The Port of Singapore & COVID-19

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Context

The port of Singapore is the second largest port in the world, following only Shanghai, China in total volume[1]. With its strategic location, it serves as a gateway between Asia and the rest of the world, offering connectivity to more than 600 other ports in 123 other countries[2]. At its peak in 2019, the port of Singapore was handling over 37 million TEU (twenty-foot equivalent unit). For comparison, the port of Los Angeles, the biggest port in the U.S., only handled 9.3 TEU in 2019[1]. Given its size and magnitude of volume handled, the port of Singapore is incredibly important in supporting the global economy.

When COVID-19 pandemic began, the port of Singapore was forced to address the disaster. The port was affected in various ways, including a decreased demand for container ships since factories were closed and port labor shortages which caused congestion[3]. However, unlike other ports, the port of Singapore was able to recover from COVID rather quickly. The Maritime and Port Authority of Singapore (MPA) began screening arrivals as soon as January 24, 2020, especially due to the fact that China is their biggest trading partner[4]. As a small island nation, Singapore was particularly interested in keeping COVID numbers low. Since 2019, they have been the highest ranked nation in Bloomberg's COVID resilience ranking[5]. By keeping their COVID numbers low, the port of Singapore was able to keep their port running relatively well which can be seen in the data analysis.

Research Question & Hypothesis

What impact did COVID-19 have on Singapore's port operations for passenger and non-passenger traffic?

Data & Data Exploration

All of our datasets were taken from data.gov.sg and we focused on those that came from the Maritime and Port Authority of Singapore. We began our data exploration by looking at the COVID period within 6 different data sets (each team member addressed 2): vessel calls, vessel arrivals, job vacancy, short work-weeks/temporary lay-offs, consumer price index, and bunker sales. We produced a variety of analytic, trend, and correlative visualizations such as histograms, box plots, and scatter plots using these data in search of insights that might drive our analysis (many of these are available in Jupyter Notebooks in our project code.) After evaluating all datasets, we found it challenging to credibly connect jobs, economic data, and the shipping datasets. While shipping has an outsized role in Singapore's economy, the manner in which the government of Singapore elects to report on occupational industries and roles did not map well to categories that might be clearly impacted by specific trends in shipping (e.g., tourism workers who support the cruise industry are lumped together with workers in other

tourism areas). Moreover, as is widely known, COVID-19 has had impacts across all sectors of national economies; without more sophisticated statistical techniques at our disposal, we felt we could not do justice even with a comprehensive dataset like the ones available on the Singapore data portal to the extensive and nuanced economic impacts of COVID-19. Relatedly, shipping traffic in Singapore is reported on via several metrics (including arrivals, calls, and cargo throughput). Having taken the time to familiarize ourselves with these concepts, comparing and contrasting these metrics raised similar issues. The differences between these measures of shipping activity are oftentimes subtle, but meaningful, and research and quantitative analysis that extend beyond the scope of this project are required to fully analyze and communicate the relationships between them. After dedicating effort to analyzing and visualizing these varied datasets, we decided to focus on multiple metrics within the vessel arrivals dataset, since we found that a comprehensive story can be told from that dataset alone. Below are our findings based on the data we analyzed.

