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Seasonality of the global cruise industry

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ABSTRACT

Seasonality is a unique characteristic of the cruise industry. Cruise lines move their ship deployment areas seasonally to meet tourism needs. Taking advantage of the climatic differences between the Northern and Southern Hemispheres could allow greater growth in the global cruise industry. This study aims to provide basic findings for governments and ports to consider ways to encourage growth by capitalizing on the seasonality of the global cruise industry. Automatic identification system data for all ocean-going cruise ships worldwide in 2019 were compiled and categorized into three travel groups (short, middle, and long) based on the latitudinal distance traveled. Differences between these three groups were analyzed in terms of deployment area/port, vessel size, and itinerary design. As a result, we found that the long travel group had the following characteristics. Cruise ships were deployed to Alaska and Northern Europe in summer and dispersed to the equator and Southern Hemisphere in winter. The vessel size was standard and neither too large nor too small. Specifically, long travel of cruise ships was limited by the maximum gross tonnage, length, and breadth of the ship, but there was no draught restriction. Although the number of nodes and edges, and the average degree comprising the itineraries were high, hub ports appeared only in the summer. Furthermore, despite the long distances traveled by season, the number of communities tended to be small, reflecting the design of their itineraries. In conclusion, the development of several ports in the Southern Hemisphere that can accommodate mega-sized cruise ships with standard draught, while considering overtourism, would allow cruise ships to take advantage of the seasonality and, thereby, grow the cruise industry.

1. Introduction

Since the late 1960s, the cruise industry has experienced constant growth, except for temporary negative growth during the oil crisis of 1974-75 and the shutdown of the world's cruise ships during the coronavirus disease 2019 (COVID-19) pandemic, starting in March 2020 (CDC (Center for disease control and prevention), 2020; Pallis, 2015). Although the global financial crisis of 2008-09 had a major impact on maritime cargo shipping, cruise lines, and cruise ports continued to experience an increase in passenger numbers (Pallis, 2015). The global cruise passenger numbers increased from 3.8 million in 1990 to 29.7 million in 2019. The average annual growth rate over the last 30 years has been 7.37% (CLIA, 2011, 2019, 2020).

Seasonality plays a key role in the cruise industry (Charlier and McCalla, 2006; Charlier, 1999). Cruise lines change their cruise ship deployment areas seasonally to accommodate the tourism needs of passengers. These cruise lines attempt to optimize the year-round utilization of their assets by repositioning to take advantage of the seasonality of cruise markets (Rodrigue and Notteboom, 2012).

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Seasonality is also affected by the geographic and climatic conditions of the ports. For example, ports in polar regions, where cruise ships may not be able to enter during certain periods because of snowfall or sea ice, tend to be highly seasonal. Additionally, ports in equatorial regions may be less seasonal because cruise ships can call at any time of the year. The seasonal characteristics of the cruise industry remain unclear. Why are some cruise ship itineraries highly seasonal and others less so? Does vessel size affect seasonality? In which areas and ports are cruise ships deployed during which seasons? How is the network structure consisting of itineraries affected by seasonality? If governments and ports can understand the seasonal behavior and characteristics of cruise lines, they can design attractive cruise products that take advantage of seasonality, leading to growth in the global cruise industry.

Several studies have been conducted on the seasonality of the cruise industry. Li et al. (2021) conducted an empirical study on seasonality, capturing the trajectory of the Queen Elizabeth cruise. Esteve-Perez and Garcia-Sanchez (2019) analyzed the seasonality of cruise ships using a clustering approach with the 17 most important cruise ports in the northeastern Atlantic as the study area. Rodrigue and Notteboom (2012) focused on the Atlantic Ocean and found that the Caribbean and Mediterranean Seas have their peak season in winter and summer, respectively, based on the number of calls to each port. Santos et al. (2020) regionally analyzed the specific characteristics of cruise traffic on the Atlantic coast of the Iberian Peninsula, focusing on passenger traffic of the main cruise ports in the region and its seasonality throughout the 2007–2016 period.

However, these previous studies only tracked a single cruise ship or analyzed a small number of ports or regions, and did not focus on seasonal changes in seasonality differences by deployment area/port, vessel size, and itinerary design. This study aims to provide basic findings for governments and ports to consider ways to encourage growth by capitalizing on the seasonality of the global cruise industry. Automatic identification system (AIS) data for all ocean-going cruise ships worldwide were compiled and classified into three travel groups (short, middle, and long travel groups) using the distance traveled between north and south during 2019 as an indicator. We then analyzed the differences in the seasonality characteristics of these three groups in terms of deployment area/port, vessel size, and itinerary design.

The remainder of this paper is organized as follows. Section 2 is a literature review on the seasonality characteristics of area selection by cruise lines, itinerary design, the use of AIS data on cruise ship trajectories, and the application of network science to the cruise industry. Section 3 outlines the methodologies, such as deployment area/port, vessel size, and characteristics of itinerary design based on AIS data using network science. Section 4 organizes the results, Section 5 provides the discussion, and Section 6 presents the conclusions.

2. Literature review

Several previous studies have analyzed the impact of seasonality on the cruise industry. The Caribbean is predominantly serviced during winter, whereas the Mediterranean Sea experiences a summer peak season. The two markets do not function independently but are interconnected operationally, particularly through the repositioning of ship units to cope with variations in seasonal demand among the geographical markets. The seasonality of Alaska, Bermuda, and Canada/New England is also evident (Rodrigue and Notteboom, 2012). The seasonal pattern of cruise destinations is not only conditioned by weather and market demand constraints but also by the seasonality patterns of neighboring destination regions (Esteve-Perez and Garcia-Sanchez, 2019). Cruise ships tend to voyage in a stable temperature range of 10–20°C; therefore, they flee the winter, catch up with the summer and spring, and mainly stay in the temperate maritime climate zone, subtropical monsoon humid climate zone, and Mediterranean climate zone to form several branch networks (Li et al., 2021).

