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CRUISE AND DIGITAL TOURISM

Title/Author	**Building social capital in cruise travel via social network sites / Surucu-Balci, E., & Balci, G.**
Source	***Current Issues in Tourism*** **(March 2022) https://doi.org/10.1080/13683500.2022.2047904 (Database: Taylor & Francis Online)**

Title/Author	**Cabin as a home: A novel comfort optimization framework for IoT equipped smart environments and applications on cruise ships / Nolich, M., Spoladore, D., Carciotti, S., Buqi, R., & Sacco, M.**
Source	***Sensors*** **Volume 19 Issue 5 (Mac 2019) 1060 https://doi.org/10.3390/s19051060 (Database: MDPI)**

Title/Author	**Cruise tourism: social media content and network structures / Tiago, F., Couto, J., Faria, S., & Borges-Tiago, T.**
Source	***Tourism Review*** **Volume 73 Issue 4 (Oct 2018) Pages 433–447 https://doi.org/10.1108/TR-10-2017-0155 (Database: Emerald Insight)**

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Title/Author	Exploring the development of Malaysian seaports as a hub for tourism activities / Jeevan, J., Othman, M. R., Abu Hasan, Z. R., Pham, T. Q. M., & Park, G. K.
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Title/Author	Sentiment analysis for cruises in Saudi Arabia on social media platforms using machine learning algorithms / Al sari, B., Alkhaldi, R., Alsaffar, D., Alkhaldi, T., Almaymuni, H., Alnaim, N., Alghamdi, N., & Olatunji, S. O.
Source	*Journal of Big Data* Volume 9 Issue 21 (Feb 2022) https://doi.org/10.1186/s40537-022-00568-5 (Database: Springer Open)

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Source	*Journal of Hospitality and Tourism Technology* Volume 13 Issue 4 (May 2022) Pages 626–649 https://doi.org/10.1108/JHTT-05-2021-0155 (Database: Emerald Insight)

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Title/Author	Structural and Logical Model of Transport Maritime Functioning Based on Modeling Information Technology / Logunova, N., Chernyi, S., Zinchenko, E., Krivoguz, D., Sokolov, S., & Nyrkov, A.
Source	*Economies* Volume 10 Issue 1 (2022) https://doi.org/10.3390/economies10010005 (Database: MDPI)

Title/Author	Systems engineering and digital twin: a vision for the future of cruise ships design, production and operations / Arrichiello, V., & Gualeni, P.
Source	*International Journal on Interactive Design and Manufacturing* Volume 14 Issue 1 (2020) Pages 115–122 https://doi.org/10.1007/s12008-019-00621-3 (Database: Springer Link)

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Building social capital in cruise travel via social network sites

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ABSTRACT

The purpose of this study is to investigate what type of Facebook posts help cruise lines build bridging and bonding social capital. The study applies the Chi-Square Automatic Interaction Detection (CHAID) method to identify which types of posts establish bridging and bonding social capital. The analysis is conducted on an international cruise line's official Facebook posts posted between 1 January 2018 and 1 January 2020 before the Covid-19 pandemic. The results highlight that media type, embedding passenger motivation, and a ship image help establish both bridging and bonding social capital, while content type helps establish bridging social capital. The paper is original because it helps understand how cruise lines can improve bonding and bridging social capital via social media. The paper also enhances understanding of social capital theory in the travel industry by investigating the relationship between Facebook post types and social capital in cruise shipping.

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Cruise tourism; travel; decision tree; Facebook; online engagement; social capital

1. Introduction

Digital platforms, including social network sites (SNSs), have altered the communication between consumers and brands from one-way to bidirectional interactions (Denktaş-Şakar & Sürücü, 2020). SNSs such as Facebook, Twitter, and LinkedIn are well-known sites and considered vital marketing platforms for companies. Barnes et al. (2020) indicated that 95% of the Fortune 500 companies actively use Facebook. While companies use SNSs for such tasks as advertising their product and services, sharing the latest information, interacting with their customers, enhancing their reputation, and undertaking marketing research, users utilize SNSs for networking, creating content, and gathering information about brands.

The use of SNSs is prevalent in tourism. SNSs in the tourism sector are used by tourists for holiday planning, accessing tourism information, choosing holiday destinations and sharing travel experiences (Gon, 2020). The research also shows that SNS usage significantly affects travellers' holiday types and destination choices (Narangajavana et al., 2017). Accordingly, organizations in the travel and tourism industry extensively use SNSs to reap the benefits of SNSs' interactive nature. By effectively using SNSs, travel and tourism organizations can enhance their destination marketing, maximize customer engagement, and secure travellers' loyalty, thereby increasing sales (Yost et al., 2021).

Cruise lines are active users of SNSs. Eighty-two percent of the Cruise Lines International Association (CLIA, 2019) global cruise line members have Facebook pages.. Cruise tourism (CT) deserves a

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particular attention while studying SNSs as it involves combination of travelling, city and shore excursions, accommodation, recreational activities, dining, and onboard entertainment (Sun et al., 2011). Thus, it attracts tourists with both transportation, destination, accommodation, and entertainment motives (Niavis & Tsiotas, 2018). This multidimensionality of CT is also reflected in cruise travellers' service perceptions which is affected by different range of elements such as ships, entertainment, excursion, port, room, food, and embarkation (Arasli et al., 2020). Cruise travellers are also distinct from other tourists because, alongside all tourism dimensions, ships themselves play a major role in their experience (Kwortnik, 2008). Cruise travellers are also considered as a distinct type of tourist segment having their own virtual communities due to peculiarities of cruise tourism (Roth-Cohen & Lahav, 2021).

Number cruise travellers increased rapidly until COVID-19 that it increased from 17.8 million in 2009–28.5 million in 2018, which is expected to exceed 30 million by the end of 2019 (CLIA, 2019). However, another peculiarity of CT is that, sailing overseas and visiting multiple destinations, CT is severely affected by both local and global disruptions such as weather conditions, natural disasters, and pandemics. For instance, COVID-19 has impacted the entire tourism industry The tourist psyche is negatively impacted by COVID-19 (Kock et al., 2020). However, its impact on the cruise industry is particularly remarkable (Choquet & Sam-Lefebvre, 2021). Several tourism studies also indicate the negative impacts of COVID-19 on the cruise travel industry and the perceptions of passengers (Pan et al., 2021; Roth-Cohen & Lahav, 2021). Furthermore, the industry is regularly challenged by pressure on corporate social responsibility due to air pollution and over-tourism (Rodrigue & Wang, 2021; Seraphin et al., 2018). Management of these diverse challenges requires cruise lines to be well-connected to their stakeholders, extend their network, and enhance the relationship intensity. These network extension and relationship enhancement efforts can be considered the social capital (SC) building process of cruise lines.

SC – which refers to benefits received from relationships between people and groups (Lin, 2017) – is a vital asset for individuals and business organizations (Kim et al., 2019). It can be built both through offline and online connections. SNSs offer significant opportunities for cruise lines to efficiently and effectively improve their SC. The use of SNSs to build SC has been well documented in previous studies (Abuljadail & Ha, 2019; Sias & Duncan, 2020). However, despite some scholarly papers discussing SNSs in the cruise sector (Roth-Cohen & Lahav, 2021; Satta et al., 2018), forming SC in cruise travel through SNSs has not been analyzed.

Prior research in other sectors has demonstrated that receiving user actions such as liking and re-sharing influences organizations and individuals' SC building efforts (Horng & Wu, 2020). Hence, it is of significant importance to figure out what type of posts trigger more reactions from the network. Moreover, the literature suggests that SNS users' liking and re-sharing attitudes are not identical (Satta et al., 2018; Surucu-Balci et al., 2020; Villamediana-Pedrosa et al., 2019). Thus, it is also critical to identify whether the same or different posts trigger more liking and re-sharing.

Motivated with social capital theory (SCT), this paper focuses on one particular SNS, Facebook, and aims to investigate what type of Facebook posts help cruise lines extend their network and improve their network engagement. More specifically, this research aims to identify Facebook posts that enable cruise lines to build bonding social capital (BOSC) and bridging social capital (BRSC) with their network. To do this, a Chi-Square Automated Interaction Detection (CHAID) method is applied on Facebook posts of a leading global cruise line. The liking of the cruise line's Facebook posts is considered as the reflection of BRSC, whereas the re-sharing is considered as the reflection of BOSC. This paper has novelty because it helps understand how cruise lines can improve their BOSC and BRSC via Facebook, which has not been investigated to the authors' best knowledge. Considering the recent COVID-19 and common challenges the cruise lines face, this paper's results present meaningful implications for the industry. The paper also enhances the understanding of SCT by revealing Facebook posts' effect on BOSC and BRSC separately.

2. Literature review

2.1. Social capital through social network sites

SC exists in the relationships among persons and organizations (Coleman, 1988) and consists of social ties between people and benefits achieved from social participation (Teng, 2018). SC creates close relationships and strengthens communication (Ali et al., 2019). To maintain SC, social interactions and networks must be continuing. The SCT is implemented on various levels of individual and organizational context. The theory is also applied in the tourism literature. For instance, Zhao et al. (2011) used SCT to investigate why some residents in certain areas preferred to establish and operate tourism businesses. Kim and Shim (2018) highlighted the structural relationship among SC, innovation, and the performance of small and medium-sized enterprises in a tourism cluster. McGehee et al. (2010) examined tourism-related SC and its relationships with other capital forms, including cultural, natural, political, human, and financial capital.

Putnam (2000) classified social capital as bridging (identified as weak ties) and bonding (identified as strong ties). The connections between people with different backgrounds form BRSC. Hence, BRSC represents weak ties or acquaintances (Ali et al., 2019). BRSC enables one to gain new perspectives and expand social horizons (Ellison et al., 2007). On the other hand, the relations between people who share similar characteristics or social identity form BOSC. BOSC represents strong ties or close relationships (Ali et al., 2019). BOSC enables inward growing and dense relations (Ellison et al., 2007).

With the rise of Internet usage, SNSs are stepping forward as essential communication tools that help establish and maintain SC (Steinfield et al., 2009). SNSs gather people having similar interests, views, and goals and allow users to exchange ideas, opinions, and comments. These exchanges, including interpersonal relationships and organizational networks, are primary SC sources (Lin, 2017). Williams (2006) ascertains that BRSC and BOSC can be established in the online context. Different parties can build networks, which might be broad but weak, with little online effort. These efforts help to establish BRSC. Similarly, different parties can develop a sense of belongings to networks, establish healthy relationships, and get emotional benefits. These efforts help to establish BOSC.

SNSs such as Facebook make simultaneous interaction accessible between users and organizations. As a result, the information flow between users and organizations substantially increases. High utilization of SNSs enables the creation of UGC and engagement with the organization. This creation and engagement are generated with users' activities such as 'share,' 'comment,' and 'like' (Dolan et al., 2016). Although these three options contribute to social network engagement, they are different from each other and symbolize the different levels of user commitment and effort (Swani & Labrecque, 2020).

'Like' and recently added reactions (love, care, haha, wow, sad, angry) on Facebook are the most commonly used engagement option. However, they symbolize the lowest level of engagement action (Swani et al., 2017). 'Like' requires only one click and is effortless and spontaneous (Shen & Bissell, 2013). In other words, 'Like' establishes the lowest ties between the user and the organization. 'Comment' involves further steps than 'Like' because, in order to comment, the user needs to click the comment button first and then type the message and click to send it. 'Comment' engagement action is slow, reflective, and intended (Swani et al., 2017). Similar to 'Comment,' 'Share' also requires additional steps. When a post is shared, it can be shared directly to the user's news feed or in a private, personalized message (Swani & Labrecque, 2020).

'Share' is the only engagement option that gives the opportunity in all SNSs for disseminating the organization's post on the user's timeline. Kim and Yang (2017) argue that most of the time, users prefer the 'Share' option when the user wants/feels to express himself/herself in the same way as the brand. Thus, the 'Share' engagement option establishes the most substantial ties between the user and the organization. With users' engagement activities, SNSs establish and make visible the hidden ties between users and organizations. Thus, SNSs generate and maintain strong and weak ties simultaneously (Ellison et al., 2007).

Adopting BRSC and BOSC to the social networking engagement context, this study considers the 'like' action as the BRSC while defining the 'share' action as the BOSC. In most cases, to share positive feedback, support, joy, or empathy, users utilize the 'like' action (Lee et al., 2016). Since the 'like' action is the simplest way to maintain the relationship, users prefer the 'like' function to keep weak ties without additional effort. The 'share' action is considered the highest engagement level considering the user reactions (Song et al., 2020) because when a user shares content, it also appears on the user's wall and news feed, and the user's friend can also see the shared post. Kim and Yang (2017) highlight that sharing the post is related to self-identity presentation, emphasizing that the users found something from themselves in the previously shared post and shared their wall. Thus, sharing another's post indicates strong ties.

2.2. Effect of post characteristics on bridging and bonding social capital

Earlier studies revealed that post characteristics impact the number of user activities. In other words, the number of likes and shares are significantly affected by the post's features such as the media type (MT), the content type (CT), and the length of the post (Denktaş-Şakar & Sürücü, 2020; Luarn et al., 2015; Surucu-Balci et al., 2020). Since this study mirrors the number of likes as BRSC and the number of shares as BOSC, it is argued that the characteristics of posts determine the level of BRSC and BOSC.