Data Analysis

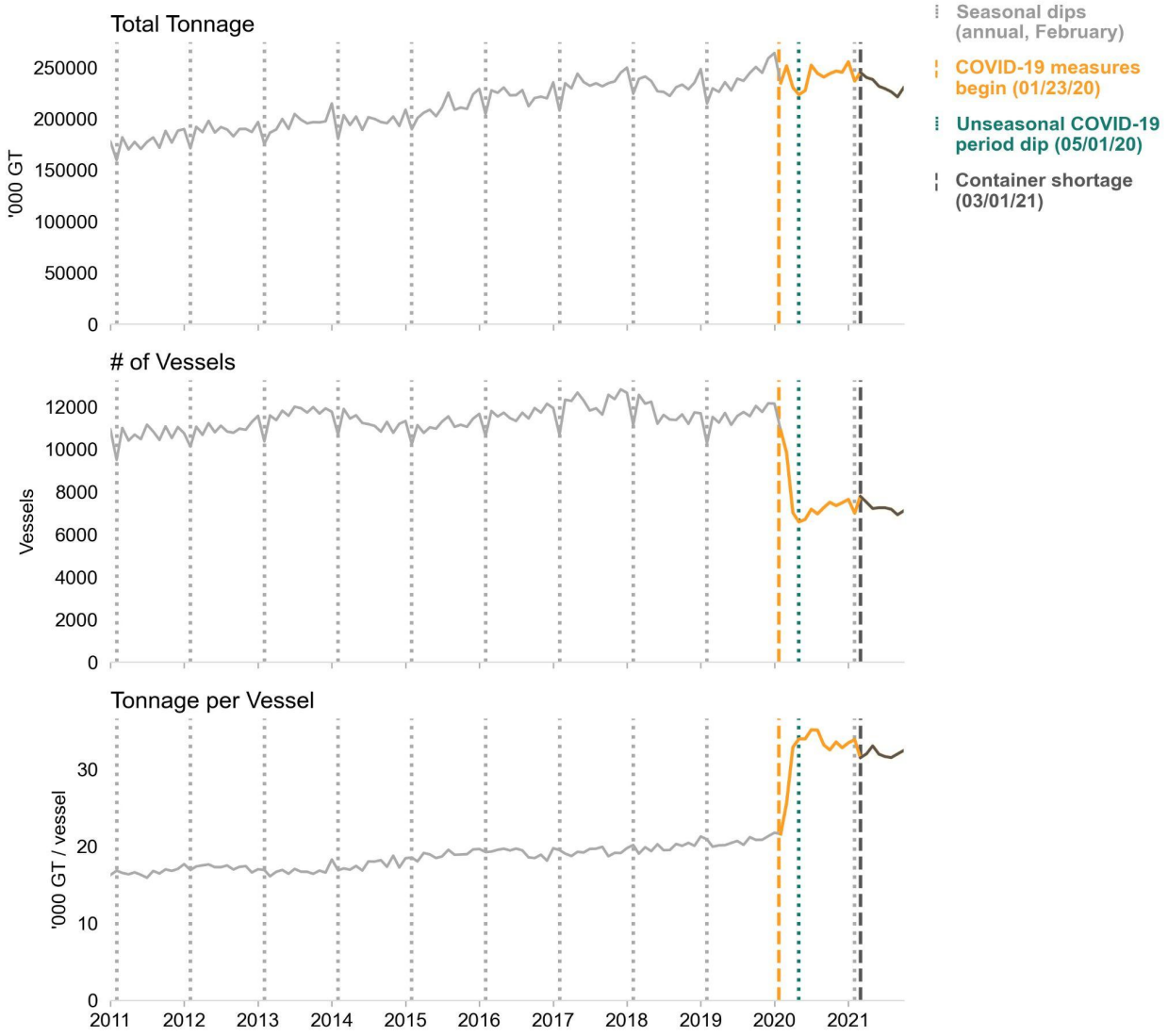
All Vessels

The shipping industry is a historically seasonal industry, due to various peaks and falls that occur on an annual basis. Looking at **Figure 1**, there are are two main features to highlight in this section: annual seasonal dips and COVID measures with an unseasonal COVID dip.

The seasonal dips are caused by varying demand for goods throughout the year. They are most clearly visible in Total Tonnage and # of Vessels, so we will focus on those charts in this section. Looking at the charts, in the majority of cycles there is one large dip that takes place in February of every year (vertical gray dashed lines). This dip is likely to be related to peak shipping season wrapping up. In the shipping industry, peak season begins at the end of summer and continues through the end of the year. During peak season, demand grows and supply lowers which causes tight capacity and high freight rates[5]. Peak season demand begins with back-to-school shopping at the end of summer and is followed by holiday season shopping, which includes retail events like black friday and cyber monday. Once peak retail season is over, the demand for goods decreases which is why we see the February dips.

Secondly, we want to highlight when COVID hit and the unseasonal dip that followed. In **Figure 1**, we see a dip in Total Tonnage, a dip in # of Vessels, and an increase in Tonnage per Vessel. The major drop that occurs in # of vessels (and correspondingly Tonnage per Vessel) will be addressed in later sections, and we will focus on Total Tonnage in this section. Coincidentally, COVID hit right at the end of peak shipping season. COVID measures were instated on January 23, 2020 when we would typically see total tonnage drop anyway. What is different about 2020 is that it continued to drop until May. This is likely when the full force of the pandemic hit Singapore and peak lockdowns were in place. As mentioned earlier, Singapore was quick to recover from the pandemic and keep their COVID numbers low, so beginning in June/July we do see the number begin to increase again.

Lastly, you will see that there is a dark gray vertical line for the container shortage that began in March 2021. This shortage will be highlighted in the Non-Passenger Vessel section.