The seasonality of the cruise industry can be attributed to the itinerary design of the cruise lines. Several previous studies have examined cruise line itinerary design. According to Marti (1990), cruise lines constantly focus on developing new ports to develop products that can differentiate them from their competitors, and they determine the number of ports that they can call depending on the location of the port of embarkation, port of call, ship's speed, and the number of voyage days. Moreover, they design itineraries by considering the following four factors: sailing speed, port of embarkation, voyage duration, and tourist destinations (Rodrigue et al., 2013). Cruise lines want to build itineraries comprising different ports because the different attractions of each port offer different opportunities for different experiences. Furthermore, in the process of seeking new ports of call, cruise lines consider the geopolitical factors, political stability, and level of security at the port during and after tourism, to provide a safe and comfortable itinerary (Pallis, 2015). Additionally, cruise lines need to develop more competitive cruise products and concurrently minimize operating costs by constantly considering how to optimize the deployment of their cruise fleet in terms of minimizing and maximizing revenues. Other factors that influence cruise ship operators' deployment strategies and itinerary design include the seasonality of cruise demand, optimal cruise vacation periods, a balance between sailing and anchoring times, presence of well-known ports of call, and customer satisfaction (Rodrigue and Notteboom, 2013).

Seasonality and itinerary design can be captured by AIS data. However, few studies have analyzed AIS data for cruise shipping. Tichavska and Tovar (2015) used AIS data to measure the pollution status of exhaust gas from cruise ships at the Las Palmas Port in the Canary Islands. Vicente-Cera et al. (2019, 2020a) arranged the cruise ship operating hours, repair times, and berthing times, estimated the seawater pollution status of cruise ships, and assessed the environmental pressures related to global cruise traffic along their paths based on AIS data. Vicente-Cera et al. (2020b) used AIS data to aggregate cruise ship calling patterns at European ports and evaluated the diversity of cruise ship calls at each port. Ito et al. (2020) organized port call patterns before and after the suspension of cruise ship operations owing to the COVID-19 pandemic and analyzed the relationship between cruise ship operations and the spread of infection at the port of call using AIS data.

Moreover, few studies have analyzed cruise shipping itinerary designs using network science techniques. Tsiotas et al. (2018) showed the double role of the cruise network, which consists of the profit-driven strategies of cruise companies and port authorities, using data from the 2013 itineraries of Costa Cruises and Mediterranean Shipping Company Cruises in the Mediterranean cruise market. Jeon et al. (2019) investigated the centrality of cruise ports in the Asian cruise shipping market and proposed the hub and authority centrality metric as a directional synthesis of hub centrality and authority centrality to explore cyclical and directional features of centrality in the cruise shipping network. In a recent cruise network study, Kanrak and Nguyen (2022) revealed that the cruise shipping network is scale-free, using itinerary data from Asian and Australian cruise network websites. Lopez Rodriguez et al. (2021) suggested that Caribbean ports are the most important for hub and authority centrality, using 2018 itineraries for each cruise line from 902 ports in the Caribbean and Northern Europe. Ito et al. (2022) analyzed spatiotemporal changes in the cruise network structure in Northeast Asia from 2014 to 2019 using network science techniques.

To the best of our knowledge, no network science approach using AIS data has elucidated structural changes in the seasonality of the cruise industry. In particular, no previous studies have focused on cruise markets around the world, not just major markets such as the Caribbean and Mediterranean Seas, as well as seasonality differences by deployment area and port, vessel size, or seasonal changes in network structure as a result of itinerary design, for all cruise ships worldwide.

3. Methodology

3.1. Classification of cruise ships by latitude travel distance

AIS data on the ports of arrival for all ocean cruise ships worldwide in 2019 were used. In total, there were 390 ships. We classified cruise ships into three groups based on the longest latitudinal travel distance (i.e., the difference between the northernmost and southernmost latitudes) during the year for each cruise ship. Seasonality is measured by latitudinal distance because the best season for cruise tourism is summer in the Northern Hemisphere and winter in the Southern Hemisphere, and many cruise ships travel year-round, looking for a comfortable climate. We named the group with the longest travel distance the “long travel group,” that with the shortest travel distance the “short travel group,” and the group in between the “middle travel group.” Fig. 1 divides all 390 cruise ships into three groups of 130 ships based on each ship’s longest latitudinal distance in 2019. The short travel group ranged from 0.07° to 26.97°, the middle travel group ranged from 27.16° to 61.37°, and the long travel group ranged from 63.75° to 133.05°. Fig. 1 is arranged in ascending order of latitude travel distance for cruise ships belonging to each travel group, and because the graph is discrete, there is a difference in the values of the boundary line of each group.

3.2. Measurements of deployment area/port, vessel size, and itinerary design

Seasonality is measured using three indicators: deployment area/port, vessel size, and itinerary design. Deployment areas/ports of call help governments and ports understand when cruise ships call at their ports throughout the year. Vessel size can help governments and ports design the size of their facilities. Moreover, itinerary design helps governments and ports develop port marketing strategies for cruise lines. The deployment area/port is measured by the total number of cruise ship calls. The classification of deployment areas is shown in Fig. 2. Vessel size is measured using four indices: gross tonnage (GT), length, breadth, and draught. The characteristics of itinerary design owing to seasonality are captured using network science methods.

The network resulting from the itinerary design is analyzed using an undirected and unweighted graph. The analysis of itinerary design focuses on four aspects: seasonal changes in the number of ports and routes are measured by the number of nodes and edges. The diversity and degree of concentration of routes in ports are measured by the average degree and the degree centralization. Seasonal changes in port clusters are measured by the number of communities and modularity.

A network is composed of components called nodes and the direct connections between them are called edges. The average degree, $\langle k \rangle$, is defined as follows:

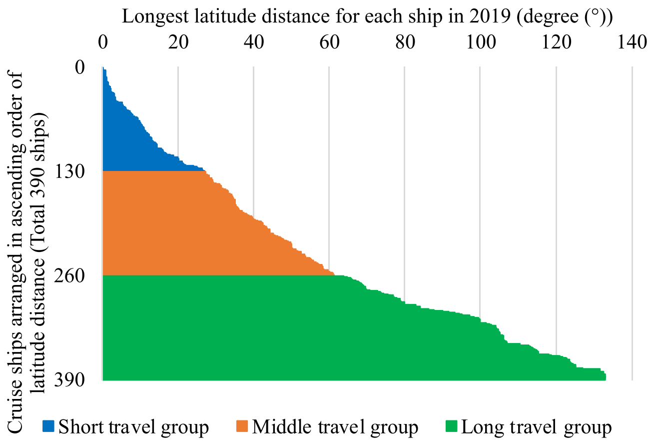

Fig. 1. Three groups classified by latitude distance in 2019.

