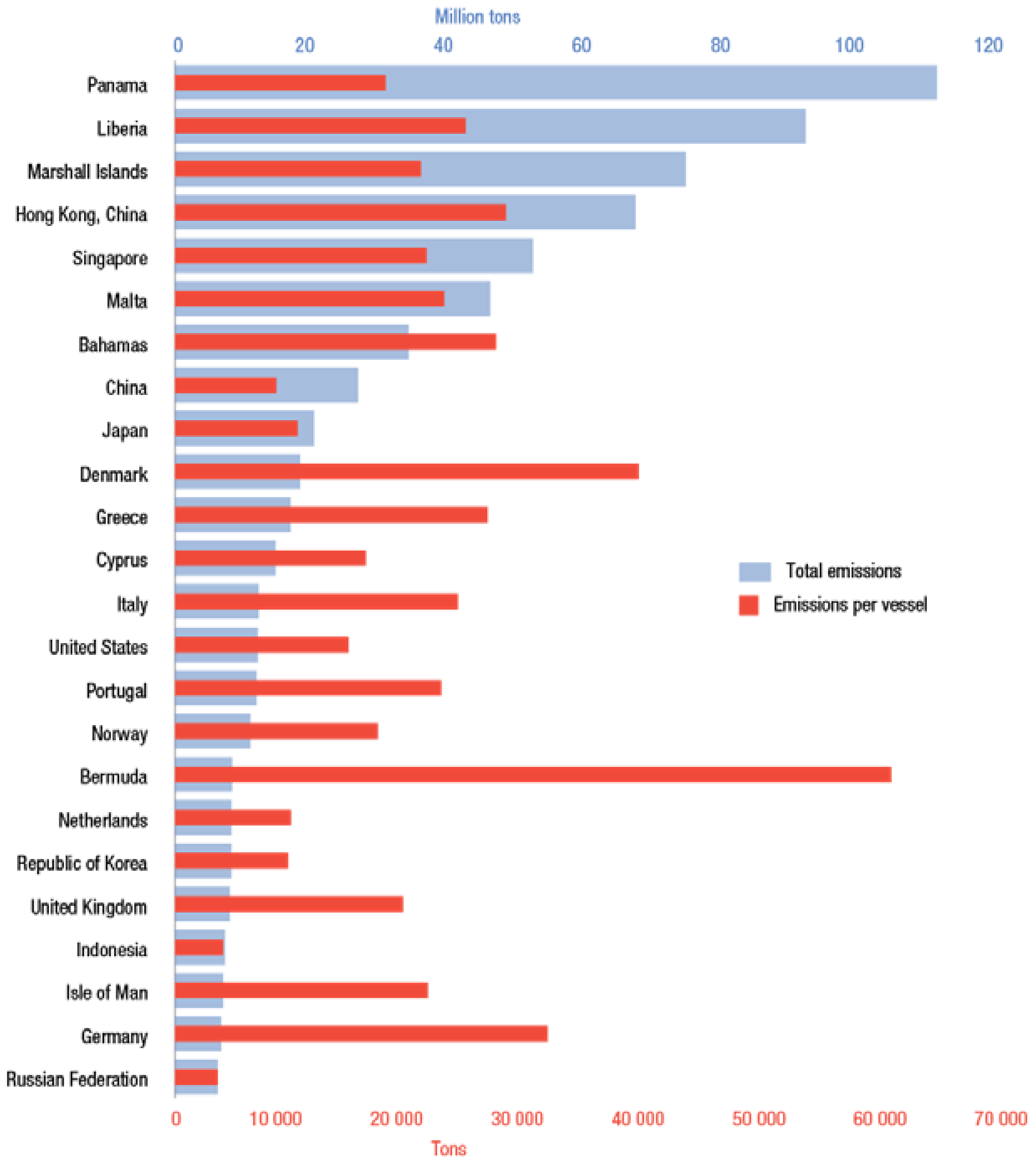
With regard to the implementation of the initial strategy on reduction of greenhouse gas emissions of IMO, flag States will have to ensure that ships are compliant with applicable IMO rules. In addition, they could also provide incentives for the ships registered under their flag to reduce carbon-dioxide emissions and help ensure the collection of future fees or contributions associated with such emissions. For example, the International Chamber of Shipping proposal mentioned above suggests that contributions to the proposed fund will be made commensurate with the ship's annual fuel oil purchased for consumption, as verified by the flag State.