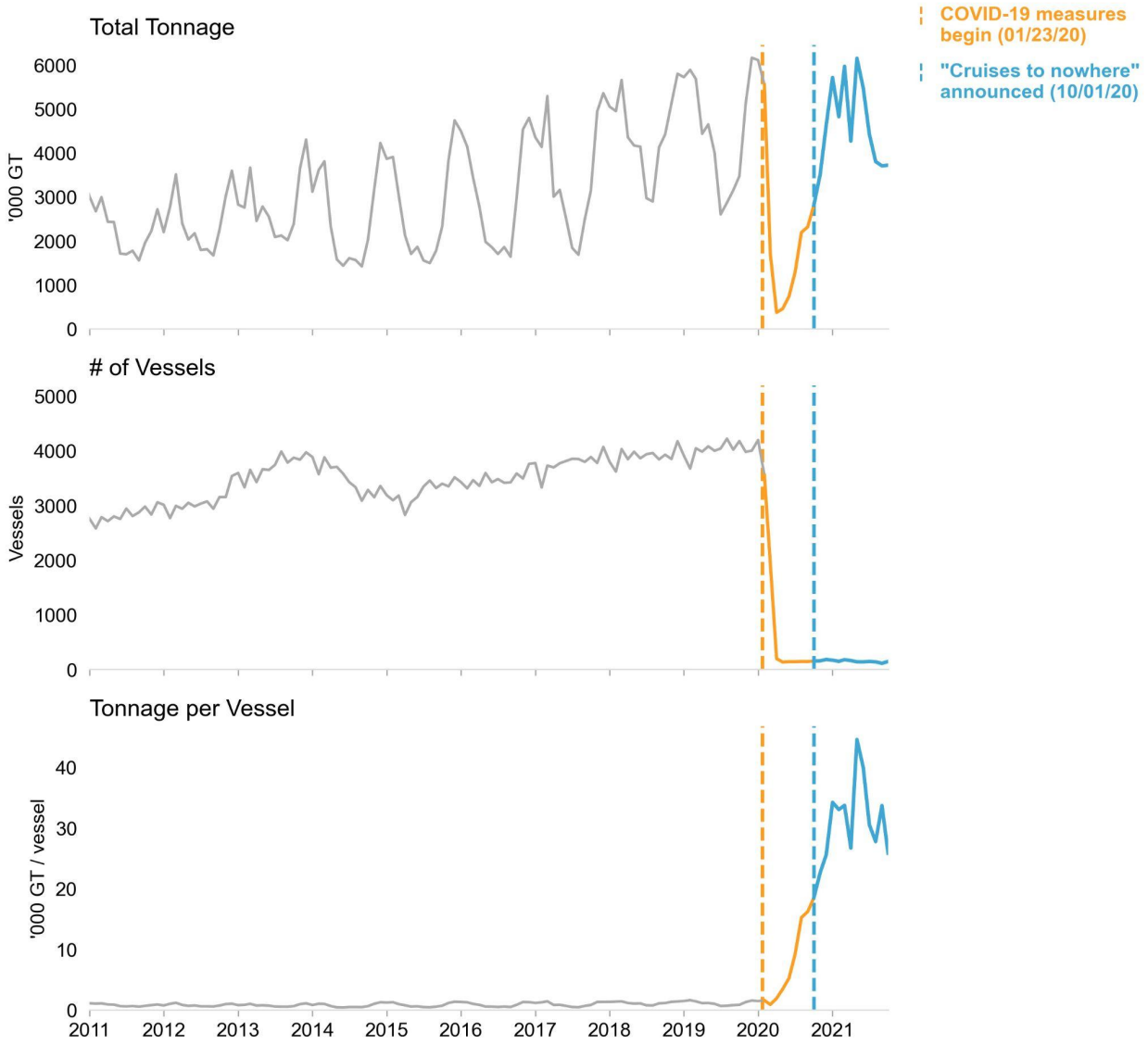


All Vessels: Total Tonnage, # of Vessels, and Tonnage per Vessel (Figure 1)

Passenger Vessels

As with other sectors of Singapore's nautical transport industry, the COVID pandemic has had considerable ramifications for sea-going passenger traffic arriving in Singapore. Prior to the pandemic in 2019, Singapore ranked first among Asian cities as a port of call (intermediate stop for a ship on its sailing itinerary) for cruise ship traffic.[6] Given its central location near the high-traffic waters of Southeast Asia, it has furthermore served as a destination for a significant amount of non-cruise-ship passenger traffic; 12,155 individual passenger vessels arrived in Singapore in Q4 of 2019. This traffic figure includes all vessels above 75 gross tonnes (GT), a significant range that encompasses ships from small, personal yachts weighing less than 100 gross tonnes to cruise liners at tens of thousands GT.[7]

The onset of official COVID restrictions in Singapore beginning on January 23, 2020 and evolving throughout the initial months of the pandemic produced a dramatic reduction in passenger ship arrivals.[8] The nature of this reduction was two-fold, following patterns also seen in other countries. First, the general flow of international passenger traffic was sharply curtailed. While Singapore did not immediately shut down international travel, by March of 2020 short-term visits to the country from foreign points of origin were banned, including by ship.[9] Second, cruise ships were specifically impacted owing to feared high transmissibility of COVID onboard. In spite of the prominence of the cruise industry in its economy, by the spring of 2020, Singapore had closed its port to foreign cruise ships and implemented strict health measures for domestic-based cruises.[9] As a result of these limitations, as well as a significant reduction in popular demand due to COVID fears, a thriving cruise industry ground effectively to a halt.



Passenger Vessels: Total Tonnage, # of Vessels, and Tonnage per Vessel (Figure 2)

Accounting for both cruise- and non-cruise passenger traffic, Singapore consequently saw a drop to 195 total arrivals by passenger vessels in April 2020, a reduction of 95.1% from December 2019 (**Figure 2; Appendix, Table 1**). Predictably, the total tonnage weight of these

vessels fell to historically low levels as well, given that heavy cruise ships with high vessel weight and laden with passengers more or less stopped sailing in Singapore's waters. These trends stand out not just in contrast to the recent pre-COVID period, but are historic in scale. As shown in **Figure 2**, this level fell far short of any monthly count of vessels in 10 years, and in fact was the lowest single-month measurement for passenger vessel arrivals in the available data, dating back to 1995.