MT and CT are commonly used post features that are predictors of BRSC and BOSC. In parallel to this, the tourism and hospitality literature also indicates that different MTs lead to different levels of engagement. Villamediana-Pedrosa et al. (2019) found that the number of shares among Facebook users regarding tourist destinations is higher when a video is included in the post. Kucukusta et al. (2019) revealed that visual content significantly increases engagement in the hospitality context. Su et al. (2015) revealed that photos could boost the number of sharing. In the cruise tourism context specifically, Satta et al. (2018) highlighted that posts that include videos receive more likes and shares. Similar to MT, CT also impacts the engagement level. For instance, Kucukusta et al. (2019) demonstrated that informative posts have the highest level of engagement. Pino et al. (2019) found that emotional posts trigger the engagement level in the tourist destination. Satta et al. (2018) revealed that emotional content positively impacts the number of likes and shares.

Several studies indicate that the messages' length impacts the engagement level (De Vries et al., 2012). For instance, Surucu-Balci et al. (2020) indicated that the length of Twitter messages significantly affects the engagement of container shipping stakeholders; while, Pino et al. (2019) highlighted that the number of likes decreases as the message's length increases. Satta et al. (2018) revealed that the longer the post, the less the received engagement reactions. On the other hand, Villamediana-Pedrosa et al. (2019) found that the post's length does not affect the number of likes and shares.

Besides generic predictors of user engagement, cruise travel-specific post characteristics can also affect the number of likes and shares as cruise travel involves peculiar characteristics. For instance, we argue that the existence of a ship image may influence the BRSC and BOSC. Hung and Petrick (2011) identified that some passengers describe themselves as sea fetish and enjoy being on the ship or see the ship other times. The ship is the most crucial tangible resource (the most impressive image) of the cruise lines, and they frequently share photos or videos of their ships. A study conducted on cruise passengers' Tweets revealed that ship is one of the most frequently used words in cruise-related tweets (Park et al., 2016).

Passengers may have various motivations for their cruise travels, and SNS posts with different motives may lead to the different levels of SC. This argument is also confirmed by Park et al. (2016), who found that motivation-related tweets can get more interaction from cruise travellers. Having entertainment options both onboard and at the shore, having facilities for relaxation, discovering new places, cost of travel, socializing with other passengers, and loyalty appear to be primary motivators of the cruise travelling.

3. Methodology

This study applies CHAID to classify Facebook posts by utilizing dependent and independent variables. We explain sampling and data collection, variables and coding, and the CHAID method in this section.

3.1. Sampling and data collection

As of October 2020, Facebook is the fifth commonly visited web page globally (Alexa, 2020). With 2.7 billion monthly active users and an average of eighteen minutes fifty-three seconds daily time spent on site, Facebook is the biggest SNS worldwide (Statista, 2020). This makes Facebook an important channel for organizations to advertise, enhance their brand attractiveness and engage with consumers.

The study focused on a global cruise line's Facebook. The number of fans in Facebook changes variably for each cruise line. For instance, a cruise line has 121,543 followers, while the another line has 5,030,845 followers. This significant difference has led to focus on one cruise line in this study. Thus, we focused on a global cruise line with one of the highest number of Facebook followers. The data was collected in November 2020. We manually collected Facebook posts of the selected cruise line between 1 January 2018 and 1 January 2020. A total of 633 Facebook posts were collected.

Data bias should be carefully handled in SNS studies when collecting the data (Morstatter & Liu, 2017). The bias may occur due to the uneven distribution of users' profiles in terms of their age, gender, etc., language differences in posts, and doubtful or incomplete information that may be shared by some users (Wang et al., 2020). Data bias issue is handled by several approaches in our study. First, we focused on a single cruise line's Facebook page to eliminate the heterogeneity in the number of users among lines, which might significantly affect the number of likes and shares regardless of post characteristics. Second, the selected line's all posts were shared in English; thus, no heterogeneity exists regarding the language of the post. Third, the data is collected and coded manually by two researchers, and the inter-reliability is measured, as explained in the following section, to mitigate discrepancies in data.

3.2. Data coding

We employed De Vries et al. (2012)'s and Luarn et al.'s (2015) data coding protocol while coding the selected cruise line's Facebook posts. One of the authors and another researcher, who does not know the studies' assumptions, coded the selected cruise line company's posts between 1 January 2018 and 1 January 2020 separately, after receiving 60 min of training about the coding procedure. After completing the coding, results were compared, and in case conflict occurs, coders discussed the post and reached a consensus about the coding. Also, we calculated inter-coder reliability using Perreault and Leigh's (1989) method to assess the degree of agreement among coders. According to Perreault and Leigh (1989), inter-coder reliability should be between 0.8-1.0, and this study's inter-coder reliability is calculated as 0.85. In this study, we utilized six independent variables and two dependent variables.

3.2.1. Independent variables

This study postulates that BRSC and BOSC in cruise travel can be affected by posts' MT, CT, message length, the existence of a ship image, and type of cruise travel motivation. MT consists of three categories, which are 'video,' 'gif,' and 'photo.' Thus, if a post includes a photo, it is coded as 'photo.' For instance, the post, which was shared on 1 January 2020, included a photo. Thus, the post was coded as the photo for MT. On 18 December 2018, the selected cruise line shared a gif. Hence, this post was coded as a gif. The selected cruise line shared a video on 10 January 2018. Therefore, it was coded as video.

'Emotional' and 'functional' are the GT categories. If the cruise line celebrates a special day such as fests, New Year, mothers' day, fathers' day, it is coded as emotional. For instance, on 26 November 2019, the selected cruise line shared a post to celebrate its followers' Thanksgiving. Thus, this post was coded as emotional. When the cruise line posts about one of their ships' travel destinations and day information, it is coded as functional. For instance, on 6 July 2018, the cruise line shared a post about their ship's trip to Grand Turk Islands. Thus, this post was coded as functional.

'Relaxation,' 'fun,' 'exploring new things (doing something new),' 'socializing,' 'being cost-sensitive,' 'loyalty,' and 'convenience' consist of the passenger motive categories. If the cruise line shares a post while passengers have fun on the deck, it is coded as entertainment. For instance, on 10 February 2018, the cruise line shared a post where passengers were dancing with the animation team. This post was coded as entertainment. If the cruise line shares a post while their passengers are zip lining, it is coded as exploring new things. For example, on 30 October 2019, the cruise line shared a video where passengers were zip-lining in travel destinations. This post was coded as exploring new things. The length of the post message is calculated by counting the total characters in each post, and the data is input as a continuous metric variable to the CHAID analysis.

3.2.2. Dependent variables

We have two dependent variables in this study, which are BRSC and BOSC. In this study, the BRSC is measured with the number of likes for each post received. Thus, the number of likes for each post was coded as BRSC. The BOSC is measured with the number of shares received for each post. Hence, coders were coded the number of shares per post as BOSC.

3.3. CHAID method

This paper aims to explore cruise lines' Facebook post characteristics that generate a higher number of likes and shares and to compare whether predictors of these two dependent variables differ or not. We have chosen CHAID methodology, a decision tree method used for classification and prediction purposes. First developed by Kass (1980), CHAID method splits the whole dataset into homogenous subgroups based on the relationship between independent variables and the dependent variable, or the criterion variable, in other words. The method finds out distinct subgroups of the total sample regarding the criterion variable. With these characteristics, CHAID is an ideal method in our study. The method can find cruise lines' SNS engagement predictors that reveal distinct post groups related to the number of likes and shares.

Since our purpose is to find out and compare predictors of BRSC (number of likes) and BOSC (number of shares) in SNS, two separate CHAID analyses are conducted as the method classifies objects based on only one dependent variable at each time. Despite the obstacle of employing multiple dependent variables, CHAID is still the ideal option for this study for several reasons. First, it can employ several independent variables, which can be both categorical and continuous. The ability to utilize both types of data as independent variables makes CHAID ideal for finding more engaging SNSs' post characteristics, categorical and numeric. Second, CHAID partitions the sample into sub-samples by identifying the most significant predictor based on the interaction with the criterion variable (Díaz-Pérez & Bethencourt-Cejas, 2016). The CHAID algorithm then splits sub-groups into their sub-groups by determining each step's most significant predictor variable. This process lasts until no predictor partitions those sub-groups into further sub-groups. This characteristic of the CHAID method allows us to compare predicting – partitioning, in other words – variables of two different dependent variables in our study (number of likes and shares).

The total sample in CHAID is called the root node displayed at the top of the tree. Those partitioned nodes are named as parent nodes if they are also further split into sub-groups. When no partition exists, the final node is called the child node. Just like independent variables, the criterion variable in CHAID can be both categorical and continuous. In our study, both criterion variables are continuous in those two different CHAID analyses. Same independent variables are entered in both analyses to be able to make the proper comparison. The significance level to split the posts of the sampled cruise line is set to be 0.05. The parent/child node ratio is adjusted as 30/15, which means the minimum sample size of a parent node can be 30 while it can be 15 for a child node. The maximum number of tree branch levels is set to five so that no more nodes will be created after both trees reach a total of five layers.

The CHAID methodology is used in several tourism and travel segmentation studies, which indicates its success in classification based on prediction in the tourism industry (do Valle et al., 2012; Legohérel et al., 2015; and Díaz-Pérez et al., 2020). The strength of CHAID over other classification and prediction techniques in the tourism context has also been demonstrated by the study of Díaz-Pérez and Bethencourt-Cejas (2016). However, to the authors' best knowledge, none of the papers in tourism research has employed the method for SNSs, although it is quite appropriate for the usage of CHAID considering the size and variety of data available in SNSs.

4. Results

4.1. Descriptive results

The results of the Facebook posts of the selected cruise line show that the average number of likes is 2006.6, while the average number of re-sharing is 364.7 ($N = 631$). Regarding independent variables, 38.8% of posts include cruise ship images in photos or videos, while 61.2% do not have any ship image. As shown in Table 1, almost 60% of posts are shared with a photo, while around 17% include a video, and almost 25% of posts included a gif. Regarding the CT, 43% of posts include emotional content, while 53% have functional content.

Table 2 illustrates that 37% of sampled Facebook posts have fun-related passenger motivation. This percentage is followed by relaxation motivation with the rate of 21%. The third most frequent passenger motivation is about socializing. The least two frequent motivations in sampled Facebook posts are cost and loyalty with 1.1% and 2.4% ratios. Our sample's mean value of post length is 123.7 characters with a maximum value of 535 and a minimum value of 0 (a total of 15 posts do not have any text message).

4.2. CHAID results

Two CHAID trees were built based on two dependent variables: Number of likes and number of re-shares. Regarding the number of likes, which illustrates BRSC, passenger motivation, the existence of a ship image, CT, and MT significantly partitioned posts into sub-groups (see Figure 1). These four variables are also considered as determinants of the number of likes. Among four variables, passenger motivation is the most significant predictor of the number of likes as it is the first independent variable splitting the sample. Posts including relaxation and convenience motivations attract

Table 1. Frequencies of the media type and content type.

Media Type			Content Type		
	Number	Percentage		Number	Percentage
Photo	371	58.8%	Emotional	270	42.8%
Video	105	16.6%	Functional	361	57.2%
Gif	155	24.6%	*Total*	*631*	*100%*
Total	*631*	*100%*			

Table 2. Frequencies of passenger motivation.