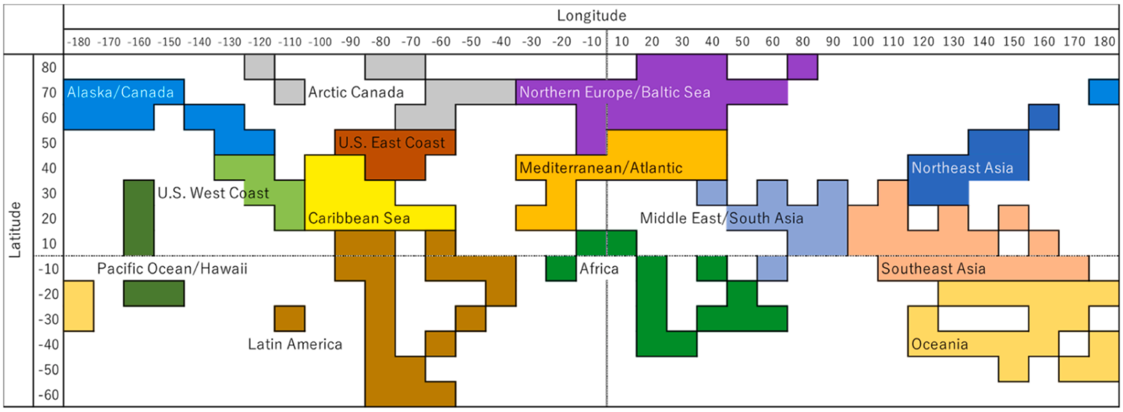

Fig. 2. Classification of the deployment area.

$$\langle k \rangle = \frac{1}{n}\sum_{i=1}^{n} k_i \tag{1}$$

where k_i is the degree of node i and n is the number of nodes.

Degree centralization, C_D, is based on a normalized variance in the degree centrality to compare distinct networks based on their highest degree centralization scores (Krnc and Škrekovski, 2020). Degree centralization is defined as

$$C_D = \frac{\sum_{i=1}^{n}(k_{\max} - k_i)}{\max\sum_{i=1}^{n}(k_{\max} - k_i)} \tag{2}$$

where $k_{\max}$ is the largest degree in the network. The more concentrated the network, the less homogeneous it is.

A community is defined as a group of nodes belonging to one group and is connected with a higher probability than nodes belonging to other groups. Community detection was performed using modularity optimization. Modularity is a measure of the quality of community partitioning results. Modularity Q, is defined by

$$Q = \frac{1}{m}\sum_{c}\left(m_c - \frac{k_c^2}{4m}\right) \tag{3}$$

where m_c is the number of internal edges in community c, and k_c is the total degree of nodes in community c.

Community detection was conducted using the Louvain algorithm, which is based on modularity optimization (Blondel et al.,

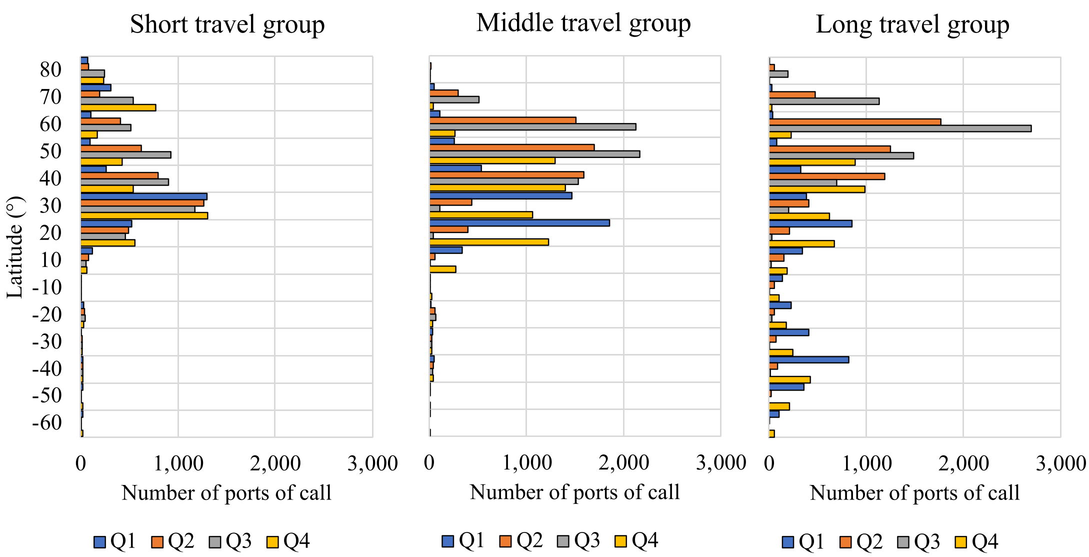

Fig. 3. Quarterly port calls by latitude.

2008). The Louvain algorithm is a heuristic algorithm that optimizes modularity over the divisions of a network into any number of communities. This is an agglomerative algorithm that works by taking single nodes and joining them into groups, then joining groups with other groups, and so forth, to find the configuration with the highest modularity. We used the automatic identification system (AIS) data (https://maritime.ihs.com) to track cruise ships' movement. Network analysis and visualization were conducted using Gephi (the open graph Viz platform).

4. Results

4.1. Deployment area/port

The x-axis in Fig. 3 shows the number of port calls per quarter, and the y-axis shows the ship's deployment area in latitude. The first quarter (Q1) is from January to March, the second quarter (Q2) is from April to June, the third quarter (Q3) is from July to September, and the fourth quarter (Q4) is from October to December. The left graph in Fig. 3 shows that the short travel group had ships staying at N latitude throughout the year. In particular, the Caribbean Sea corresponds to the 30° N latitude area, where the vessels stayed year-round. They did not move to the Southern Hemisphere. The middle graph in Fig. 3 shows that the middle travel group was north of 40° latitude in the second and third quarters, and moved south of 30° north latitude in the fourth and first quarters. They also did not move to the Southern Hemisphere. In contrast, the graph on the right side of Fig. 3 shows the long travel group. This shows that they made extensive movements throughout the year from north to south. They were north of 40° latitude in the second and third quarters and moved south of 30° latitude in the fourth and first quarters. Notably, from the fourth to the first quarter, they shifted their deployment areas to the Southern Hemisphere.

Fig. 4 shows the number of cruise ship calls to the deployment area by travel group by month. The short travel group showed little change in deployment area by season. In the Caribbean Sea, which has the highest number of port calls throughout the year, the number of port calls did not change between summer and winter. The Mediterranean/Atlantic, which had the next highest number of port calls, has an increased number of port calls during the summer months but showed less variation than the other groups. The Northern Europe/Baltic Sea area had the highest number of port calls during the six months from July to December. The middle travel group had different cruise ship deployment areas during summer and winter. This group was deployed in the Mediterranean/Atlantic and Northern Europe/Baltic Sea in summer and the Caribbean Sea in winter. It seems to be interconnected with Europe (Northern Europe and the Mediterranean Sea) and the Caribbean Sea.