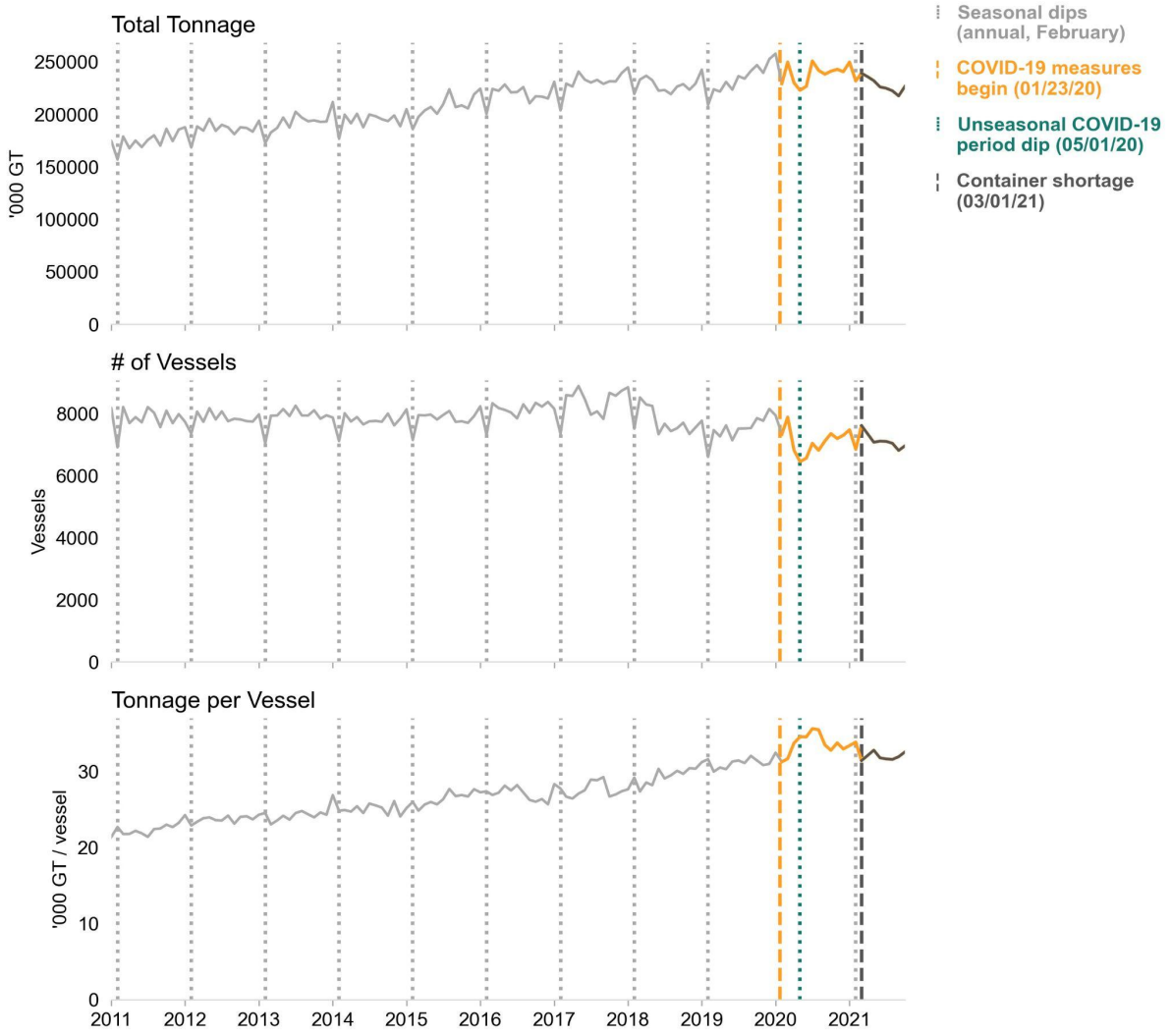
Contrastingly, the immediate net effect on shipping tonnage per passenger vessel was minimal. Because of the large number of passenger vessels of all sizes and weights arriving in Singapore in previous periods, though total shipping tonnage was considerably higher than in the early months of COVID, the average carrying weight of each vessel has been consistently quite low (e.g., 1.54 thousand GT in December 2019 (**Appendix, Table 1**).) After COVID measures were implemented, a simultaneous, steep reduction in both number of vessels and total tonnage produced a similar average weight per vessel through the early months of 2020. However, in the following months, this trend was to change, providing insight into Singapore's novel response to COVID's toll on the cruise industry.

Singapore enforced limitations on international passenger travel and protective health measures through several months of 2020 in spite of the evident detriment to the nautical passenger travel industry. While more general passenger shipping traffic remained constrained, owing to Singapore's relative success at minimizing rates of infection and severe disease, some domestic cruise ship activity did begin to take place through the summer of 2020. Then, in October 2020, the Singapore Tourism Board, an organ of the state Ministry of Trade and Industry, announced an initiative officially labelled the "CruiseSafe program," but which quickly came to be called "cruises to nowhere."[10] These cruises would be available only to residents of Singapore and would proceed aboard Singapore-based cruise ships. They were to visit no other countries, but rather would spend several days at sea before returning to port while featuring all of the amenities of a standard cruise, albeit under strict health protocols.