Passenger motivation	Number	Percentage
Relaxation	135	21.4%
Fun	236	37.4%
Exploring	44	7.0%
Socializing	109	17.3%
Cost	7	1.1%
Loyalty	15	2.4%
Convenient	85	13.5%
Total	*631*	*100%*

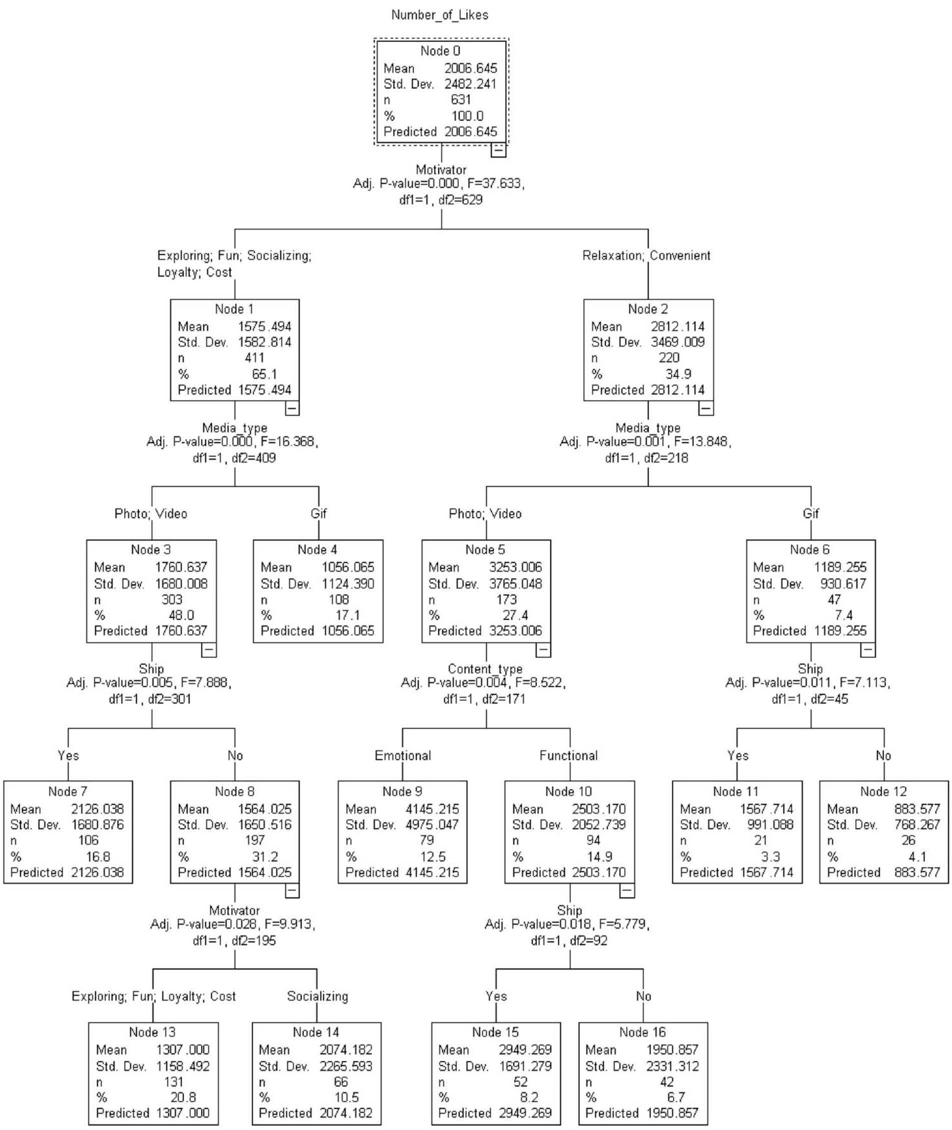

Figure 1. Number of likes CHAID decision tree.

significantly higher likes of the cruise line's followers than other motivations. These two parent nodes (Node 1 and Node 2) are further split into sub-groups by the MT of posts, which is the second most significant predictor of the number of likes. In both partitions, gif posts have significantly fewer likes than posts with videos and photos. This is demonstrated in Figure 1 as Node 4 and Node 6 likes are significantly lower than Node 3 and Node 4, respectively. Three of these four nodes are further split into different nodes by the existence of a ship image and CT. The existence of a ship is the third most significant predictor of the number of likes. Existence of a ship image partitions Node 3 and Node 6 into sub-groups. In both groups, the posts with a ship image (Node 7 and Node 11) lead to a higher number of likes. On the other hand, CT partitions Node 5 into two subgroups (Node 9 and Node 10), among which emotional posts have a significantly higher number of likes compared to functional posts.

A total of seven parent nodes (Nodes 1, 2, 3, 5, 6, 8, and 10) and a total of nine child nodes (Nodes 4, 7, 9, 11, 12, 13, 14, 15, and 16) are achieved in the tree of the number of likes. Node 9 consists of posts with relaxation and convenience motivations, including photos or videos as the MT, and emotional content has the highest number of likes. The second-highest number of likes is Node 15, which consists of posts with relaxation and convenience, including photos or videos as MTs, but with functional content including a ship image. The third highest likes are received by Node 7, which involves posts with motivations other than relaxation and convenience, including photos or videos with ship images. Node 14 has the third-highest number of likes among all child nodes. This shows that when posts do not have any ship photo or video, socializing motivation attracts more likes than other motivations. Node 12, on the other hand, has the lowest level of liking among all child nodes. This group of posts contains gif shares without any ship image and has relaxation and convenience motivations. The second-lowest number of likes belongs to Node 4, which again includes GIFs and other types of motivations than Node 12 Figure 2.

Regarding the number of re-sharing of the post or BOSC in SNSs, the same independent variables partition the total sample, except the CT, which does not create any group in re-sharing. The most significant predictor of the number of re-sharing is the MT. Posts with videos are shared significantly higher than posts with photos and gifs. The average sharing score of video posts (Node 2) is 766, while photo and gif posts (Node 1) are 284. The existence of a ship is the second-best predictor of the number of re-sharing as it partitions Node 1 into two different sub-groups. Accordingly, posts with a ship image lead to significantly higher re-sharing than those without a ship image. The last partition is done by passenger motivation, which splits those photo and gif posts without a cruise ship image.

The decision tree of the number of re-sharing has created two parent nodes (Node 1 and Node 4) and five child nodes (Node 2, 3, 5, 6, and 7). Among child nodes, Node 2 has the highest number of re-sharing. This node ($n = 105$) consists of videos and is not further partitioned into sub-groups. The second-highest number of re-sharing is Node 7, which includes photo and gif posts without a ship image and convenience motivation. However, this group of posts' population is also the smallest, having only 2.4% of all samples. Node 3, on the other hand, is the largest child node having a total of 207 posts (32.8% of the sample) and has the third-highest number of re-sharing with a mean score of 402. This node consists of photo and gif posts with a cruise chip image. The lowest re-sharing score is Node 6, consisting of photo and gif posts without a ship image and fun and loyalty motivations.

5. Discussion

This paper indicates that cruise lines' SC building through SNSs is significantly affected by post characteristics. The majority of our assumptions are approved as a total of three independent variables successfully partitioned the total dataset. These variables are MT, passenger motivation, and the existence of a ship image. CT, on the other hand, only partitions the dataset in the number of likes. The length of the message does not have any influence on BOSC or BRSC.

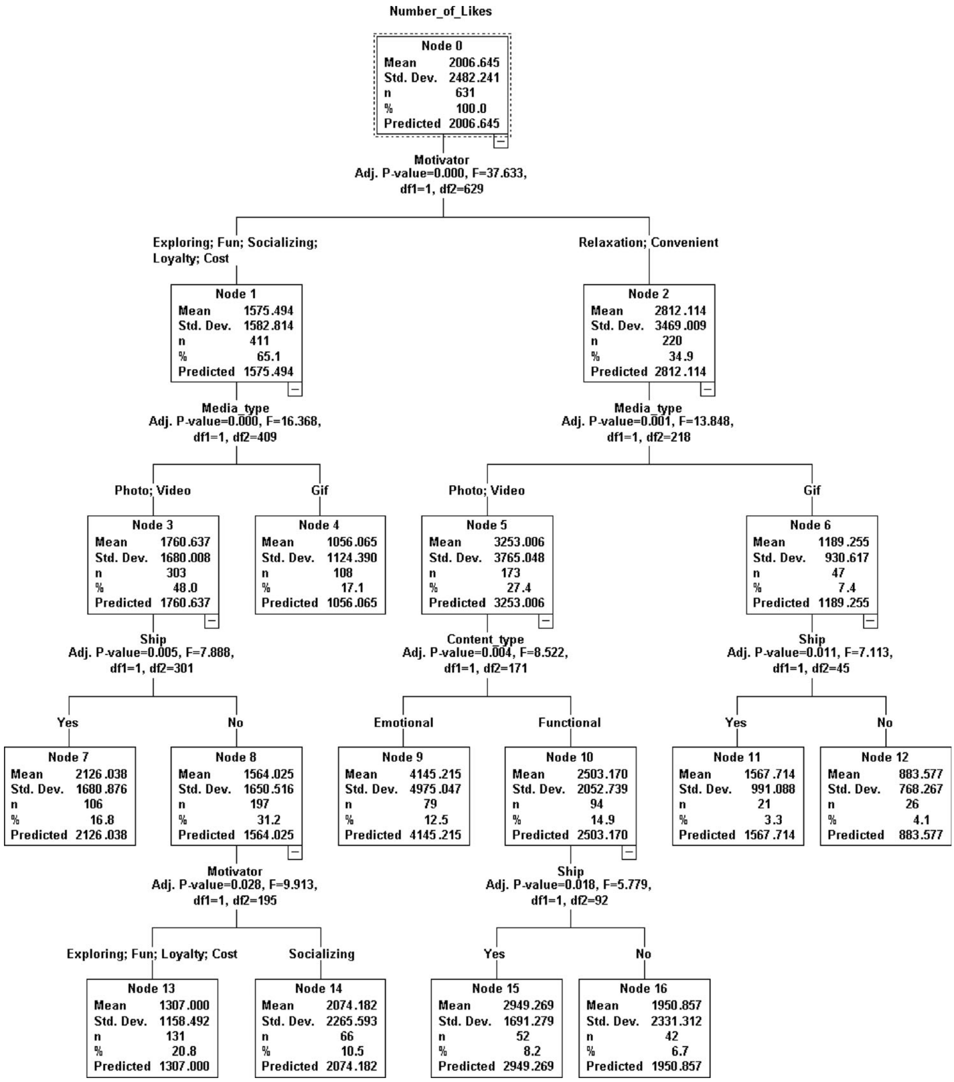

Figure 2. Number of shares CHAID decision tree.

According to results, the number of liking has more partitioning independent variables compared to the number of re-sharing. The tree of liking is also a lot larger than the tree of re-sharing, the former has nine child nodes while the latter has five. In other words, there are more distinct sub-groups of Facebook posts while forming BRSC. This result indicates that the liking attitude of followers is more heterogeneous than the re-sharing attitude. This result in building social capital reflects that Facebook posts' characteristics affect BRSC more than BOSC. This result makes sense because in BRSC, weak ties occur between followers and the cruise line. Instead of liking the post regardless of their characteristics, followers' liking attitude is more determined by post characteristics. Post characteristics also determine the re-sharing attitude; however, since stronger ties occur between followers and the cruise line, posts' characteristics have less impact on re-sharing attitude. These assumptions, of course, need further validation.

Although similar independent variables partition both liking and re-sharing of posts, the significant level of these variables vary in liking and re-sharing. The first significant splitting variable in liking is passenger motivation, while it is MT in re-sharing. According to CHAID results, posts that include relaxation motivators play a vital role in establishing BRSC compared to other motivators, such as exploring fun, socializing, loyalty, and cost. As Park et al. (2016) found that motivation-related posts receive more interaction, we expected this result. Since relaxation is one of the primary motivators of cruising, posts with a relaxation motive receive more engagement and form BRSC.

CHAID results demonstrate that convenience motivator leads to establishing both BRSC and BOSC. Unlike other types of tourism, cruise tourism offers many opportunities such as transportation, accommodation, entertainment, etc., at the same time. This convenience is an important factor while preferring cruise tourism, and the results showed that the followers also interact more when they see such posts.

The MT of the posts also significantly partitioned the posts regardless of the type of motives. In both cases, photo and video posts boost the number of likes more than the posts with GIFs. In other words, posts that include photos and videos can be utilized to form BRSC. This result is consistent with Kucukusta et al.'s (2019) findings, suggesting that embedding visual content increases engagement. Followers can like and move on to the next post after glimpsing at the photo or briefly browsing the video. The purpose of such action is to show their support to the company. Furthermore, since the number of likes mirrors weak ties, this result is quite logical.

Regarding BOSC, CHAID results show that video posts receive more shares than photo and gif posts. To put it in another way, cruise lines must share posts, including videos, to create BOSC. This result concurs with the study of Satta et al. (2018), who also found that video posts increase the number of shares. Our results also support the findings of Villamediana-Pedrosa et al. (2019), who found that posts that include video receive more share action.

The fact that video posts receive more shares is quite logical because the follower shares the video only when he/she finds something of himself or has a similar experience, which is shown in the video. Posts embedded video transmit the message more quickly. Video posts tend to be more entertaining, informative, and have emotional content, while transmitting the message takes longer. Re-sharing the video post means that the follower watches the video, receives the message, and has similar experiences or feelings, and that is why he/she decides to share it on their Facebook wall. Thus, sharing video posts reinforces the ties between cruise lines and followers.

Among the photo and video posts that embedded relaxation and convenience motivators, the CT has a parting effect on posts. According to CHAID results, emotional posts receive more likes than functional posts; in other words, emotional posts can be used to establish BRSC. Similar to the findings of Pino et al. (2019) and Satta et al. (2018), CHAID results revealed that emotional posts positively influence BRSC. One possible explanation for this finding might be that messages with emotions trigger followers' attention, leading to liking posts. However, the CT does not create any sub-group of posts in re-sharing, or the CT does not make any difference while establishing BOSC.

Among the photo and video posts that embedded exploring, fun, socializing, loyalty, and cost motivators, the image of ship splits the dataset. Accordingly, posts that include ship images help to establish BRSC. Furthermore, among the posts with photos and GIFs, having a ship image partition the received number of likes. Thus, posts that include a ship image are more shared than posts that do not have a ship image. Hence, based on the study results, posts with ship images help establish BRSC and BOSC. Our results validate Lobo's (2008) statement, which suggests that cruise passengers started to pay more significant emphasis on their cruise ship experience rather than those destinations the ship calls. Lobo's (2008) suggestion probably explains that passengers like and share posts with cruise ship images. These results show that customized solutions are needed for these two types of SC tools through SNSs. Thus, SNSs or marketing managers of cruise lines are suggested to follow a differentiated posting strategy for BRSC and BOSC.