Conversely, the long travel group also differed between ship deployment areas in summer and winter. This group moved to Northern Europe/Baltic Sea and Alaska/Canada in summer (May to September) and to Oceania, Latin America, and the Caribbean Sea in winter (November to March). In spring and autumn (around April and October), when they were in the middle of their north-south migration, they sailed around the Mediterranean/Atlantic and Northeast Asia. Thus, the long travel group had an operational pattern of positioning itself in the Northern Hemisphere during summer and in the Southern Hemisphere during winter to adapt to seasonal changes.

Fig. 5 lists the 50 ports in descending order of the number of annual port calls per port for each travel group. In this figure, the darker black months indicate a higher number of port calls, while the colorless months indicate no cruise ship calls. The short travel group was characterized by little variation in shading throughout the year. Furthermore, there was a tendency for calls to be concentrated in several high-ranking ports. In the medium-ranked travel group, there were ports with many port calls in summer and ports with many port calls in winter. Ports in the Mediterranean Sea, such as Civitavecchia, Barcelona, and Piraeus, were frequently visited in summer. Ports in the Caribbean Sea, such as Port Everglades, Cozumel, and Phillipsburg, were frequently visited in winter.

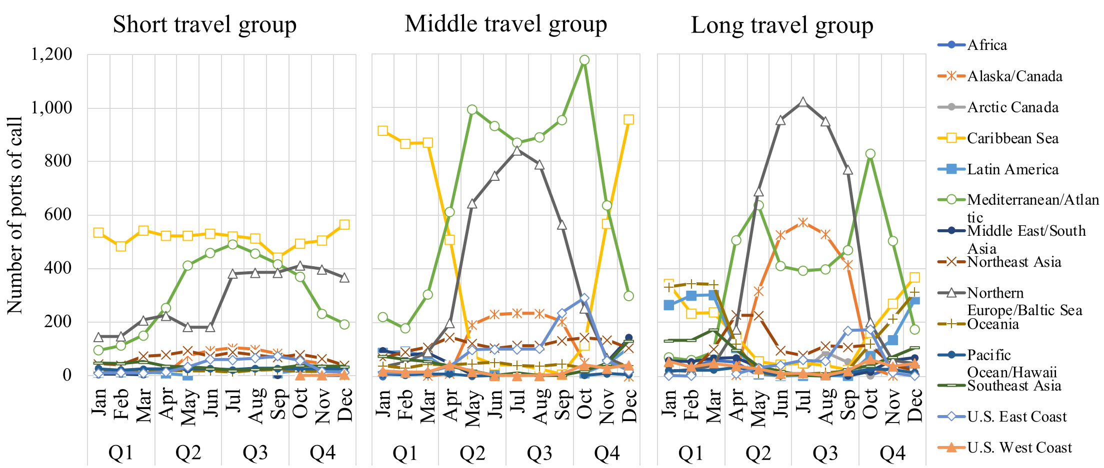

Fig. 4. Monthly number of port calls by area.

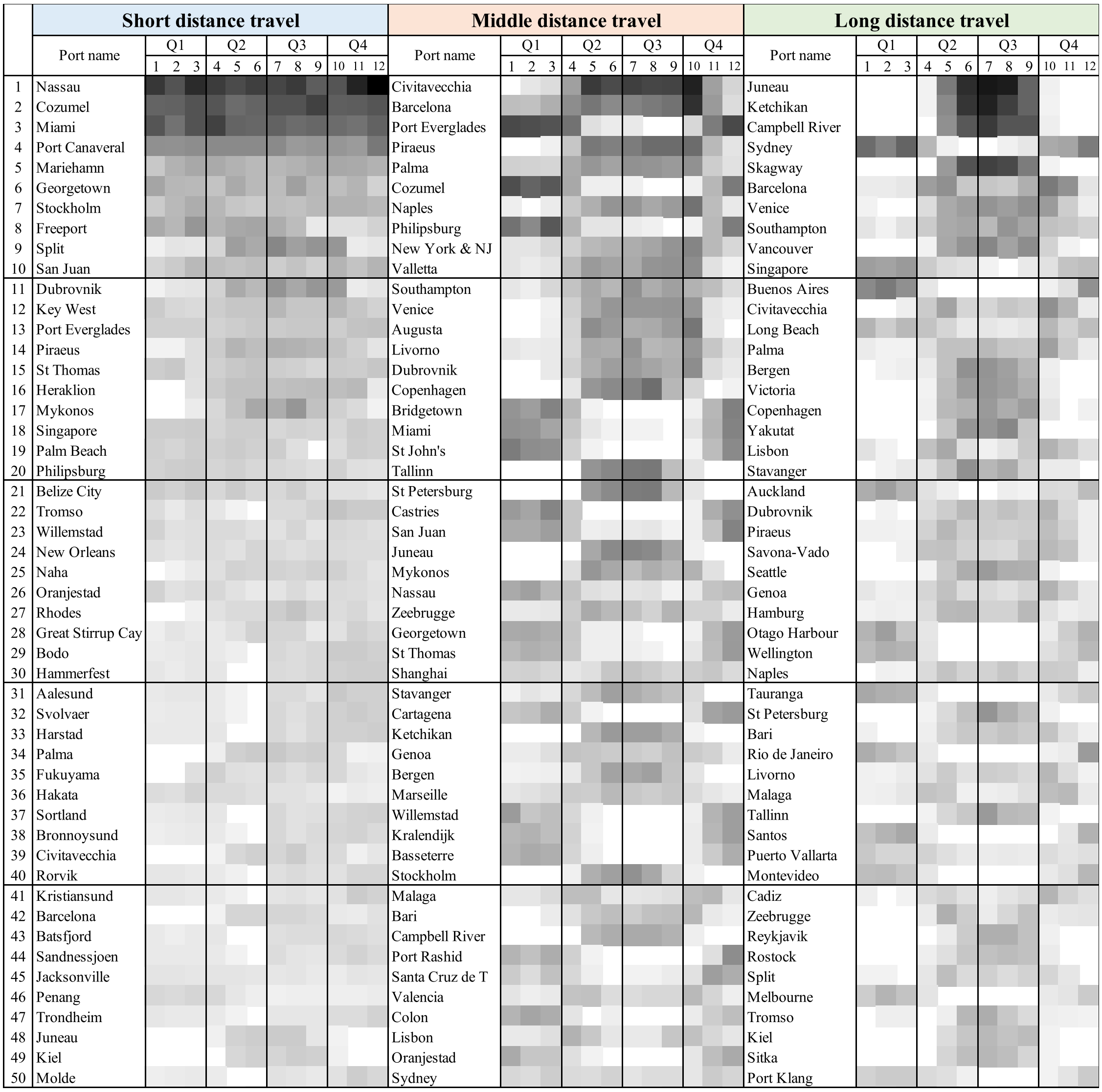

Fig. 5. Top 50 ports of call by month.