The cruises to nowhere, which ramped up through October into November, were a popular initiative among Singaporeans who had been confined to the island for the bulk of a year. Over the subsequent months, passenger shipping traffic as measured by tonnage surged back to pre-pandemic levels, reaching almost 6 million GT by March 2021 (**Appendix, Table 1**). By that time, Singapore had become host to one third of the cruise ship passengers in the world, with the cruise industry still dormant across much of the rest of the globe.[11] However, this resurgence in passenger ship traffic was accomplished with a relatively miniscule fleet; vessel arrival numbers have remained at near-zero levels in spite of the huge increase in total tonnage. The novelty of this approach is therefore evident in rates of tonnage per vessel, which for the first time in Singapore's data record have reached levels as high as 44.56 thousand GT (May 2021), far outpacing any previous measurement of this indicator (**Figure 2**). The temporary makeover of Singapore's passenger shipping industry could hardly be more complete. What once was a highly populated nautical transport sector with thousands of vessels arriving month by month now appears in the data as a small but busy fleet of cruise ships, packed with Singaporeans eager to travel, even if only to "nowhere."

Non-Passenger Vessels

As seen in **Figure 3**, non-passenger Total Tonnage and Total Tonnage per Vessel have experienced relatively steady growth since 2011, until the COVID pandemic began in January 2020. Until early 2020, not only was the overall total tonnage arriving into Singapore's port increasing but average tonnage per vessel was increasing as well. In comparison, the number of non-passenger vessel arrivals has been relatively stable since 2011. This is further highlighted in **Figure 4** where this data is disaggregated by vessel type.



Non-Passenger Vessels: Total Tonnage, # of Vessels, and Tonnage per Vessel (Figure 3)

Looking at the data in **Figure 3**, there are clear decreases from COVID in the number of Vessels and Tonnage per Vessel. Between December 2019 and January 2020, there was a decrease from 8,147 non-passenger vessels to 7,939 vessels (**Appendix, Table 2**). We typically do not see a decrease from December to January, but given the timing and the state of COVID at that time, we can assume that this decline was due to a halt in vessels coming from China. There is a small increase from February to March, potentially because people underestimated the magnitude of COVID, but around March 2020 we see the effects of the pandemic begin to

have a large effect. As seen in **Figure 3**, the number of non-passenger vessel arrivals and total tonnage started to decrease until they hit lows in May 2020. Between March and May 2020, the number of vessel arrivals decreased by 18% from 7,882 to 6,449 and total tonnage decreased by 11% from 249,678 GT to 222,866 GT (**Appendix, Table 2**). Conversely, total tonnage per vessel increased in this period by 9% from 31.68 to 34.56 gross tons per vessel (**Appendix, Table 2**). Even though the number of vessels coming in decreased, the amount of cargo on each increased. It appears that due to COVID, the port of Singapore tried to limit access to the country by lowering the number of vessels arriving and rather tried to put more cargo on each ship arriving.

The decrease in total tonnage from March to May 2020 can be explained by expectations of stakeholders in global trade. When national lockdowns began, production of many goods shut down due to public health concerns, and shipping companies, anticipating a slowdown, began sending out fewer cargo ships[12]. However, rather than a decrease in demand, there was a shift in consumption patterns[3]. There was actually an increased demand for manufactured goods due to the lockdown. Many people wanted goods to improve their at-home experience (e.g. exercise equipment, office equipment, etc.)[13]. About 80% of goods consumed are carried by seagoing vessels, and the strong demand tools shipping companies by surprise, making it hard for them to meet demand[3].