Flag States could also consider such involvement a business opportunity, where more transparent and reliable flag States provide better services than others. In addition, many major flag States are affected by the impacts of climate change. For example, the Panama Canal is confronted with a shortage of fresh water; Liberia has developed a national adaptation plan to mainstream climate change adaptation into planning and budgets; and the Marshall Islands are among the low-lying small island developing States most at risk from sea-level rise (UNCTAD, 2020f). Therefore, it should be in these countries' interest to support the reduction of global greenhouse gas emissions, including from shipping (UNCTAD, 2017b).

Data generated from the automatic identification system tracking system for ships, including the above-mentioned information on vessel characteristics, speed, type of fuel and ballast situation, makes it possible to calculate estimates for carbon-dioxide emissions from each ship and aggregate those estimates. On this basis, ships registered in the Marshall Islands, Liberia and Panama accounted for almost one third (32.96 per cent) of carbon-dioxide emissions from shipping in 2019 (figure 3.31).

Using the same metrics, in 2019, ships (commercial vessels of 1,000 dwt and above) registered in the top 10 economies accounted for 67.15 per cent of total maritime carbon-dioxide emissions. As of 1 January 2020, these 10 flags represented 48.52 per cent of the

Figure 3.31 Annual carbon-dioxide emissions per vessel by flag of registration, 2019



Source: UNCTAD calculations, based on data provided by Marine Benchmark.

world fleet and 65.73 per cent of world gross tonnage. World maritime carbon-dioxideemissions rose by 8 per cent between 2014 and 2019, based on the latest analysis by Marine Benchmark.[19]

F. SUMMARY AND POLICY CONSIDERATIONS

The growing availability of port and shipping data helps the maritime industry to monitor and improve its performance. It also allows analysts to compare and report on differences among ports, countries and fleets, which in turn helps Governments and port and maritime authorities to make adjustments to their activities and policies, if necessary. Based on the performance indicators discussed above, the five points set out below would merit consideration by analysts and policymakers:

- **First, economies of scale are important, but they do not benefit all stakeholders.**

  The different data sets covering port and shipping performance all show that larger ports, with more ship calls and bigger vessels, also report better performance and connectivity indicators. Clearly, economies of scale are still relevant to maritime transport and port performance.

  At the same time, for those ports that aim to attract ever larger ships and call sizes, a note of caution is warranted. The economies of scale presented above reflect averages: they do not cover the total costs of door-to-door logistics. While a shipowner will be satisfied if a ships spends less time in port (sections A to D) and is more fuel efficient (section E), the shippers, ports and intermodal transport providers may well be confronted with diseconomies of scale.

  If the average call size goes up without any corresponding increase in the total cargo throughput, the higher call size will lead to more peak demand for trucks, yard space and intermodal connections, with additional investment needed for dredging and bigger cranes. Those costs will have to be borne by shippers, ports and inland transport providers, while shipowners will reduce the number of ship calls to deliver the same volume of trade. The concentration of traffic in fewer major ports may also imply that shippers could suffer from the choice of fewer ports and costs of trucking extra distances.

  All things being equal, the concentration of cargo in bigger ships and fewer ports with a given cargo volume often implies that there is business for fewer companies in the market. The resulting reduction in competition levels may lead to a situation where not all cost savings made on the seaside will be passed on to the clients in terms of lower freight rates, especially in markets with only few service providers to start with, such as in the case of many small island developing States.

- **Second, small island developing States continue to face challenges in maritime trade.**

  Some small island economies are among those with the longest port ship turnaround times and lowest service frequencies, as they may lack infrastructure or specialized port equipment, and they will not attract more ship calls if there is not much cargo to carry. These States are thus confronted with diseconomies of scale and – at the same time – low levels of competition and limited options in choosing their importers and exporters.