The long travel group was dichotomized as follows: ports with more port calls from the second to the third quarter and ports with more port calls from the fourth to the first quarter. This group made more port calls to Juneau, Ketchikan, and Skagway in Alaska, Campbell River in Canada in the Northern Hemisphere during the second to the third quarter period, and more to Sydney (Australia), Singapore, and Buenos Aires in the Southern Hemisphere during the fourth to the first quarter.

4.2. Vessel size

Fig. 6(a) shows the gross tonnage (GT) index. While most of the short travel groups were under 1000 or 5000 GT, there were mega-sized vessels of 250,000 GT or less. Ships in the middle travel group were mostly from over 50,000 to 150,000 GT, whereas those in the long travel group ranged from over 10,000 to 150,000 GT. The length of the ship is shown in Fig. 6(b). Vessels less than 100 m in length were more common in the short travel group, whereas in the middle travel group, vessels from over 250 m to less than 350 m were more common. The short travel group also had very long vessels (< 400 m). The long travel group was distributed over a wide range of sizes, from over 100 m to less than 350 m. Fig. 6(c), which shows the breadth of the vessels, shows that most of the short travel groups were below 15 m, whereas most of the middle travel groups were above 30 m to below 40 m. The short travel group also had very wide vessels of less than 50 m. Long travel groups were widely distributed from over 15 m to 40 m or less. In Fig. 6(d), regarding the draught of the ship, there were many short travel groups with draughts of 4 m or less, whereas there were many middle travel groups with drafts of over 8 m and less than 9 m. The long travel group was mostly distributed from over 4 m to 9 m or less.

Fig. 7 shows the maximum vessel size based on the deployment area of cruise ships. The maximum GT in Fig. 7(a) was 168,666 GT

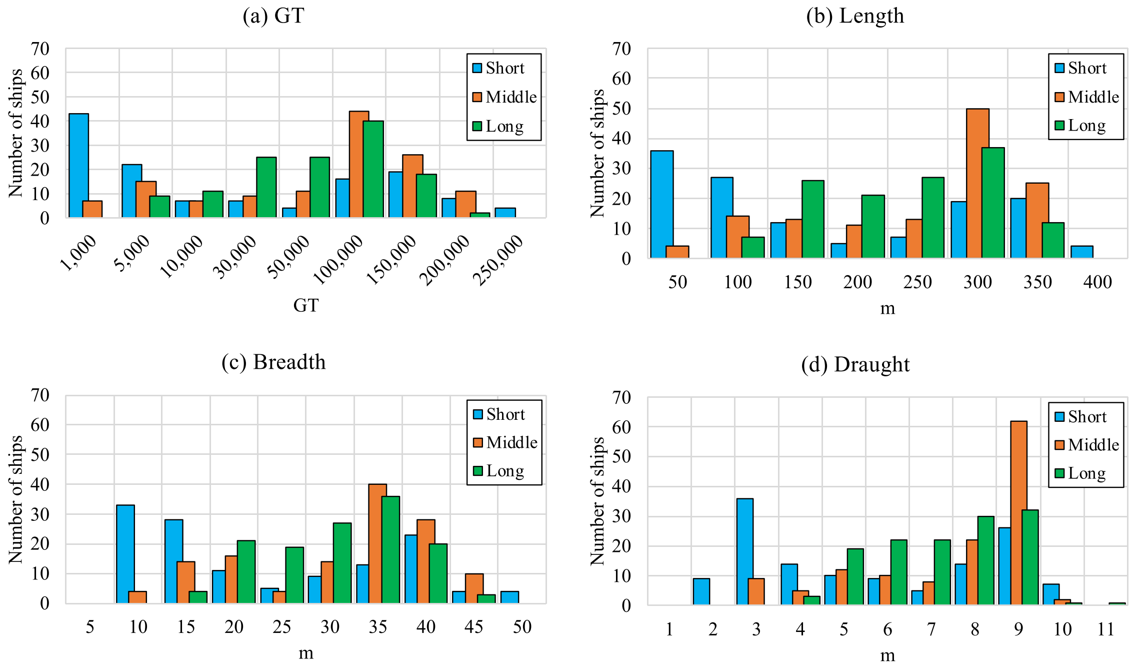

Fig. 6. Vessel size by the travel group.
Note: GT, gross tonnage

for the long travel group, and 171,598 GT for the middle travel group, while vessels of more than 220,000 GT for the short travel group were deployed in the Caribbean Sea (228,081 GT) and Mediterranean Sea (226,838 GT). In terms of maximum length, in Fig. 7(b), the long travel group had a maximum length of 345 m in many deployment areas, while the middle travel group had a maximum length of 347 m, slightly longer than the long travel group, and the short travel group had the longest vessels, exceeding 360 m deployed in the Caribbean Sea (362.12 m) and Mediterranean Sea (360.0 m). The maximum breadth in Fig. 7(c) was 41.2 m in most areas for the long travel group, while the maximum breadth for the middle travel group was 43.0 m, slightly longer than this, and the maximum breadth for the short travel group was over 47 m. Vessels with maximum breadths exceeding 47 m were deployed in the Caribbean Sea (47.03