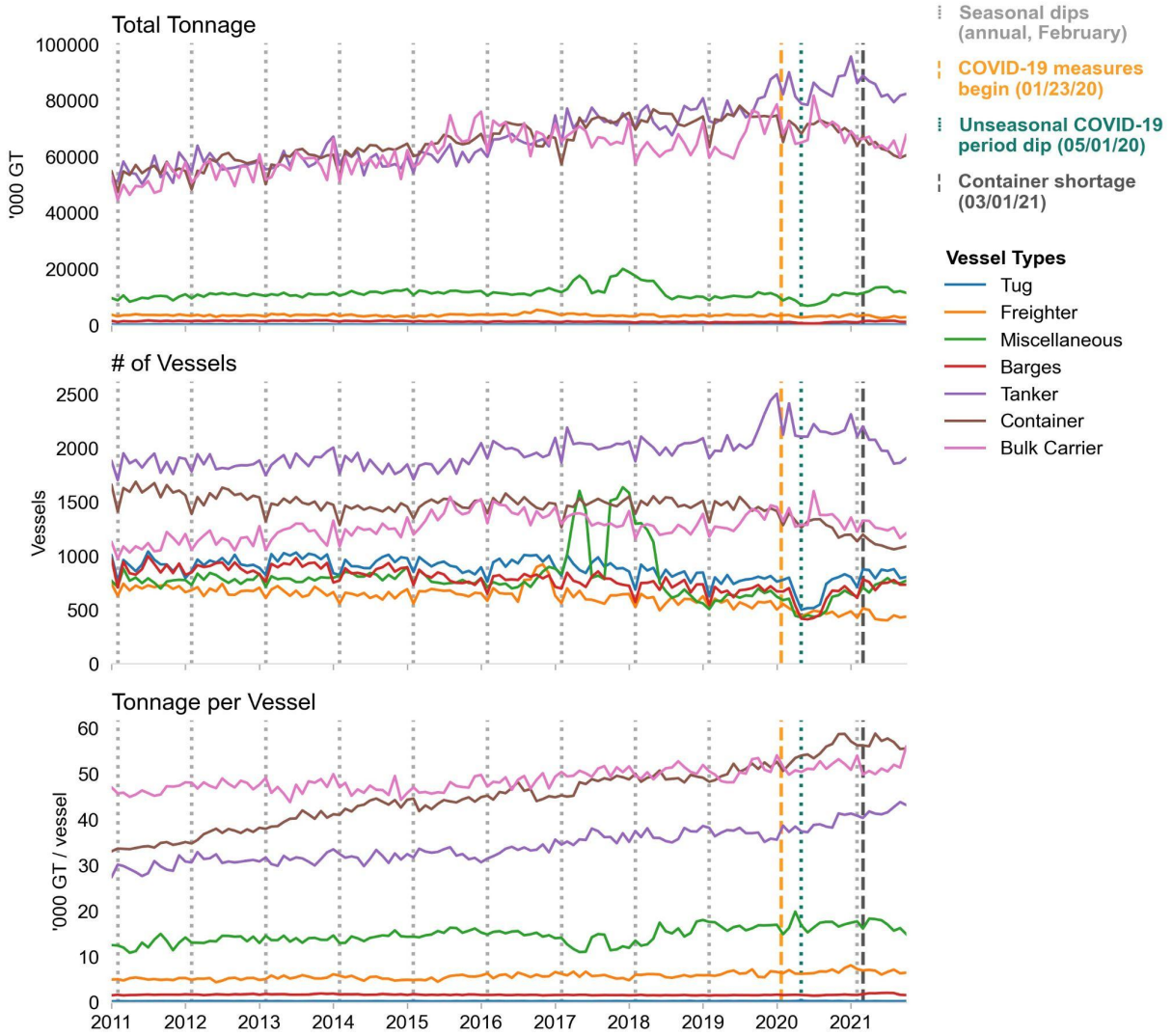
In **Figure 3**, looking at the section between May 2020 and March 2021 (vertical blue line to grey line) we begin to see some recovery in Total Tonnage and number of Vessels. Beginning in June 2020, lockdowns began to loosen in many countries and shipping began to increase. After suffering from delays in early 2020, many companies saw value in increasing their inventories in anticipation of new waves of COVID[12]. Contrarily, total tonnage per vessel decreased by 9% from 34.54 to 31.42 gross tons per vessel (**Appendix, Table 2**), indicating that while the number of vessel arrivals was increasing, each vessel itself was bringing in less tonnage to the port. This implies that the signs of recovery for total tonnage were likely caused by the increase in overall vessels arriving but each vessel wasn't necessarily arriving with more goods.

The period of relative recovery lasted until around March 2021 (vertical grey line), when we begin to see a decrease again. This is especially seen in Total Tonnage and number of Vessels, both experiencing declines until September 2021. The total tonnage decreased by 9% and number of vessel arrivals by 11% (**Appendix, Table 2**). Total Tonnage per Vessel fluctuated between March and September 2021, likely due to specifics related to vessel types, which is covered below. Typically, we would not see a decline between March and September. Even in 2020, during the earlier stages of the pandemic, we did not see this happen. The decline between March and September 2021 is more likely related to the ongoing global shipping crisis.

As previously mentioned, in early 2020 many shipping companies reduced the number of cargo ships being sent out, which resulted in many uncollected empty containers stacking up at cargo ports, creating a backlog of containers[14]. This caused a shortage of containers that can actually be used for shipping. Additionally, there are ongoing delays due to the pandemic. Due to increased public health restrictions, many ports, including Singapore, introduced regulations to decrease contact. These regulations caused a decrease in the manpower capacity of ports being able to carry out tasks at normal levels[15]. This has all led to congestion at ports around

the world, with vessels having to spend more time waiting to unload and load, refuel, etc. When congestion arises at one port, it has a trickle-down effect on connecting ports. Given that Singapore has one of the most connected ports in the world, it is facing a bottleneck of vessels waiting to be tied to a berth (a vessel's allotted space at a port)[15].