Length of post message does not affect user reactions in our dataset. This result is similar to Villamediana-Pedrosa et al. (2019), who found that message length does not matter. However, the result contradicts the findings of Pino et al. (2019) and Satta et al. (2018). This result shows that the literature does not reach a consensus regarding the effect of message length. The conflicting results may occur due to differences in investigated SNS platforms, the context studies, and the language of posts. However, the available data and results do not suffice a comprehending justification for a conclusion.

Compared to previous SNS studies in cruise travel, our study differs from Satta et al. (2018) as we perform a different method and use more diverse set of post contents, which result in more granulated results. For instance, the ship plays a major role in cruise traveller's perception (Kwortnik, 2008) and our results validated it. However, this important element of CT is not measured in their studies. Some of our results also contrast to their findings. The length of message does not impact the number of likes or re-shares whereas Satta et al. (2018) state the opposite. The difference may result from differences in the sampling in which our study focused global posts in English while their study focused on Italian pages of cruise lines. This assumption requires a validation by a further study. Our paper also differs from Roth-Cohen and Lahav (2021) as we analyze Facebook posts of a cruise line quantitatively with a SC perspective while they examine CT Facebook groups qualitatively with an netnography perspective. While our results present characteristics of posts that lead to higher BRSC and BOSC, they classified messages shared by users based on their content such as information sharing and solidarity between cruise lovers.

6. Theoretical and practical implications

This study contributes to the literature in several aspects. First, this paper contributes to SCT by investigating it within the SNS context. SC helps organizations in various ways, such as resilience achievement and customer retention (Ali et al., 2019). In recent years, the importance of SC in organizations is particularly recognized by academia (Kim et al., 2019). Our study adopts different types of SC to the SNS context and finds out whether different characteristics of SNS posts influence BRSC and BOSC. Results of our study enrich the literature investigating SNSs and SC.

This study can be considered as one of the pioneering studies which investigate the cruise line SNS context. This study is the first to utilize a cruise ship and cruising motivator in a SNS context. Our study results indicate that cruise travel-specific variables such as cruise motivation and a ship image's existence significantly impact the number of likes and re-sharing. This result encourages tourism literature to use travel-specific variables while investigating SNS studies in addition to those generic variables such as CT and MT. This also calls for a more in-depth investigation of the type of holiday and potential unique variables.

In addition to travel-specific variables, our paper also provides methodological implications to SNS studies in the tourism literature. Although the CHAID method has been used in survey-based tourism studies (do Valle et al., 2012; Legohérel et al., 2015; and Díaz-Pérez et al., 2020), it has not been utilized adequately despite its superiority in terms of capability in handling large datasets and ability to use both categorical and continuous variables. Significant results of our study confirm that CHAID can be successfully used in tourism SNS studies as well. The cruise travel industry is recently facing unprecedented challenges (Pan et al., 2021; Roth-Cohen & Lahav, 2021), and SC seems to be one of the methods to cope with these challenges. However, very few papers investigate the role of SC in cruise travel literature. As the first study investigating the Facebook posts' impact on establishing SC efforts of cruise lines, we expect our study to drive more research in the relationship between SC and cruise travel.

The results of this paper also present several implications for the practice. The most prominent issue cruise lines are recently dealing with is the COVID-19 pandemic. The negative impacts of COVID-19 on tourists and cruise travellers, particularly tourist perception and psychology, are well documented in the literature (Kock et al., 2020; Pan et al., 2021; Roth-Cohen & Lahav, 2021). In such an environment where travellers' perception is negatively affected, managers in cruise lines should be well-connected to travellers through SNS and create a positive image about cruise travelling during and post-COVID periods. While creating a positive image in SNS, possibly by ensuring travellers with COVID measures, managers are suggested to use cruise ship images and videos as they positively influence SC building, according to our results. Moreover, cruise ship images in SNS posts will help travellers build nostalgia, which may help in positive perceptions (Roth-Cohen & Lahav, 2021). Since creating BOSC requires a more extended period, we suggest managers focus more on creating BRSC to manage SNS in regard to COVID-19 issues that demand swift actions. Hence, besides sharing COVID-19 posts by including ship images, we suggest managers combine relaxation and convenience motivators with COVID-19-related positive messages to attract more BRSC.

Our results warn managers in cruise lines that not all posts lead to the same level of engagement with followers on Facebook. Targeting BRSC, we suggest cruise lines share posts that drive relaxation and convenient motivations of passengers. While doing this, cruise lines should prefer posts with photos or videos that involve emotional content rather than functional ones. These types of posts trigger the highest number of likes. However, it would not be practical to suggest that cruise lines only share these posts. An assortment of posts should be posted to avoid repetition. Moreover, cruise lines must also share functional content such as CSR and company information, although emotional ones receive higher likes. In such cases, we suggest cruise lines include ship images to posts as much as possible.

Cruise vessels are a distinguishing feature of cruise travel in comparison to other holiday options. Thus, it is no surprise that ship images split a total of three-parent nodes in BRSC tree, and each time posts with ship images resulted in a higher number of likes. Despite its significant role in building BOSC and BRSC in Facebook, our sampled dataset illustrates that over 60% of posts do not include any ship image. Thus, we encourage cruise lines to include more ship images while sharing a Facebook post.

Regarding BOSC, cruise lines should create more video content to drive a re-sharing attitude. When posting a video is not possible, cruise lines are suggested to include their cruise vessels' images to ensure more re-sharing. If that is also not possible, then they are recommended to involve posts with convenience motivation. Cruise lines can also share posts that stimulate relaxation, socializing, cost, and exploring motivations alongside fun and loyalty motivations. Our final recommendation is that cruise lines should avoid gif posts, resulting in significantly lower reactions in both liking and re-sharing.

7. Conclusion

This paper investigates how cruise lines can build SC through the utilization of SNSs. BRSC is mirrored as liking a post by followers while BOSC is mirrored as re-sharing a post. To do this, CHAID analyses are conducted on a global cruise line's Facebook posts to find out predictors of liking and re-sharing behaviour of followers and reveal characteristics of most liked and re-shared post groups. Results revealed that MT, passenger motivation, and the existence of a ship image help to establish both BRSC and BOSC, while CT helps to form BRSC.

One of the limitations of this study is that it focuses on one SNS that is Facebook. However, different post characteristics may be more prominent to establish BRSC and BOSC on different SNSs. It is important to determine the characters required to create BRSC and BOSC in different SNS. Thus, a similar study can be carried out to determine the post characteristics that help establish bringing and BOSC in different SNSs such as Twitter or Instagram. Another limitation of the study is that the results should be carefully interpreted in some essential cruise shipping markets, such as China, where there is no access to Facebook. Therefore, it is vital to conduct similar studies investigating SC building through SNSs in these markets' popular SNSs such as WeChat or Sina Weibo.

In this study, we only focused on one cruise line's official Facebook page because of the significant differences in the number of followers. Focusing on a single cruise line's Facebook page gave us a chance to compare the number of likes and shares more accurately. However, the same situation prevented us from making comparisons between companies and generalize results. Thus, a further study can be conducted with cruise lines' Facebook accounts with similar follower numbers.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Cabin as a Home: A Novel Comfort Optimization Framework for IoT Equipped Smart Environments and Applications on Cruise Ships

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Abstract: The international tourism competition poses new challenges to the cruise sector, such as the achievement of the tourists' satisfaction and the increase in on board comfort. Moreover, the growing sophistication of tourists' needs leads to a more user-centric touristic offer. Consequently, a personalized cabin environment, which fits the users' activities and their characteristics, could be a plus value during the cruise vacation. These topics, however, are strictly connected with the diffusion of digital technologies and dynamics, which represent the tools to achieve the goal of a customized on-cruise experience. This paper presents E-Cabin, a novel Internet of Things (IoT) framework architecture that has at its core a reasoning system tuned on data gathered from the environment and from each specific passenger and the activities he/she performs. The framework leverages on knowledge representation with ontologies and consists of a publisher–subscriber communication framework that allows all of the IoT applications to use the reasoner and the provided ontologies. The paper demonstrates the proposed system in a demo cruise cabin where, by using the E-Cabin application, it is possible to set various atmospheres based on the users and activities occurring in the cabin.

Keywords: IoT; holistic comfort; decision-making; comfort optimization; cruise cabin; cabin comfort

1. Introduction

The tourism industry is becoming more and more competitive, as tourists can choose their stay by using a variety of web-based portals. In particular, the cruise sector is growing faster than other industries in tourism [1] and is a very competitive branch of this industry. The focus of this competition regards the exploitation of the most novel technological advances in cruise ship building [2]. The competition also encompasses the quality of services a cruise cabin can deliver to its guests; in this regard, several attempts to improve comfort have been investigated. The reduction in noise and vibration is a research area that gathers a lot of attention, especially in naval engineering [3,4]. Another relevant aspect often investigated for cruise cabin regards the pricing policy and the advertising strategies adopted [5–7].

However, indoor comfort for cabins has been very little researched. Kwortnik [8] analyzed the "shipscape", defined as the leisure cruise service environment. Collecting data from 260 cruise customers, the author revealed how the cruise experience—from a passenger's point of view—is something between the theme park and the cruise. Using 100 questionnaires, Goujard [9] assessed acoustic comfort in relation to other factors (temperature and light); acoustics was found to be a significant criterion of global comfort experience and noises (squeaking, cracking, clattering, etc.) were classified as disturbing for the passengers. In 2017, Jinjin [10] investigated the role of color design in cabin's interiors, concluding that simple and bright colors can be of some influence on the passengers' mood. Recently, a survey regarding procedures and notations for passengers' comfort quantification has been conducted [11], highlighting how vibrations, noise, indoor temperature and lighting are relevant factors in determining comfort, although they are addressed in different ways in classifications. Moreover, a preliminary description of cruise cabin comfort has been proposed in Ref. [12], defining a cruise cabin comfort ontology, and the basic definition of how to use a reasoner for cabin comfort is described in Ref. [13]. Nevertheless, indoor comfort is a widely debated topic in several disciplines that emerged in the last several decades, such as Ambient Assisted Living (AAL) [14], Ambient Intelligence (AmI) [15] and Context Awareness (CA) [16]. These disciplines consider the use of interconnected sensing technologies, knowledge management, data acquisition from the environment and the inhabitants occupying specific living environments. The aim of the technologies involved by these disciplines is to improve the comfort of inhabitants by providing the possibility to overcome some person-related limitations through technology and to make the living environments "smarter", i.e., to use Internet of Things (IoT) technologies to foster automatic actuation of environmental components (such as opening windows, turning on/off the air conditioning system fostering energy saving, etc.) [17–19]. Therefore, these disciplines address several domains of knowledge—healthcare, comfort, sensors, artificial intelligence, mobile computing, etc.—and have been extensively investigated in research, with particular attention to the IoT framework [20,21]. In fact, there is a growing interest in IoT equipped smart environments, as the technological offer is growing and the costs of the implementations are decreasing. This work introduces the E-Cabin reasoning framework, one of the outputs of a project dedicated to the development of a smart cruise cabin, in which AmI and CA technologies work in a synergistic way inside a IoT framework to provide passengers with customized indoor comfort and to foster energy saving behaviours.

The main contributions of this paper are related to the definition of a modular decision-making system (DMS) based on predefined semantic classifications together with the usage of such system on a cruise cabin, as a set of comfort tests has been carried out on scenarios and use cases defined on a real cruise cabin placed in our laboratory (located inside the University of Trieste, Italy). The cruise cabin environment has been provided by Fincantieri S.p.A. (Trieste, Italy), a company that builds cruise ships for different shipholders. Moreover, all the scenarios and the use cases presented in this work have been defined with the collaboration of Fincantieri S.p.A.

The remainder of this work is organized as follows: Section 2 presents some of the most relevant works related to the field of IoT technologies and knowledge engineering adopted to make a living environment "smarter". Section 3 delves into the E-Cabin decision-making framework, describing its architecture, the technologies involved (with particular focus on the reasoning-enabling framework) and its general structure. Section 4 introduces some use cases to depict E-Cabin's possibilities and functioning in plausible contexts, encompassing passengers' specific needs, the activities they want to perform and energy saving procedures. Section 5 describes the E-Cabin application, the mobile-based Graphic User Interface (GUI) that allows the passengers to use E-Cabin's features. Section 6 illustrates a subjective study whose aim is to assess the perceived utility of E-Cabin—i.e., whether the passengers find beneficial to have a cabin able to change and adjust the indoor comfort taking into account their activities and characteristics.

2. Related Work

Considering that comfort has been acquiring a growing importance due to the spreading of AAL, AmI and CA technologies, this section investigates the most relevant works related to (a) ontology developing for indoor comfort; (b) ontology for the description of the person and his/her status in the context of a smart environment; and (c) AmI, AAL and CA systems leveraging ontologies as enabling technology to provide indoor comfort customization and activity personalization.