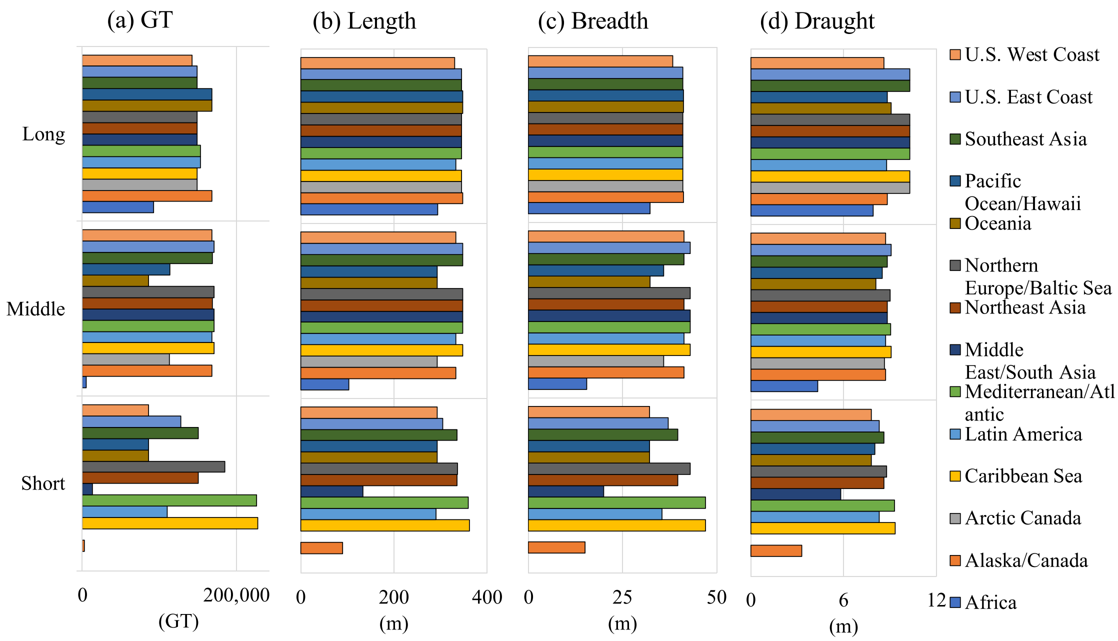

Fig. 7. Maximum vessel size by deployment area.

m) and Mediterranean Sea (47.0 m). The short travel group had the largest width of over 47 m. For maximum draught, in Fig. 7(d), the long travel group was the deepest in most deployment areas at 10.3 m, while the middle travel group had a maximum draught of 9.1 m and the short travel group had a maximum draught of 9.3 m. Interestingly, the ship size of the long travel group was smaller than the short travel group in terms of maximum GT, maximum length, and maximum breadth, while the maximum draught was the deepest. In other words, the size of cruise ships that can move seasonally was constrained by a maximum volume of 168,666 GT, maximum length of 345 m, and maximum breadth of 41.2 m, while draught was not relevant.

4.3. Network structure

Fig. 8 depicts the number of nodes and edges per month in 2019 for each travel group. The number of nodes represents the number of ports of call, whereas the number of edges represents the number of routes connecting ports. On the left side of Fig. 8, the long travel group had the highest number of nodes. This indicates that cruise ships that move seasonally were constantly calling in new ports. In particular, the months of March-April and September-October, when the number of nodes increased, were when they changed their deployment areas, which is known as repositioning. On the right side of Fig. 8, the number of edges in the long travel group was also high and increased, similar to the timing of the increase in the number of nodes. Conversely, there were fewer edges for cruise ships that did not move as much, as occurred in the short travel group. This indicates that cruise ships that move frequently need to travel along new routes and new ports of call.

The left side of Fig. 9 shows the average degree. The average degree was higher for the long and middle travel groups, and lower for the short travel group. Ports with a high average degree have routes to multiple destinations, which enable them to offer a wide variety of cruise products. Conversely, the short travel group had a low average degree of 3 throughout the year. Cruise ships in the short travel group always operate on the same route. Degree centralization on the right side of Fig. 9 indicates that the long travel group increased in summer, and the short travel group increased in winter. Many of the cruise ships in the long travel group visited Alaska and Northern Europe in summer, and most of the cruise ships in the short travel group visited the Caribbean Sea in winter. The degree centralization trend was the opposite for the short and long travel groups. A higher degree of centralization tendency indicates a higher degree of bias. That is, the order of a particular port tended to be higher in winter for the short travel group, and in summer for the long travel group. In particular, the average degree of the short travel group tended to remain the same throughout the year, whereas the degree of the specific port tended to change significantly.

The number of communities on the left side of Fig. 10 was high in the short travel group and low in the long and middle travel groups. A characteristic feature is that the number of communities in the long travel group did not change, even though the deployment area changed depending on the season. The modularity on the right side of Fig. 10 is 0.65 or higher for any travel group, indicating that the quality of community division is high. Networks with modularity in the range of 0.3 to 0.7 are usually said to have strong community structures (Newman, 2004). Therefore, the network of any group has a strong network structure.

Interestingly, although the number of communities in the long travel group remained unchanged, the geographical location of deployment varied significantly in 2019. Fig. 11 shows the seasonal changes in the geographical location of communities in the long travel group. Nodes with the same color indicate that they formed the same community. The size of a node circle indicates its degree. As discussed previously, the long travel group traveled extensively from north to south throughout the year. This group moved to Northern Europe, the Baltic Sea, Alaska, and Canada from May to September and Oceania, Central and South America, and the Caribbean from November to March. Around April and October, when they were in the middle of their north-south migration, they sailed to the Mediterranean Sea, Atlantic Ocean, and Northeast Asia. Thus, the long travel group had an operational pattern of being located in the Northern Hemisphere in summer and the Southern Hemisphere in winter to cope with seasonal changes.

5. Discussion

Seasonality was measured using three indicators: deployment area/port, vessel size, and itinerary design. The vessel size for the

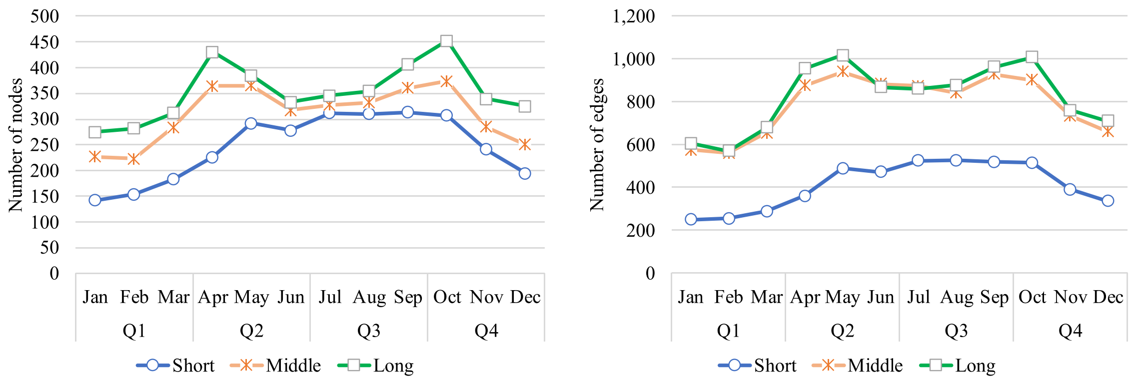

Fig. 8. Number of nodes and edges.