As of October 2021, non-passenger traffic has shown some signs of recovery. Total Tonnage, number of Vessels, and Total Tonnage per Vessel have increased by 4%, 2%, and 2% respectively (**Appendix, Table 2**). This is likely reflective of some of the actions Singapore had been taking in recent months. In September 2021, the Singapore port increased their capacity by starting to use yard space at the new Tuas mega port to handle an extra 2,000 TEUs. Since late 2020, Singapore has reopened 8 berths at its Keppel terminal and 18,000 ground slots to add 65,000 TEUs of yard capacity. More importantly, they have been increasing data sharing with key stakeholders to gain a better understanding of where the congestion is to minimize delays vessels face when they arrive at the port[15].



Non-Passenger Vessels by Vessel Type: Total Tonnage, # of Vessels, and Tonnage per Vessel (Figure 4)

Figure 4 shows the disaggregation of arrivals by vessel type (see appendix for definitions). There are various trends to be seen when looking at the vessels by type and focusing on the COVID period.

Between March and May 2020 (vertical yellow line to blue line), there are decreases in number of vessel arrivals for all non-passenger vessel types, with greater decreases seen for tugs, barges, miscellaneous, and tankers. This likely explains the overall non-passenger decrease in vessel arrivals. The drop in total tonnage likely is due to the drops in total tonnage from tankers, container carriers, and bulk carriers. Each experienced decreases by the following total tons between March and May 2020: 11,220 GT (tankers), 4,622 GT (container carriers), and 6,980 GT (bulk carriers), for a combined total of 22,821 GT or 85%, of the overall total tonnage drop of 26,812 GT (**Appendix, Table 3**).

Figure 4 shows that from around July 2020 onwards, there was an overall declining trend in container carriers and bulk carriers, in regards to Total Tonnage and number of Vessels. This decline likely started when shipping companies were sending out less cargo ships when the pandemic started, due to their expectations of what shipping demand would be. However, unlike the period of recovery that was observed in the third quarter of 2020, in the total non-passenger traffic indicators, container carriers and bulk carriers did not have any clear recovery period at this moment. Furthermore, both the number of vessel arrivals and total tonnage for container and bulk carriers continues to decrease up until October 2021. This corresponds to the congestion of such cargo ships at different ports (reducing vessel arrivals), and, in the case of the container vessels, the decreased total tonnage corresponds to the ongoing container shortage. The period of recovery seen in **Figure 3** between June 2020 and March 2021 can therefore be attributed to the increase for barges, tugs, miscellaneous, and even tankers to some extent. In total tonnage, tankers, containers, and bulk carriers did have a brief period of recovery in the third quarter of 2020. Together, these increases in Total Tonnage and number of Vessels help explain the slight recovery seen at this moment in **Figure 3**.

In **Figure 3**, it was noted that around March 2021 to September 2021, the effects of the global shipping crisis came to be more pronounced. Container carriers, bulk carriers, and tankers continually have the most Total Tonnage and number of Vessels. These three vessel types steadily declined throughout the stated period. Tug boats, barges, and miscellaneous vessels increased in number of Vessels, but their relatively low numbers did not stop the total number of non-passenger vessel arrivals from decreasing between March and September 2021 (their total tonnage did not change significantly because these vessel types are not made to carry large quantities of cargo).

The increase in the use of tug boats and barges between March 2021 and September 2021 illustrates the port of Singapore's attempt to increase operations. Larger ships need tugboats to navigate them through the congested harbor at the port, so seeing an increase in the number of tugs indicates that there were many large ships at the port at the time (although most likely waiting to be tied to a berth). The increase in barge traffic likely indicates that more goods were being transported to their next stop via rivers and canals. However, it should be noted from **Figure 4** that the number of arrivals for these types dropped significantly by May 2020, so the increases are merely bringing them closer to pre-pandemic levels. Tug boats and barges are

useful in supporting operations in a port and, given that in this time period congestion levels were high, it makes sense that the port would bring more of them.

In **Figure 3**, we saw signs of recovery in October 2021, which are reflected in **Figure 4**. Total Tonnage and number of Vessels show an increase for tankers, container carriers, and bulk carriers when looking at the last data point shown in **Figure 4**. **Figure 3** did not indicate a strong level of recovery (large increase), which is why the disaggregated **Figure 4** does not have a very large increase.

Focusing on the Total Tonnage per Vessel in **Figure 4**, it can be seen that shipping companies were trying to maximize vessel capacity across different vessel types. This is especially seen for container carriers, bulk carriers, and tankers whose total tonnage per vessel seemed to continue to increase during the pandemic, while the other vessel types stayed relatively stable. This is a logical decision by shipping companies for two reasons. First, as ports get more congested, shipping companies want to make the most of a vessel's voyage and put as much cargo on a ship as possible, knowing that there will be delays and potential complications (due to the pandemic or congestion). Second, since the pandemic began, shipping rates have been rapidly increasing to unprecedented levels, largely due to the complications in congested ports and low supply of available containers globally. With shipping rates so high, shipping companies want to make sure they are maximizing capacity per vessel in order to maximize profits, thus the increase in total tonnage per vessel.