  Often there is little small island developing States can do to improve their liner shipping connectivity, owing to their geographic position, lack of a wider hinterland and low trade volumes. At times, it is possible to attract trans-shipment services, and the resulting additional fleet deployment can then be used for shipments of national importers and exporters. A small number of island economies become hub ports for third countries' trade, and the resulting higher connectivity also benefits those countries' own importers and exporters.

- **Third, emissions reductions will require radical technological changes.**

  Larger vessel sizes, combined with multiple efficiency gains and the scrapping of less efficient vessels, has led to lower growth of carbon-dioxide emissions compared with global fleet tonnage. Container ship fleet capacity, for example, increased by 45 per cent between 2011 and 2019, while carbon-dioxide emissions from container ships went up by only 2 per cent during the same period. Despite the trend towards larger container ships, annual emissions per ship have effectively declined.

  Some further gains can reasonably be expected over the next decade, as modern ecological designs continue to replace older, less efficient designs. However, these marginal improvements will not suffice to meaningfully reduce overall carbon-dioxide emissions in line with IMO targets for 2050. Achieving these targets will require radical engine and fuel technology changes.

  As shown in the Review, thanks to new technologies that help track vessels and identify fuels, combined with reporting requirements of vessel operators, it is possible today to assign carbon-dioxide emissions to vessels and flags of registration. The resulting statistics and insights

[19] Data provided electronically on 2 August 2020 by Marine Benchmark (www.marinebenchmark.com/).

may contribute to discussions on market-based measures to reduce carbon-dioxide emissions.

- **Fourth, nowcasts, forecasts and monitoring pandemics have a growing role to play in the maritime industry.**

  Ship movements, schedules and port traffic data are often available at short notice, before official statistics on economic growth or trade are published. There is an opportunity to make use of maritime data to obtain an early picture of physical trade in goods.

  The trends reported above show that during the first quarter of 2020, the total fleet deployment in most economies was still above that of the first quarter of 2019. For the second quarter, carriers started to significantly reduce capacity. China, for example, started with positive growth in the first quarter of 2020, compared with the first quarter of 2019, but then recorded a negative year-on-year growth in the second quarter. Most European and North American countries saw a steep decline between the first and second quarter.

  Such data is being used and analysed by international organizations and professional forecasters aiming to predict the economic and trade growth of upcoming weeks. Ports and shipping companies will at least to some extent plan their fleet deployment for the same upcoming period, based on such predictions. It is important not to fall into circular reasoning, where pessimistic forecasts may lead to a further withdrawal of shipping capacity, which in turn may lead to further worsening predictions of growth.

- **Fifth, there is a need to standardize maritime data.**

  For ports and shipping companies to benefit from benchmarking, data should be comparable. Ship types, key performance indicators, definitions and parameters need to be standardized. In the long run, the UNCTAD port performance scorecard has the potential to become an industry standard and thus, a globally accepted benchmark, helping the port sector to continuously improve its efficiency. For example, a port entity member of the TrainForTrade Port Management network stated that when it prepares or updates a strategic submission to the Government, port performance scorecard values are useful in drawing up baseline metrics for a proof-of-concept appraisal, in particular when forecasting profit levels, wage profiles, employment numbers and revenue profiles.

  UNCTAD is pursuing efforts to include more port entities and countries from the TrainForTrade network that are not yet reporting in the port performance scorecard component and to collaborate with international partners, such as the International Association of Port Authorities, to further contribute to the standardization of data and tracking of port performance.

REFERENCES

Arslanalp S, Marini M and Tumbarello P (2019). Big data on vessel traffic: Nowcasting trade flows in real time. Working Paper. No. 19/275. International Monetary Fund. Washington, D.C.

BIMCO, Cruise Lines International Association, International Association of Dry Cargo Shipowners, International Chamber of Shipping, Interferry, International Parcel Tankers Association, Intertanko, World Shipping Council (2019). Reduction of greenhouse gas emissions from ships: Proposal to establish an international maritime research and development board (IMRB). MEPC 75/7/4. 18 December.