The issue related to modelling indoor comfort metrics has been widely addressed in literature; however, any ontology emerged as a "standard" model, and neither was the most adopted. Due to the variety of the comfort metrics and the different research needs, each research group relied on ontologies developed for specific purposes. Flexergy [22], a model developed to describe the sustainable comfort, is focused on the representation of sensors, actuators and device, connecting the possibility to provide personalized comfort to energy saving practices. Frešer et al. [23] modelled three indoor comfort metrics (CO_2 concentration, humidity rate and temperature) in an Ontology Web Language (OWL) [24] model with Semantic Web Rule Language (SWRL) [25] rules with the aim of triggering actuations. Based on the ISO 7730:2005, Adeleke et al. [26] formalized an Indoor Environmental Quality semantic model in order to monitor indoor air quality to identify potential risks for inhabitants' health. Some comfort metrics are also described in ThinkHome [27], a smart home system that leverages on ontological representations of knowledge to infer the most suitable comfort parameters with regard to inhabitants' age and gender. In the Smart Home Simulator [28], the authors exploited ontologies to represent comfort metrics (CO_2 concentration, humidity rate, indoor temperature, illuminance) in order to evaluate whether these are comfortable or uncomfortable for the dwellers.

Since smart environments—especially smart homes—are expected to provide tailored services to their end-users, the modelling of the person acquires a pivotal importance. The description of human activities within a smart environment has been investigated by Ni et al. [29], where ontologies are used to represent the residents in their living contexts. Semantic-based technologies have also been exploited to describe dwellers' health conditions, in order to foster actuation of services according to the specific needs of smart environments' residents. RoomFort [30]—an ontology based system for indoor comfort personalization for hotel rooms—leverages both on ontologies describing the health condition of a business traveller (using the International Classification of Functioning, Disability and Health (ICF) [31]), comfort metrics and a list of activities a business traveler can perform in the hotel room. The ICF-based approach for a health condition description is starting to emerge in several works, which combine semantic-based technologies to foster AmI and CA. In Ref. [32], the health condition description is conducted with ICF to provide a customization of the smart home services; in Ref. [33], the ICF-based health condition is the cornerstone for the reconfiguration of living environments in an AAL context.

Apart from the above-mentioned Smart Home Simulator and RoomFort, several others' recent AmI, AAL and CA systems leveraging on ontologies can be traced in literature. Sezer et al. [34] described a simulated sensors network exploiting a smart home ontology, which acts as a collector of data gathered by the sensors. Meng et al. [35] presented a rule-based service customization strategy aimed at enhancing home environments; in this work, ontologies are used to define rules for customization of services. In the field of CA for clinical support, Andreadis et al. [36] presented Dem@Home, a CA monitoring system for dementia caring at home developed to improve independent living; ontologies here are extensively employed to represent sensor observations, activity recognition and problem detection. Tila et al. [37] used semantic modelling to provide semantic interoperability among different data and to back-up the deployment of an IoT system for indoor environment control. Finally, a multi-level smart city architecture—leveraging both semantic-based technologies and wireless sensors—is presented in Ref. [38], where OWL ontologies are adopted to enrich raw data acquired by the sensors.

3. The Proposed Novel Decision Making Framework for Smart Environments

The E-Cabin framework leverages ontological representations of some domains of knowledge to enable reasoning for indoor comfort customization and for environmental actuation triggering. The proposed reasoning system can turn an IoT equipped environment into an autonomous and automatic system capable of automatic adaptation of the environment, also taking into account the passengers' personalized concept of comfort in a holistic way. Due to its aims, E-Cabin's relevant domains of knowledge are not limited to sensors, but encompass the passenger—with his/her health condition, preferences, activities, etc.—and the cabin environment.

In this paper, we present a DMS deriving from the combination of semantic reasoning over a set of domain ontologies [39]. The ontologies constitute the framework's knowledge base and provide a formal description of relevant pieces of knowledge for E-Cabin; the result of this combination consists in the capability of improving passengers' perceived comfort inside their cruise cabin. The proposed reasoning system is based on the following elements:

A. ontology related to the IoT devices in the smart environment;
B. ontology related to the person;
C. ontology related to comfort.

As stated in Section 2, in literature, there are several ontologies that can represent smart environments equipped with IoT devices. Such descriptions are commonly adopted to describe the working, monitoring and acting phases of the devices, and the monitoring and optimization of power consumption are a classical issue that is addressed. For instance, W3C-endorsed Semantic Sensor Network (SSN) ontology [40] was developed in 2012 to describe sensors and their observation. Following the NeOn Methdology [41] for ontological resources reuse and development, E-Cabin framework reuses part of the SSN ontology for the description of IoT devices deployed in the smart environment, while adopting the ontology design patterns provided in Ref. [30] for the modelling of the passenger and his/her health condition. Finally, for indoor comfort metrics, E-Cabin monitors air quality (i.e., CO_2 concentration), illuminance and indoor temperature and humidity leveraging on a domain ontology developed from scratch.

This last ontology acts as a link between the environment and the person and contains comfort metrics evaluated according to the legislation together with holistic parameters that can help the automatic adaptation of the perceived comfort. The ontologies involved in E-Cabin are described in the following subsections (from Sections 3.2–3.4).

The proposed reasoning system can reuse already defined ontologies for describing IoT devices and characteristics of persons, adding a link between these two elements in a formal and structured way. The proposed reasoning system can turn an IoT equipped environment into an autonomous and automatic system capable of automatic adaptation of the environment to the personalized concept of comfort of every given user in a holistic way.

3.1. General Architecture

The system's architecture leverages is centralized, based on the local network of the cruise ship, and it is managed by the shipowner. More precisely, the shipowner has the knowledge about the status of each cabin of the ship and about the IoT devices installed in each of them. Moreover, as each passenger of the cruise shall enroll to enter the ship, the shipowner can ask them whether they would like to adopt the E-cabin feature; in case of an affirmative answer, the passengers are required to fill in data related on their personal ontology. All data can be stored and managed on a centralized server that operates on the ship network, so all issues related to privacy and security can be addressed as for other sensitive data stored on the central servers. The system is structured as shown in Figure 1.

Figure 1 shows the Decision Making System architecture for a single cruise cabin, which is built on top of existent ontologies (such as person-related and IoT sensors and actuators ontologies). The Decision Making System proposed is connected via the E-Cabin Communication bus to the net of IoT sensors that is equipped inside the cruise cabin.

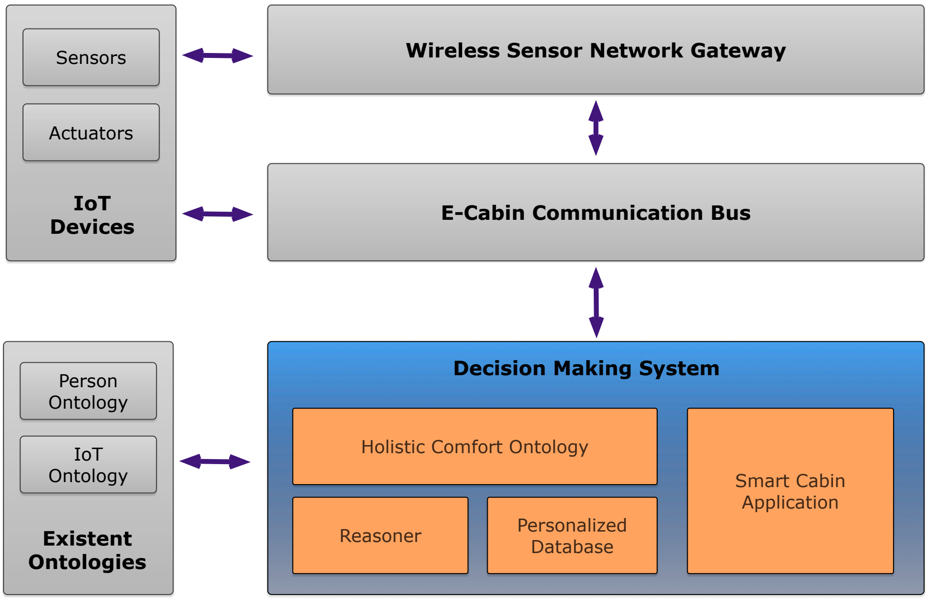

Figure 1. General architecture of the proposed reasoning system.

The data regarding all the E-Cabin equipped cabins and the related passengers data shall be stored in local database inside the ship. More precisely, the personal and sensitive passenger data shall be collected by the shipowner in a private and secure database space that operates on the ship and is managed by the ship owner. The specific characteristics of each IoT device also remain in the shipowner private and secure database space inside the local network of the ship. Thus, all the IoT and persons related data are only accessed locally and they are not transferred to any other party during the reasoning process. For these reasons, the proposed architecture is compatible with the principles of the General Data Protection Regulation (GDPR) that defines personal data privacy management rules in the European Union.

3.2. Passenger Ontology

E-Cabin's passenger is modelled relying on the Friend Of A Friend (FOAF) vocabulary [42], a model that allows for representing passenger's registry records (with properties like foaf:firstName, foaf:FamilyName, foaf:birthday; foaf:age, etc.). FOAF, developed for describing networks of people, contains all the core elements to describe the "ID card" of a passenger.

This domain ontology also assigns each passenger to his/her cabin (i.e., the cabin he/she bought when he/she purchased the cruise); moreover, the passenger can decide whether to specify or not his/her special necessities. This can be done by resorting to the International Classification of Functioning, Disability and Health (ICF) [43], a World Health Organization Standard that allows for describing the functioning of an individual. ICF is divided in four components (Body functions, Body structures, Activities and participation, Environmental factors), each of which is further deepened into Chapters, which identify the addressed domain; each component is identified by a letter (b for Body functions, s for Body structures, e for Environmental factors, d for Activities and participation) and can be deepened by adding digits. According to the number of digits following the letter, it is possible to get a code, whose length indicates the level of granularity—up to five digits (as exemplified in Figure 2).

b "Body functions"	Component	
b2 "Sensory functions and pain"	Chapter	
b210 "Seeing functions"	***b230*** "Hearing functions"	Second level item
b2102 "Quality of vision"	***b2300*** "Sound detection"	Third level item
b21020 "Colour vision"	- - -	Fourth level item

Figure 2. An example of ICF (International Classification of Functioning, Disability and Health) illustrating the structure of the classification.

The functioning or disability of an individual can be assessed selecting the suitable category and its corresponding code and then adding a qualifier (0: no impairment, 1: mild impairment, 2: moderate impairment, 3: severe impairment and 4: complete impairment). ICF has also been represented into a reference ontology [44]: E-Cabin reuses this ontology, limiting the extent of the ICF components to Body functions and Body structure, and allowing for specifying a granularity up to the second level (three digits after the letter of the component).

The modelling of the passenger's domain ontology retraces the ontology design pattern described in Refs. [28,30], where each person's health condition is described with specific descriptors requiring one ICF code and its qualifier—as depicted in Figure 3:

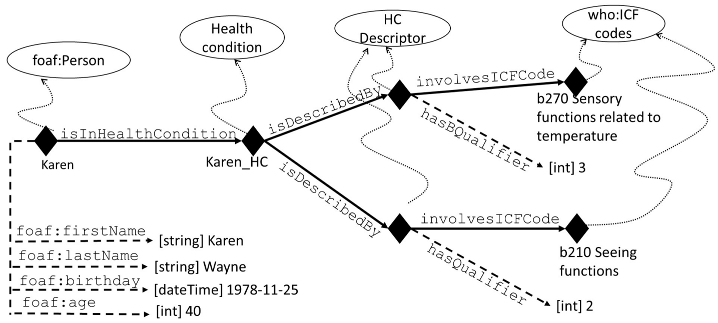

Figure 3. The modelling of a passenger with FOAF and ICF. Individuals are represented with diamonds, full line arrows indicate object-type properties, dashed line arrows indicate datatype properties, curved dotted lines state the type of an individual.

3.3. Sensor and Devices' Ontology

For modelling sensors and devices inside the cabin environment, E-Cabin relies on BOnSAI [36], an ontology developed for AmI. This model encompasses several subsets of ontologies that allow for describing sensors, actuators and the services the devices provide. Implemented in OWL with Protégé, BOnSAI provides classes to conceptualize context, services, hardware and functionalities by reusing concepts coming from other ontologies—such as Digital Environment Home energy Management System (DEHEMS) [45] and the context ontology CoDAMoS [46].

Considering that E-Cabin does not require modelling household appliances (such as oven, refrigerator, etc.), BOnSAI expressivity is more than enough to cover the cabin's environment description. Following and ontology design pattern already used in Refs. [28,30], E-Cabin's ontology adds the possibility to model the measurements performed by the sensors (illuminance sensor, thermo-hygrometric sensor, CO_2 concentration sensor) in individuals, each of which is characterized by the value of its measurement and unit of measurement—resorting to a subset of Ref. [47]. Figure 4 provides an example of sensor modelling and its measurement.