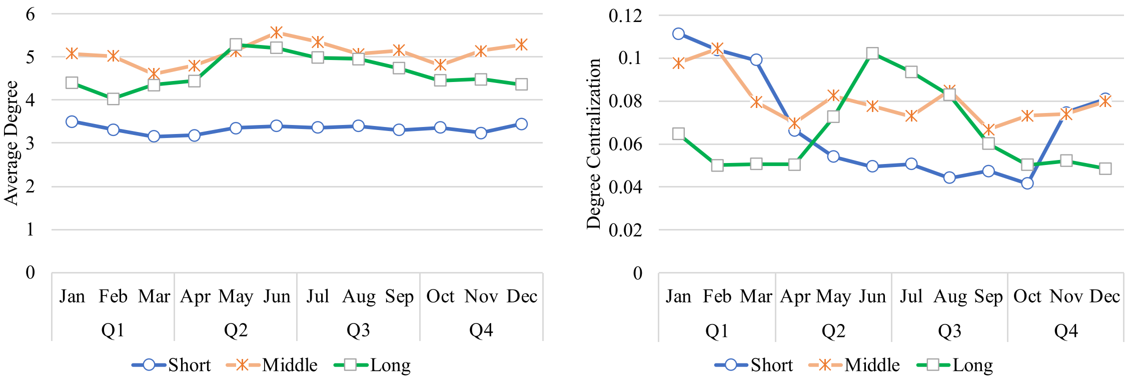

Fig. 9. Average degree and degree centralization.

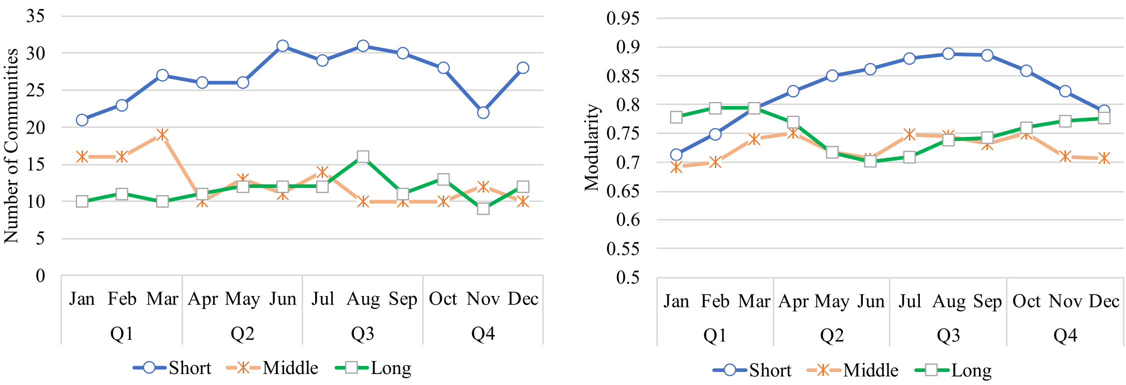

Fig. 10. Number of communities and modularity.

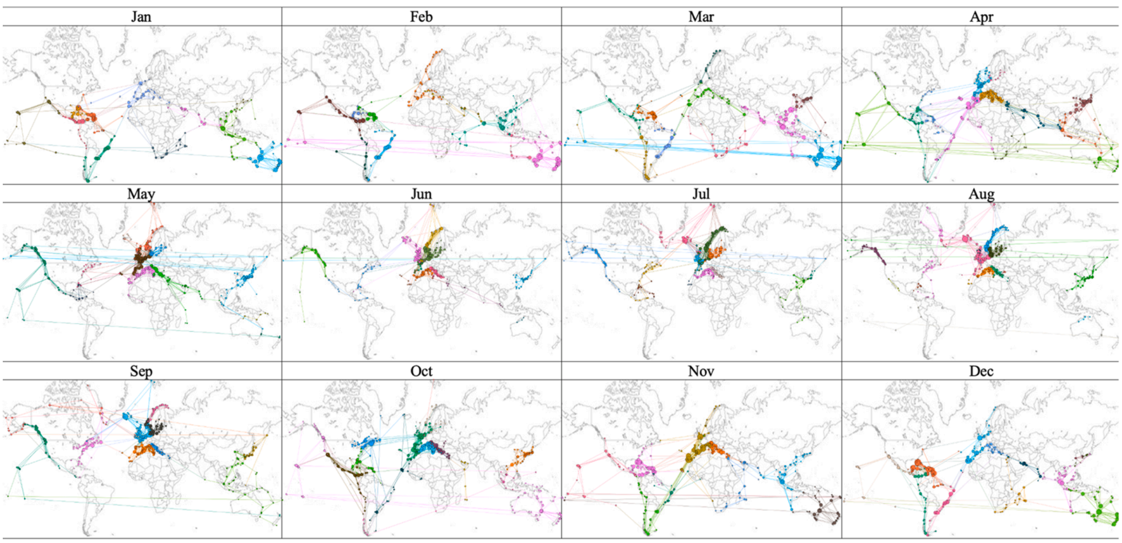

Fig. 11. Geographical changes in the community structure of the long travel group.

long travel group was standard, neither too large nor too small. On the contrary, the short travel group included extremely small and mega vessels, while the middle travel group did not. The maximum size of cruise ships for seasonally moving long travel groups was 168,666 GT, 345 m in length, and 41.2 m in breadth. Conversely, draught is unrelated to seasonal migration, because even cruise ships with the greatest draught were in the long travel groups. Bagis and Dooms (2014) pointed out that itineraries of larger vessels (mass cruise tourism) tend to be more stable than those of smaller vessels. As indicated by indicators such as GT in Fig. 6, their point is correct in that mega-sized cruise ships are stable, but very small-sized cruise ships are also stable without moving long distances, depending on the season.

Mega-sized cruise ships do not move seasonally for several reasons. The first reason is infrastructure constraints, such as port facilities and canal capacity. The Panama Canal, which lies midway between the Caribbean Sea and Alaska and is used by ships during north-south movement, is a constraint on the movement of mega-sized cruise ships. On May 14, 2018, *Norwegian Bliss*, one of the world's largest cruise ships, passed through the Panama Canal for the first time (USA Today, 2018). She has a volume of 168,028 GT, a length of 333.32 m, a breadth of 41.4 m, and a draught of 8.722. This vessel size is similar to that of the largest vessels in the long travel groups. In May 2021, the Panama Canal Authority (PCA) formally increased the maximum length and breadth for ships passing through the waterway to 370.2 m (1215 feet) long and 51.25 m (168.14 feet) wide (Maritime Publishing, 2021). The PCA announced that it is now offering 15.24 meters (50 feet) draught, the highest level allowed at the waterway (Port Technology International, 2021). Changes to this rule may change the seasonal movements of cruise ships in long travel groups.