Conclusion

Throughout the pandemic, Singapore was able to keep their port running although at a limited capacity, which can be seen in the Passenger and Non-Passenger Vessel data. This is incredibly important for the global economy, since the port is so large and it is used as a connection to so many other places. Given the number of variants and new waves of COVID that we have seen since January of 2020, it is likely that COVID will be endemic and the global economy will be forced to cope. Considering how responsive the port of Singapore has been regarding the pandemic, there is reason to be optimistic in it being able to handle future waves.

Additionally, while the global shipping crisis will likely continue in the coming months, Singapore has taken steps to alleviate the difficulties. These steps include the ships to nowhere, expanding its capacity safely amidst public health restrictions, and collaborating with relevant stakeholders to make better data driven decisions. Given that Singapore's port is already quite developed, but still growing, it will be interesting to see how their planned growth will come to fruition in the context of the ongoing pandemic.

Appendix

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Types of Vessels[15]

Tug	Tugs are boats or ships that guide vessels by towing or pushing them; used a lot to guide vessels in crowded port areas; they can also go to the open sea/ocean depending on the tug.
Freighter	Freighters (cargo ships) are merchant ships that carry cargo; many are often equipped with cranes or other mechanisms to load and unload cargo. The cargo is not necessarily always in containers on freighters.
Miscellaneous	Miscellaneous vessels may include the following (not limited to them): roll-on/roll-off ships, offshore vessels, fishing vessels, light ships, livestock carriers, icebreaker ships, research vessels, etc.

Barge	Barges are flat bottom boats built to transport heavy goods on a river or canal.
Tanker	Tankers are vessels specialized to carry large amounts of liquid cargo such as crude oil, liquified gas, etc.
Container	Container carriers are designed specifically to hold large quantities of cargo packed in standardized containers.
Bulk Carrier	A bulk carrier is a vessel that transports cargo (usually dry) in bulk quantities. There is usually no specific packaging (i.e., no containers).

Data Tables

Table 1: Changes in Passenger Traffic, COVID-19 Period

Month	Dec 2019	Apr 2020	Apr 2020	Apr 2021
Total Tonnage (‘000 GT)	6,160.93	371.15	371.15	4,265.66
% Change (Total Tonnage)		-93.97%		1,049.32%
# of Vessels	4001	195	195	160
% Change (# of Vessels)		-95.13%		-17.95%
Tonnage per Vessel (‘000 GT)	1.54	1.90	1.90	26.66
% Change (Tonnage per Vessel)		23.60%		1,300.73%

Table 2: Changes in Non-Passenger Traffic, COVID-19 Period

Month	Mar 2020	May 2020	Mar 2021	Sep 2021	Sep 2021	Oct 2021
Total Tonnage ('000 GT)	249,678.71	222,866.72	239,115.54	217,434.33	217,434.33	226,323.35
% Change (Total Tonnage)		-10.74%		-9.07%		4.09%
# of Vessels	7,882.00	6,449.00	7,611.00	6,808.00	6,808.00	6,954.00
% Change (# of Vessels)		-18.18%		-10.55%		2.14%
Tonnage per Vessel ('000 GT)	31.68	34.56	31.42	31.94	31.94	32.55
% Change (Tonnage per Vessel)		9.10%		1.66%		1.90%

Table 3: Changes in Non-Passenger Traffic by Type, COVID-19 Period

Month	Vessel Type	Total Tonnage ('000 GT)	% Change (Total Tonnage)	# of Vessels	% Change (# of Vessels)	Tonnage per Vessel ('000 GT)	% Change (Tonnage per Vessel)
Mar 2020	Tanker	90,083.91		2,417.00		37.27	
May 2020	Tanker	78,864.37	-12.45%	2,108.00	-12.78%	37.41	0.38%
Mar 2021	Tanker	88,877.69		2,203.00		40.34	
Sep 2021	Tanker	81,760.07	-8.01%	1,865.00	-15.34%	43.84	8.66%
Sep 2021	Tanker	81,760.07		1,865.00		43.84	
Oct 2021	Tanker	82,368.50	0.74%	1,908.00	2.31%	43.17	-1.53%
Mar 2020	Bulk Carrier	72,028.17		1,446.00		49.81	
May 2020	Bulk Carrier	65,048.54	-9.69%	1,290.00	-10.79%	50.43	1.23%
Mar 2021	Bulk Carrier	66,268.49		1,329.00		49.86	
Sep 2021	Bulk Carrier	59,860.56	-9.67%	1,165.00	-12.34%	51.38	3.05%
Sep 2021	Bulk Carrier	59,860.56		1,165.00		51.38	
Oct 2021	Bulk Carrier	67,754.94	13.19%	1,211.00	3.95%	55.95	8.89%
Mar 2020	Barges	1,135.78		702.00		1.62	
May 2020	Barges	670.19	-40.99%	418.00	-40.46%	1.60	-0.90%
Mar 2021	Barges	1,396.04		783.00		1.78	
Sep 2021	Barges	1,193.57	-14.50%	733.00	-6.38%	1.63	-8.67%
Sep 2021	Barges	1,193.57		733.00		1.63	
Oct 2021	Barges	1,160.52	-2.77%	734.00	0.14%	1.58	-2.90%