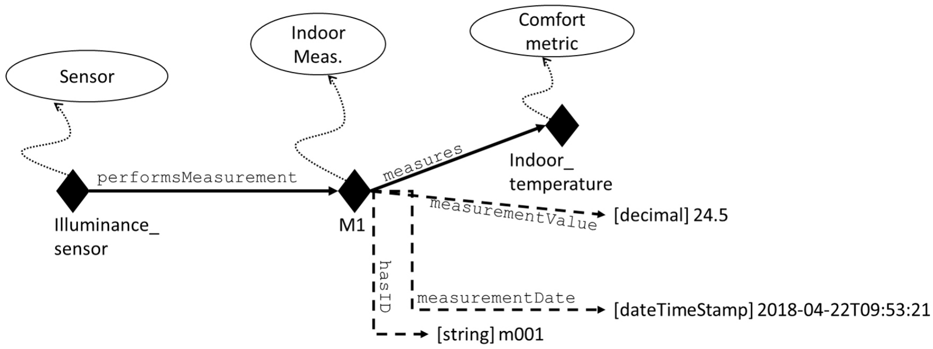

Figure 4. An example of sensor modelling and its measurement.

3.4. Comfort Metrics Ontology

The description of comfort metrics in E-Cabin relies on a domain model developed starting from Ref. [30]. Concepts representing the four comfort metrics monitored inside the cabin environment (CO_2 concentration, indoor temperature, indoor illuminance and indoor humidity rate) are modelled, and each of the classes is divided in `Comfortable` or `Uncomfortable`. Each measurement performed by the sensors—as described in the previous subsection—is classified according to its value to determine whether there is a comfortable situation or not.

Illuminance comfort is determined modelling the thresholds described in the European norm EN 12464-1, which sets a minimum of 200 lux as a minimum requirement for the occupied environment; for the amount of acceptable CO_2 concentration inside the cabin, the ANSI/ASHRAE Standard 62.1-2016 [48] sets the maximum threshold to 1000 ppm. These thresholds can be modified by the passenger in any time in order to determine his/her personal comfort.

Moreover, if the passenger declared that he/she suffers from problems related to respiration (such as those described with ICF code s430 "Structure of respiratory system") or temperature (b270 "Sensory functions related to temperature and other stimuli"), he/she is asked to specify his/her comfortable range—thus reproducing comfortable conditions inside the cabin. Therefore, each time a measurement exceeds the threshold and becomes uncomfortable, one or more actuators intervene to restore comfortable conditions (for instance, triggering the opening of a window, activating air conditioning, turning lamps on).

3.5. Semantic Repository and Reasoning Engine

The E-Cabin ontologies described in the previous subsections are hosted on a triple-store [49], a semantic repository that allows for querying, retrieving and modifying the stored semantic data using the SPARQL Protocol and RDF Query Language (SPARQL) [50]. E-Cabin chose the Stardog repository (version 5.3.4) [51]—a widely used graph platform—since it can support the querying activities and reasoning using the W3C-endorsed languages RDF, OWL and SWRL. Reasoning in Stardog is performed at query-time, which entails that the triples resulting from reasoning (for example, the triples resulting from the application of SWRL) are not materialized, and therefore are not automatically added to the ontology. On the contrary, the reasoner solves only those SWRL rules necessary to solve a query, thus reducing the time dedicated to reasoning processes.

Another interesting feature of triple-stores consists in the possibility to add and modify data using `INSERT` and `DELETE` query patterns; in this way, it is possible to customize at any time the comfort metrics personalized by the passengers and the comfort thresholds provided by norms—according to passenger's desiderata.

E-Cabin application can exchange information with the semantic repository (therefore with the knowledge base) relying on a semantic middleware (described in Ref. [30]), a software developed with Java and run every time the passenger selects an activity to be performed inside the cabin via the smartphone application. Each time a passenger selects an activity, the middleware runs and generates the corresponding SPARQL query to retrieve the (i) passenger's health condition and (ii) location in the cabin of the passenger. Then, this information is passed from the smartphone app to the middleware using JavaScript Object Notation (JSON) files, thus constituting the input for the SPARQL query. After running the query over the knowledge base hosted on the repository, the latter returns the results (i.e., the comfort metrics to be applied and the actuation necessary to provide the passenger with comfortable conditions while performing the selected activity).

4. Cruise Cabin Use Case

The notion of holistic comfort [52]—which follows the idea that the indoor environment has a key role in reaching an adequate level of comfort—arises in the field of nursery care, but can be applied also in other fields where comfort plays an important role. In the context of this work, in which comfort is fundamental, the concept of holistic comfort is applied to the cruise cabin environment—and the research focuses its attention on the cabin areas and the passengers' comfort. In fact, passenger boarding on a cruise expects a holistic experience that has to satisfy his/her demand and has to offer a wide range of services, products, and experiences. Therefore, cruise ship operators transport passengers by sea for pleasure, and passengers' comfort is one of their main priorities [53]. The research focuses the attention on the cabin space and its comfort. The cabins available on the market already provide the passengers with a high level of comfort, but their indoor environments cannot be personalized since they are unable to consider passengers' characteristics and needs. Therefore, by relying on the holistic comfort concept, a higher level of comfort is considered.

Introducing an extended and holistic comfort concept can play an important role as an attraction tool for the more demanding tourists and, consequently, it can be also a plus value for the cruise operators. By reducing the uncomfortable feeling and increasing the comfort perception, the attractiveness of the cruise ship exponentially increases and the Cruise Operators income can consequently increase.

In the scientific research, it is verified that cabin comfort, sizes, amenities and cleanliness are key factors in the accommodation quality evaluation [6]. However, the elements of the cabin (furnishings, materials, sounds, smells, temperature, humidity, ventilation, brightness, hygiene, etc.) are not enough to satisfy the holistic concept of comfort. It is necessary to consider also the passengers' characteristics, their needs and their feelings in the cabin environment.

To verify this hypothesis, some scenarios and use cases are described. Moreover, the use cases depict the interaction between the passengers and the Smart Cabin. In the following use cases, the cabin is linked to a passenger in order to demonstrate how the smart environment could help the user to perform his/her activities inside the cabin.

The actors of the various scenarios are: the person, the cabin environment, the devices and the DMS. Various attributes are linked to the actors as follows:

1. Person: the Person class has two derived classes (Passengers and Crew) and the following attributes: Age (children, teenager, adult, elderly), Genre (men, woman, other), and Activity (sleeping, reading, light activity);
2. Cabin: the Cabin class has four derived classes (Indoor cabin, outdoor cabin, cabin with balcony and suite) and the following attributes: Position (low deck, high deck, bow, central, stern), Bed (standard, family);
3. Device: the Device class has three derived classes (Sensors, Actuators, and Sensors–Actuators) and the following attributes: Class (environmental, energy consumption, physiological), Quantity (temperature, humidity, luminosity, colour, movement, etc.), and Unity (degrees Celsius, % of Relative Humidity, lux, ecc.)
4. DMS: the DMS class has three derived classes (Automatic, Semi-automatic, and Decision Making Systems).

4.1. Scenario 1: Reading Activity in the Cabin Environment

This scenario takes into account the reading activity in the cabin. Different categories of people could be considered, such as young or elderly. Generally, to create a good and efficient reading environment, it is fundamental to delete annoying reflections and eliminate the shaded areas by creating a diffused light in the cabin and a punctual light on the book. Moreover, this scenario has to consider that the necessary light for a comfortable reading varies from person to person; consequently, the light characteristics are a relevant subjective factor.

Use Case 1.1: Start of the Reading Activity

The Use Case 1.1 describes the process related to the starting point of the reading activity in the cabin with balcony. The precondition is that the passenger is already registered on the Smart Cabin Application and he/she is logged in (see Section 5 for further details):

1. The person is inside the cabin.
2. The person decides to focus on the reading activity.
3. The person decides the category of reading (study, work, hobby, relaxation) and the type of reading support (book, magazine, newspaper, school text, professional text, digital book).
4. The person chooses the position of reading, for example: sitting at the desk, sitting on the couch, lying on the bed, etc.
5. The person uses the E-Cabin App to set the desired activity: reading. The E-Cabin App combines different sets of lighting parameters related to visual comfort (lighting level, light tone, direction of light, glare, shadow distribution, illuminance distribution) and environmental parameters linked to thermo-hygrometric comfort (temperature, humidity, airflow). The combination of these parameters together with the reading activity and the passenger's characteristics (visual skills, gender, age, physical impairments, etc.) creates the output for improving the comfort conditions. Moreover, in the case of background noise, or if the person prefers to read with music or with background music, the E-Cabin App sets a suitable sound environment.
6. The passenger moves from the "non-reading" phase to the "start reading" phase.

Figure 5 shows the sequence diagram of the Use case 1.1. In the unified modeling language (UML) diagram, four specific objects (person in the cabin, DMS, devices and cabin) are reported with the respective connections. The passenger perceives a variation of comfort due to the sequence of adjustments imposed by the DMS to the devices to regulate comfort.

4.2. Scenario 2: Sleeping Activity in the Cabin Environment

This scenario takes into account the adaptation of comfort conditions for the passenger who wants to perform a sleeping activity in the cabin. The cabin settings adapts automatically to the person's needs; in particular, the activity linked to awakening from sleep at a set time, may involve different categories of people, for example young or elderly. Consequently, also the awakening process has to be personalized as follows:

- Acoustic alarm (defined by a sound signal, music or radio station);
- Luminous alarm (defined by changing the intensity and colours of different lights);
- Combination of acoustic and luminous alarms.

Use Case 2.1: Forced Awakening Due to a Fixed Commitment (Such as an Excursion)

The Use Case 2.1 describes the process related to the passenger's activity who has to wake up at a certain time, for example, for an excursion organized by the cruise company. Even in this Use Case, the precondition is that the person is already registered on the Smart Cabin Application, he/she is logged in, and he/she has already set the alarm on the Smart Cruise App (see Section 5 for further details):

1. The Smart Cabin Application recognizes the person in bed.
2. The person wakes up autonomously: the Smart Cabin Application detects it and cancels the awakening procedure.
3. The person is in the bed at the predefined time: the Smart Cabin Application activates the awakening procedure.
4. The application creates the personalized comfort environment and by doing so facilitates the user's awakening. Lighting comfort, thermo-hygrometric comfort and acoustic comfort are combined with the activity and the user's characteristics (visual skills, gender, age, physical impairment, etc.) for optimizing the awakening process.
5. The person delays the alarm: the Smart Cabin Application sets a new procedure for waking up.
6. The person gets up: the Smart Cabin Application detects the movement and ends the awakening procedure.

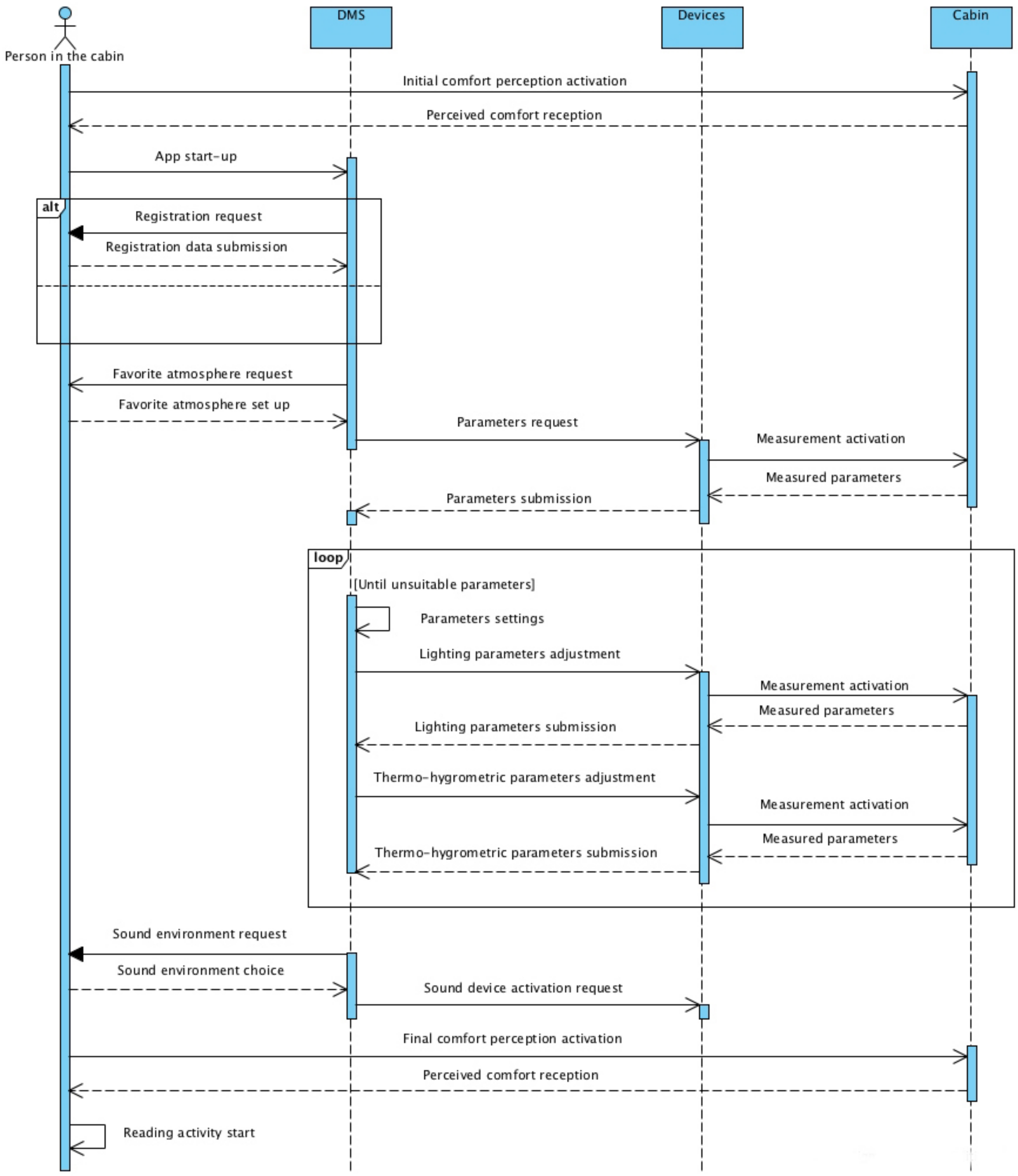

Figure 5. Sequence diagram for the Use Case 1.1.