The second reason is that a huge number of tourists is required to fill a mega-ship, and only a limited number of ports can attract that many passengers. In other words, mega-ships cannot move not only due to these physical restrictions but also the operational and commercial aims of cruise lines: they need to fill their ships to make money. Numerous tourist destinations in the southern hemisphere are not patronized by many people, and cruises become expensive by distance; therefore, the risk of not being full is high. Moreover, several ports and harbors in such places have limited facilities and cannot accommodate such large ships. This is one reason why moving to the southern hemisphere is difficult for mega-ships.

The third reason is overtourism in cities visited by mega-sized cruise ships. Ports adjacent to smaller cities receive mega-sized cruise ships, which affects the lives of citizens, congestion in tourist destinations, the environment, and wildlife. Many ports have regulations concerning mega-sized cruise ships. For example, the Italian government has decided to ban mega-sized vessels from sailing through the Venetian Lagoon and docking. New restrictions limiting the size of the vessels to 25,000 GT were approved in July 2021 (The Guardian, 2021). In 2018, the Port of Dubrovnik implemented a strategy to limit the number of cruise ships carrying 5000 tourists to two per day to reduce overcrowding in the tourist area. Additionally, the Greek island of Santorini imposes quotas on the number of tourists. The Cyclades have chosen to accept no more than 8000 cruise passengers per day (Ship Technology, 2019). The port of Juneau, Alaska, can accommodate only five cruise ships per day. Furthermore, all cruise ships carrying more than 3500 passengers have been banned from visiting the tropical paradise of French Polynesia (Cruise Fever, 2023). In November 2020, Key West voted to limit cruise ships visiting the island to a maximum of 1300 passengers (Cruise Hive, 2022). Thus, to promote the seasonal movement of cruise ships and grow the cruise industry, it is necessary to solve problems such as urban overtourism involving mega-sized cruise ships.

Cruise ships in the long travel group were deployed to Northern Europe/Baltic Sea and Alaska/Canada in summer and dispersed to the equator and Southern Hemisphere in winter. Cruise ships in the middle travel group were in Northern Europe/Baltic Sea and the Mediterranean during the summer months and moved to the Caribbean during the winter months. On the contrary, cruise ships in the short travel group were in the Caribbean all year round. In terms of cruise ship deployment areas, Northern Europe/Baltic Sea, Alaska/Canada, and the Mediterranean/Atlantic were concentrated in the second and third quarters. By contrast, no deployment areas were concentrated in the fourth to the first quarter, which means that governments and ports need to develop ports that are attractive during the winter season. Port development in Rodrigue and Notteboom (2012) pointed out that the Caribbean was predominantly serviced during winter, while the Mediterranean Sea experiences a summer peak season. This assertion was true for the short and middle travel groups. However, the long travel group moving north and south was concentrated in Alaska and Northern Europe during the summer and was interconnected with many regions, such as South America, Australia, the Caribbean Sea, and the Mediterranean Sea during other seasons. This suggests that Alaska and Northern Europe, which are popular summertime destinations, increase the seasonality of cruise ships. If destinations comparable to these areas can be increased in the Southern Hemisphere, the movement of global cruise ships may become more active. Notably, this study used latitudinal distance to classify cruise ships; if they were sorted by longitudinal distance, they could have been be sorted into different groups.

The itinerary characteristics of the long and middle travel groups in terms of seasonality showed that the number of nodes and edges increased from April to May and from September to October, and decreased from June to August. The short travel group also increased in the number of nodes and edges from April to May and from September to October, but did not decrease even from June to August. Thus, it can be seen that cruise ships in the long and middle travel groups are characterized by changing ports of call during these periods. The degree centralization of the long travel group increased from June to August. The number of port calls at Alaskan ports also rose rapidly during this period; therefore, the development of another port is an important issue during this period to avoid port traffic congestion. Furthermore, despite the long distances traveled by season, the number of communities tended to be small. The long travel group was characterized by an increase in the number of nodes and edges in spring and fall, but both the average degree and the number of communities remained stable over the year. This means that, even if the deployment area shifts with the season, cruise lines do not significantly change their approach to designing itineraries by considering several ports as a group.

6. Conclusions

This study aims to provide basic findings for governments and ports to consider ways to encourage growth by capitalizing on the seasonality of the global cruise industry. We found that the cruise industry has built its market on a global stage, with cruise ships deployed in different areas depending on the season. As cruise ships continue to grow in size, it will be necessary to create conditions that will allow mega cruise ships to travel around the world seasonally. In particular, more cruise ships would benefit from the advantages of seasonality if ports in the Southern Hemisphere during the winter months could develop deployment areas comparable to those in Alaska and Northern Europe during the summer months. It is necessary to develop not just one but several ports working together on a regional basis, led by governments and ports. In addition, the development of ports needs planning to allow standard-sized cruise ships to enter the port. Furthermore, it is essential to deal with problems such as overtourism in cities by mega-sized cruise ships. If a group of ports in the Southern Hemisphere can handle these situations, the global cruise industry will grow.

Regarding recommendations for future work on seasonality in the cruise industry, we would like to propose four themes. The first is to analyze the seasonal characteristics of the cruise industry not only in terms of latitude (north-south) but also in terms of longitude (east-west). This allows us to understand factors other than seasonal climatic variations in the northern and southern hemispheres that influence the selection of cruise ship deployment areas. The second is to investigate how the combination of ports of arrival and departure and ports of call changes with the seasons. Considering that AIS data can only depict a ship's trajectory, using cruise line brochures to distinguish between ports of arrival and departure and ports of call is necessary. The third is to explore how different cruise lines characterize the different strategies for changing areas where cruise ships are deployed depending on the season. If the differences in the seasonal characteristics of each cruise line were known, it would make it easier for governments and ports to attract cruise lines. The fourth is to evaluate how seasonality is affected by global warming, which has made it easier for cruise ships to sail to the Arctic and Antarctic. Once this impact is understood, the degree of business development in the cruise industry owing to future changes in seasonality can be understood.

Declaration of Competing Interest

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