Cerdeiro DA, Komaromi A, Liu Y and Saeed M (2020). World seaborne trade in real time: A proof of concept for building AIS [automatic identification system] -based nowcasts from scratch. Working Paper. WP/20/57. International Monetary Fund. Washington, D.C.

Englert D and Losos A (2020). Zero-emission shipping: What's in it for developing countries? World Bank Blogs. 24 February.

Environmental Defence Fund (2020). Shipping's green $1trn is a profitable investment, not a cost. 30 January.

Global Maritime Forum (2020). Getting to Zero Coalition. Available at www.globalmaritimeforum.org/getting-to-zero-coalition.

IMO (2018). Initial IMO Strategy on reduction of GHG [greenhouse gas] emissions from ships. MEPC 72/17/Add.1. Annex 11. April.

MDS Transmodal (2020). Port liner shipping connectivity index. Available at www.portlsci.com/index.php.

Parry I, Heine D, Kizzier K and Smith T (2018). Carbon taxation for international maritime fuels: Assessing the options. Working Paper. WP/18/203. International Monetary Fund. Washington, D.C.

Pavlenko N, Comer B, Zhou Y, Clark N and Rutherford D (2020). The climate implications of using LNG [liquefied natural gas] as a marine fuel. Working Paper 2020-02. International Council on Clean Transportation.

Rutherford D, Mao X, Osipova L and Comer B (2020). Limiting engine power to reduce [carbon dioxide] CO_2 emissions from existing ships. Working Paper 2020-10. International Council on Clean Transportation.

Sánchez RJ, Hoffmann J, Micco A, Pizzolitto GV, Sgut M and Wilmsmeier G (2003). Port efficiency and international trade: Port efficiency as a determinant of maritime transport costs. *Maritime Economics and Logistics*. 5(2):199–218.

Shell International (2020). *Decarbonizing Shipping: All Hands on Deck – Industry Perspectives*.

United Nations (2020). International Trade Statistics Database (Comtrade). AIS [automatic identification system]: Trade volume. Trade, transport and travel dashboards. Available at https://public.tableau.com/views/CerdeiroKomaromiLiuandSaeed2020AISdatacollectedbyMarineTraffic/AISTradeDashboard; https://comtrade.un.org/.

UNCTAD (2017a). *Review of Maritime Transport 2017*. (United Nations publication. Sales No. E.17.II.D.10. New York and Geneva).

UNCTAD (2017b). *UNCTAD Framework for Sustainable Freight Transport* (United Nations publication. New York and Geneva).

UNCTAD (2019a). Container ports: The fastest, the busiest, and the best connected. 7 August.

UNCTAD (2019b). Digitalization in maritime transport: Ensuring opportunities for development. Policy Brief No. 75.

UNCTAD (2020a). Navigating through the coronavirus crisis and uncertainty: How maritime transport data can help. Transport and Trade Facilitation Newsletter No. 87.

UNCTAD (2020b). *Digitalizing the Port Call Process*. Transport and Trade Facilitation Series. No. 13 (United Nations publication, Geneva).

UNCTAD (2020c). Decarbonizing shipping: What role for flag States? Transport and Trade Facilitation Newsletter No. 86.

UNCTAD (2020d). Towards the decarbonization of international maritime transport: Findings from a methodology developed by ECLAC [Economic Commission for Latin America and the Caribbean] on shipping [carbon-dioxide] CO2 emissions in Latin America. UNCTAD Transport and Trade Facilitation Newsletter No. 86.

UNCTAD (2020e). Decarbonizing maritime transport: Estimating fleet renewal trends based on ship-scrapping patterns. Transport and Trade Facilitation Newsletter No. 85.

UNCTAD (2020f). *Climate Change Impacts and Adaptation for Coastal Transport Infrastructure: A Compilation of Policies and Practices*. Transport and Trade Facilitation Series No. 12 (United Nations publication. Sales No. E.20.II.D.10. Geneva).

World Bank (2020). COVID-19 trade watch #3 – Signs of recovery? 29 June.