Figure 6 shows the sequence diagram of the Use Case 2.1. In the UML diagram, four specific objects (person in the cabin, DMS, devices, and cabin) are reported with the respective connections. The passenger perceives a variation of comfort due to the sequence of adjustments imposed by the DMS to the devices to regulate comfort.

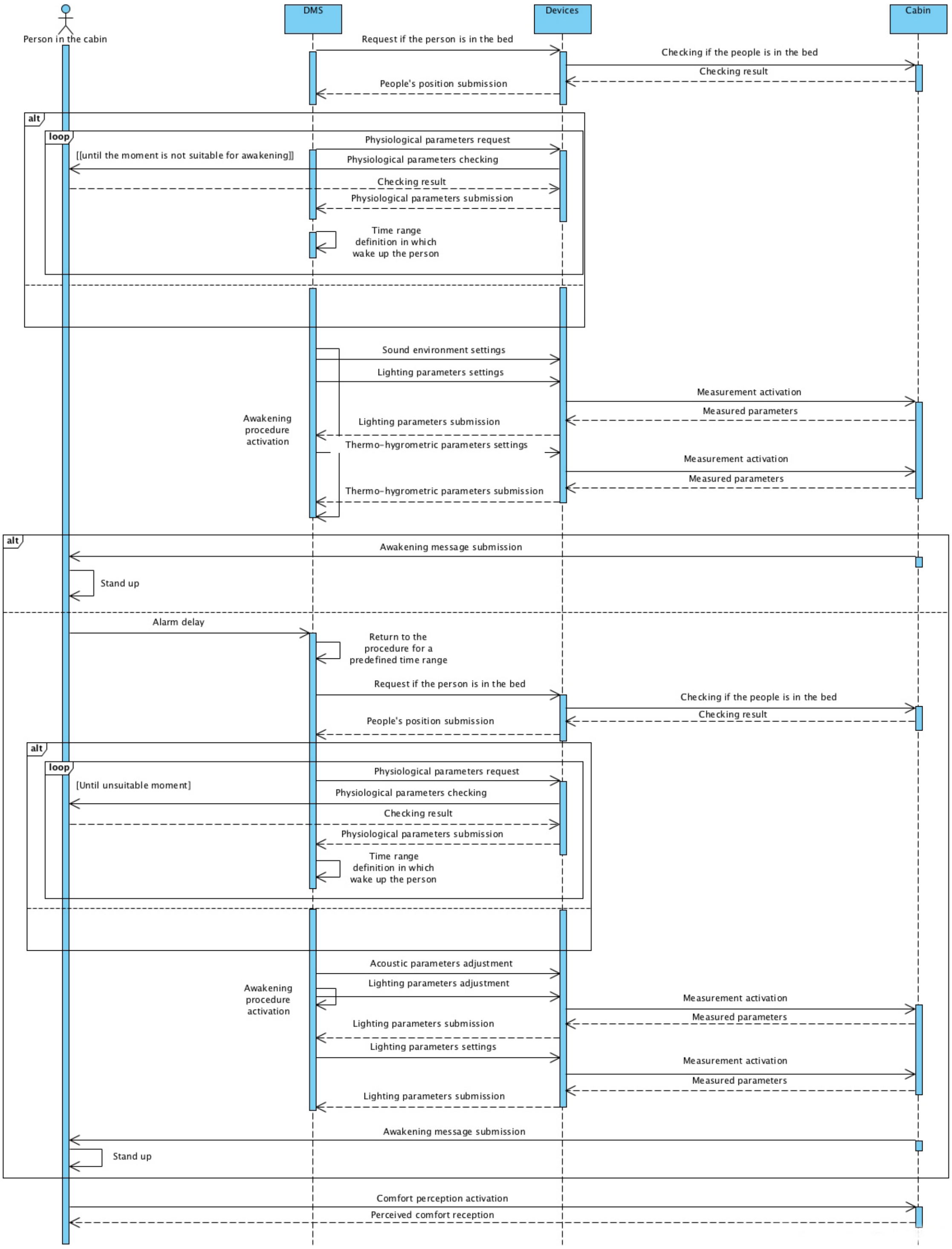

Figure 6. Sequence diagram for the Use Case 2.1.

4.3. Scenario 3: The Environment Changes Due to the Passenger's Absence

This scenario is focused on the energy efficiency and takes into account the passenger's activity of entering or exiting his/her cabin. During the passenger's absence from the cabin, a new scenario aimed at saving energy is set. The person has to wear the bracelet/beacon during the period of absence from the cabin. In this way, the passenger's position can be detected and the system can both set the cabin in the energy saving scenario—in case the person exits from the cabin—and restore the state of the cabin before he/she enters. Ancona et al. [54] pointed out the importance of maximizing the energy efficiency and minimizing the thermal energy dissipation. In this research, to make the passenger more sensitive about this topics, a pop up message appears on the smartphone or tablet when the person re-enters in the cabin (Figure 7).

The message provides the passenger with the partial energy savings (accumulated in the time interval of passenger's absence from the cabin) and the total energy savings (calculated from the beginning of the cruise). Moreover, the data describing the energy savings are read through the middleware and they can be made available also to the Cruise Company.

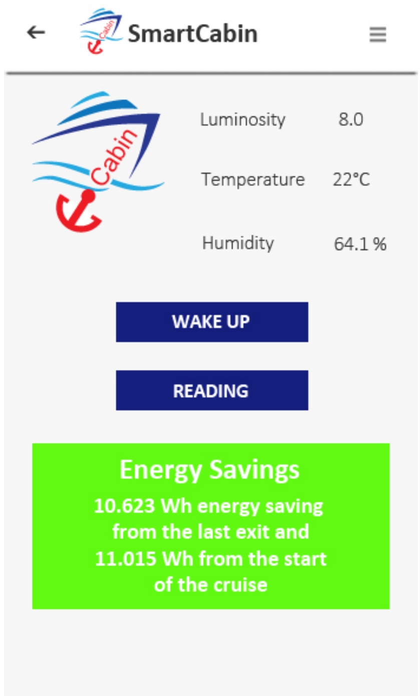

Figure 7. Energy savings message.

4.3.1. Use Case 3.1: Energy Saving after a Passenger Leaves His/Her Cabin

The Use Case 3.1 describes the process concerning the passenger's temporary absence from the cabin and the consequent reorganization of the energy saving scenario. The precondition for this use case is that the person is already registered on the Smart Cabin Application, he/she is logged in, and he/she wears the bracelets/beacon:

1. The person leaves the cabin.
2. When the person reaches a certain distance from the cabin, the DMS starts the procedure for energy saving scenario. By combining different sets of lighting parameters and environmental parameters, the cabin environment is reconfigured with metrics aimed at saving energy.
3. The Cabin is in the Energy Saving modality.

4.3.2. Use Case 3.2: Cabin's Indoor Comfort Restoration Just before the Passenger's Return

The Use Case 3.2 describes the process concerning the cabin restoring tailored indoor comfort metrics due to passenger's return to the cabin. The precondition is that the person is already registered on the Smart Cabin Application (see Section 5 for details), he/she is logged in, he/she wears the bracelets/beacon, and he/she has left the cabin before and he/she is returning to his/her cabin:

1. The person decides to return to the cabin.
2. The person is identified (by smart devices installed in the public spaces) near his cabin.
3. The DMS reactivates the cabin's settings that were in force before the passenger left the cabin.
4. The person enters in the cabin and finds the same environmental configuration that he/she had left before exiting.

Figures 8 and 9 show the sequence diagram of the Use Cases 3.1 and 3.2. In the UML diagram, four specific objects (person in the cabin, DMS, devices, and cabin) are reported with the respective connections. The cabin perceives a variation of status due to the sequence of adjustments imposed by the DMS to the devices to adapt to the new scenario.

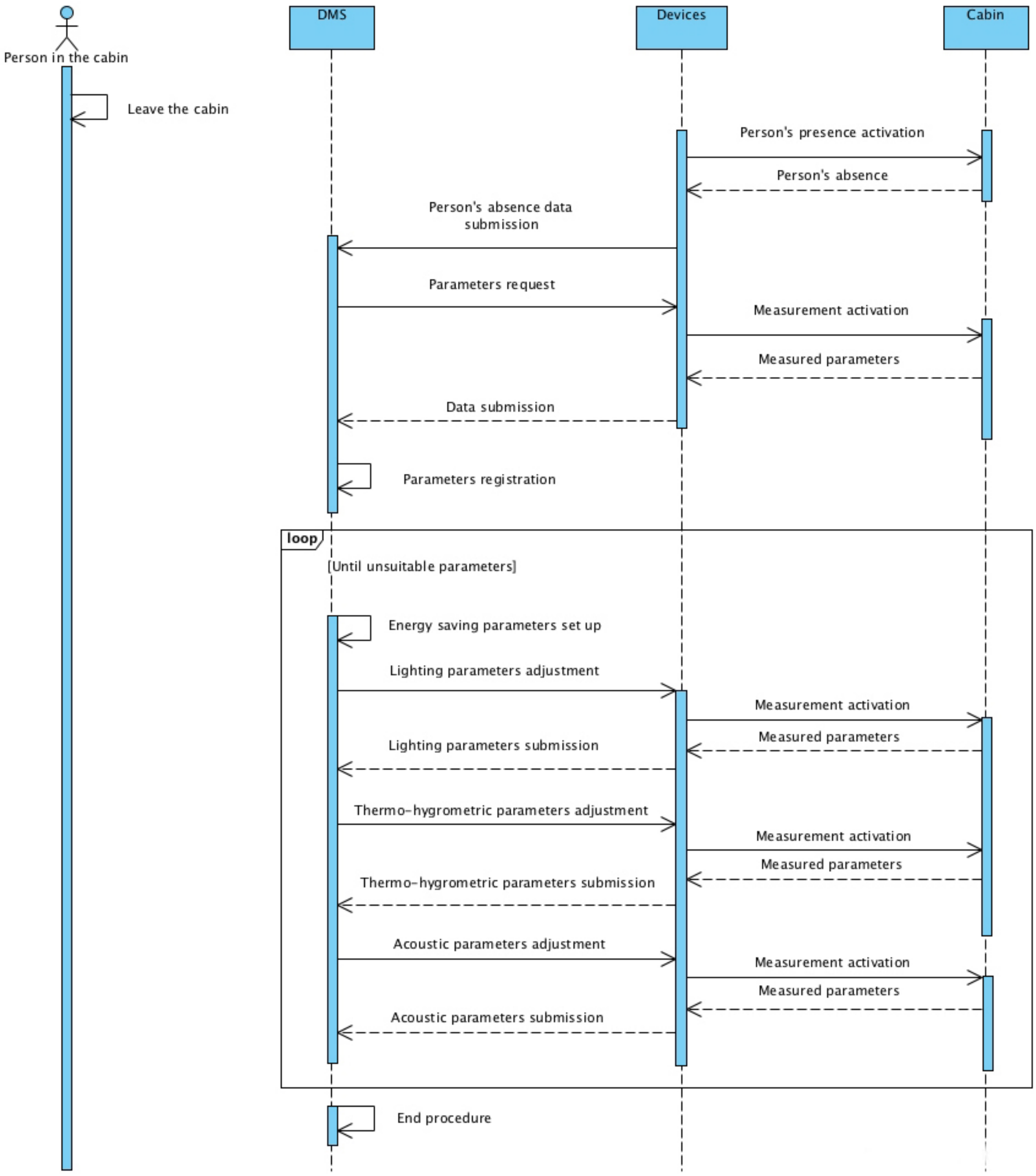

Figure 8. Sequence diagram for the Use Case 3.1.

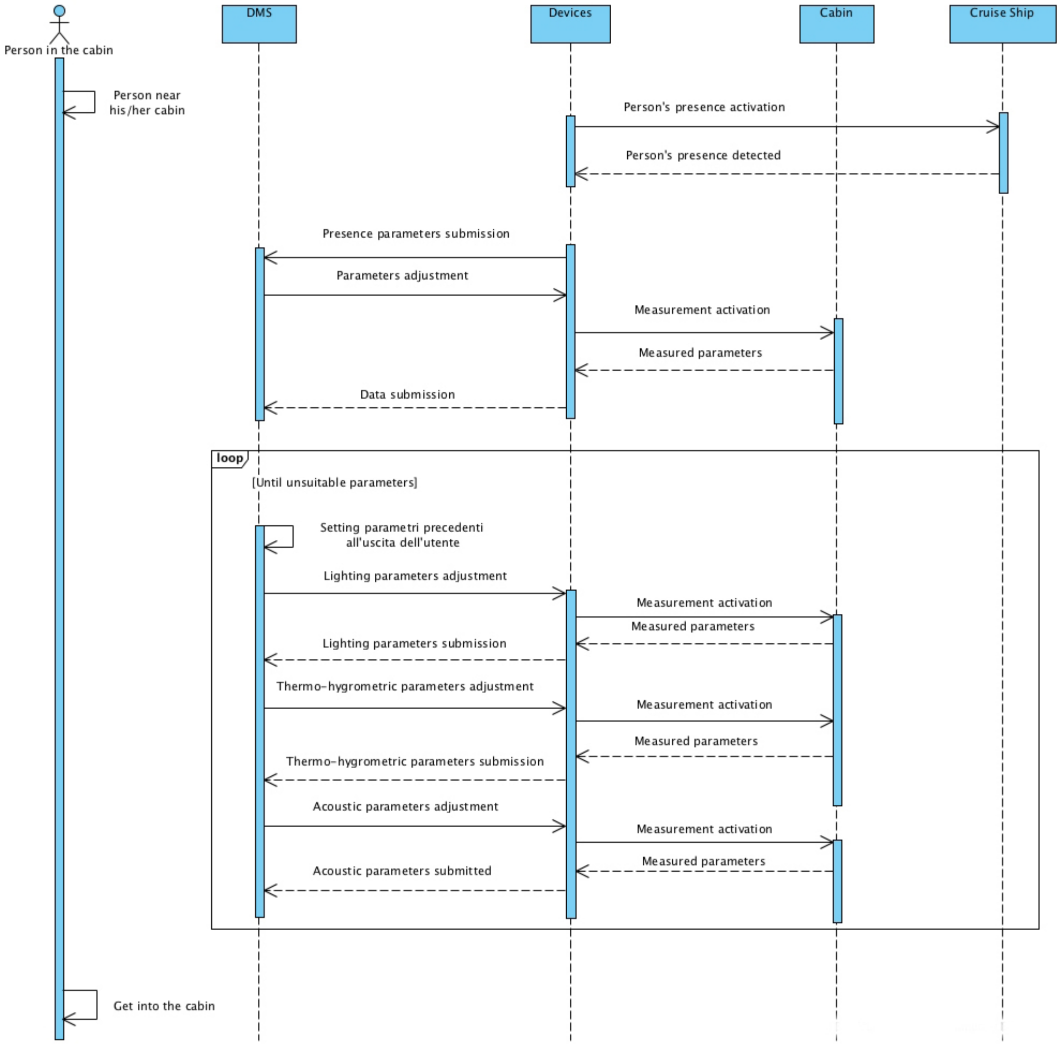

Figure 9. Sequence diagram for the Use Case 3.2.

5. Smart Cabin Application

Smart Cabin Application has been designed to monitor and regulate the environmental parameters and, consequently, to guarantee to the passengers the best performance of comfort (visual, acoustic and thermo-hygrometric) during various activities (for example, sleeping, reading and changing clothes) carried out in the cruise cabin. Moreover, the application presents an added value compared to the domotic systems currently on the market because it proposes an integrated system—the E-Cabin platform—that allows the integration of heterogeneous sensors and actuators in a unified way. It implements a personalized comfort in the cabin based on the characteristics of the passenger through queries to the reasoner and the use of basic knowledge. After the Application's download from the store, it is necessary to launch the application and start the registration phase.

As a first step, the cabin number is requested. In this way, the system is able to find all the information that the passenger stated during the check-in; all these data are comprised in the semantic repository. As a second step, the passenger can provide additional information on a web page that structures the personalized database. The stated data are reported in Table 1.

Table 1. Passenger's characteristics.

Semantic Repository	Personalized Data Base
Name and surname	Favorite colour
Gender	Preferred atmosphere
Date of birth	Favorite music genre
Disability (motor, auditory, visual etc.)	Smoker
Special needs (for example if he is vegetarian)	Sport

5.1. Smart Cabin Architecture

As introduced in the previous section, the Smart Cabin App is an application that works as a Decision-Making System. The user can monitor the status of the cabin by using the GUI (Graphical User Interface) of the App. The App is connected to the semantic repository and all the smart devices installed in the cabin environment through the E-Cabin platform. The App architecture involves four elements that interact among each other. More precisely, the elements in the App architecture are:

- DMS module;
- Data Base;
- Graphical User Interface (GUI);
- Interface with the E-Cabin platform.

The E-Cabin platform is based on a publisher–subscriber communication framework. The E-Cabin platform provides Topics and Messages for interfacing with IoT sensors and actuators, and with the reasoner. The structure and logic of the Smart Cabin App architecture are described in Figure 10. The Service components and the Content Provider are constituted by an independent module. The Service tasks are to notify the main activity on the presence of a Bluetooth Low Energy (BLE) beacon. The notification system is based on Intent, and, in the receiving Activity, provides a Broadcast Receiver for the presence. The Service has also another task; based on the information provided by the external Web Service, the Service updates the data in the application database. The database is managed through the Content Provider. In this way, the access and the use of the various components of the application are safe.

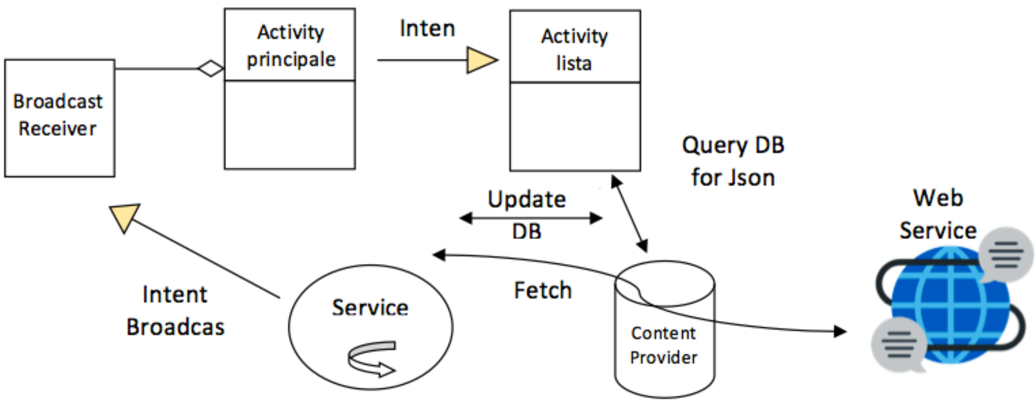

Figure 10. Smart cabin architecture.

5.2. Smart Cabin Application User Interface

The layout, aesthetically pleasing and appealing, and the graphic interface, intuitive and functional, are designed to improve the visual comfort of the end user. This section describes the main features of the application divided in: log in, default settings, home page, and main menu.

5.2.1. Log in

When the application is launched, a login screenshot appears on the screen (Figure 11). The user, already registered on the E-Cabin system, can insert the nickname and the password.

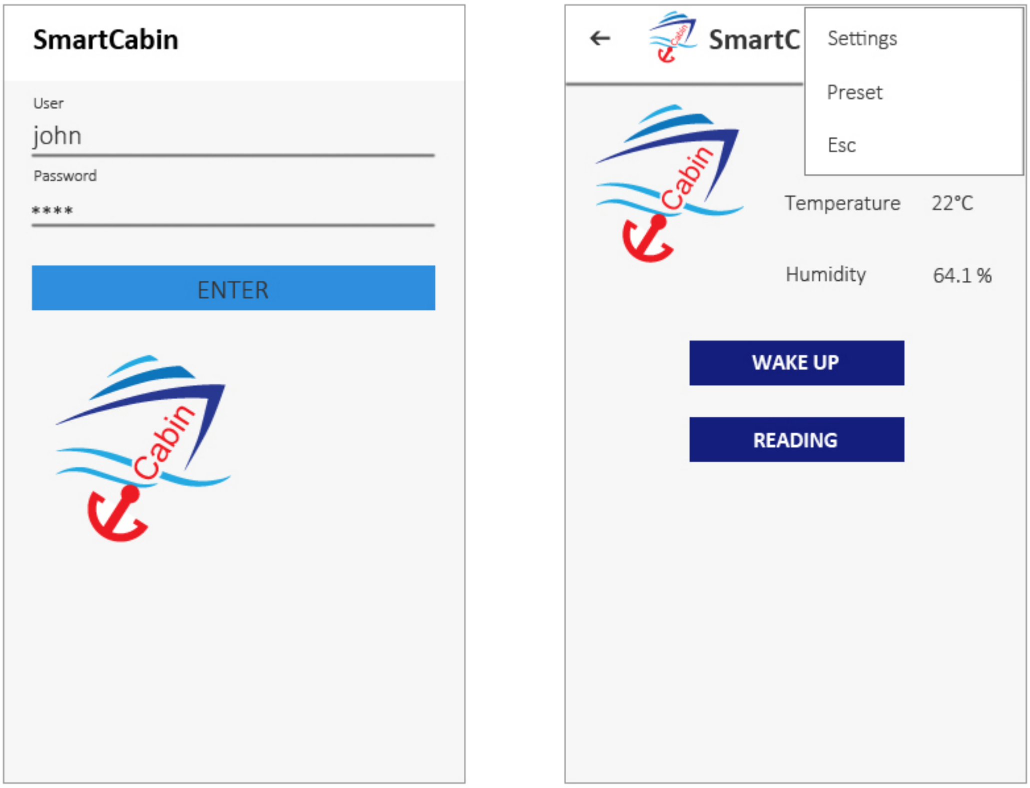

Figure 11. Log in screen-shoot (on the **left**) and Home Page screen-shoot (on the **right**) of the Smart Cabin Application.

5.2.2. Default Cabin's Settings

After the login procedure, the default settings of the cabin are activated. The indoor atmosphere deployed is personalized based on the user's characteristics that have has just been logged in.

5.2.3. Home Page

After the log in procedure, the main home page appears as shown in Figure 11. The GUI has grid's disposition of elements, which facilitates the users in the accessing, understanding, and using the application [55]. The Home page layout is divided into three main parts: weather station, menu and activities.

In the following paragraph, the main parts composing the home page structure are described:

- Weather Station: The temperature, humidity, and illuminance are reported in real time. Since the cabins are equipped with various ambient sensors that monitor the environmental status, it is possible to provide this information to the passenger.
- Activities: This section allows the passenger to choose the desired activity (e.g., reading on the sofa, reading in bed and waking up). This section, with the appropriate cabin equipment, could disappear as a consequence of a full automated cabin.
- Menu: The Menu button links to another screen with additional features (Settings, Preset and Exit). In the following paragraph, the functionalities of the buttons are described.

    1. Exit: this button closes the application;

2. Settings: this section allows the user to modify some settings. The user can turn on/off the lights, log out or set the initial cabin "preset" with the default cabin's settings (already described in Section 5.2.2).
3. Preset: this section allows the user to customize the atmosphere in the cabin. He/She can change some parameters of the various actuators by using the application on the smartphone or tablet. For example, as shown in Figure 12, the passenger can change the colour and intensity of the light and can decide to turn the music on/off.

Figure 12. Demo Cabin: red light atmosphere.

6. Test and Validation

The development of the above-mentioned application constitutes a plus value compared to the domotic systems available on the market, since it enables the adaptation of the comfort conditions according to a guest's current activity and to his/her preference. To verify this hypothesis, a double typology of tests has been performed. The application test has been used to validate the use cases, while the subjective test has been done to understand if users find it useful to have a cabin where the environment changes according to their activities and characteristics.

6.1. Subjective Test

The subjective test presented in this research is based on the participants' opinion and involves their personal feelings about comfort in the cruise cabin. The test has been done to understand if users are familiar with smart devices and if they consider it useful that the environment changes according to their characteristics and their different activities in the cabin.

6.1.1. Participants

Thirty adults—13 males and 17 females—were enrolled in the study. The people interviewed are representative of the Italian working class, with a medium-high level of education, an average age of about 45 (14 is under 40, 16 are over 40). Everyone declared a good propensity to travel. Except for two persons, the interviewees did not attend cruises. They all were in a good general health status. Exclusion criteria were: moderate to severe motor impairment or vision impairment; cognitive decline; inability to read Italian language; and inability to provide informed written consent. Table 2 reports all other demographic characteristics of the study participants. The subjects participating in the study provided informed written consent.

Table 2. Sample's characteristics.

Parameters	Value
Participants (number)	30
Gender (male/female)	13/17
Age	44 ± 18
Education (years)	15.6 ± 3

6.1.2. Equipment

The test took place in a Demo Cabin (Figure 13). The cabin is divided into four functional areas: sleeping area, living area, bathroom (not accessible area) and entrance. The guest can enter in the cabin only through the balcony door, as the entrance door is not accessible. Consequently, the guest is immediately in the sleeping area and then continues to the living area, where the test took place. The cabin dimensions—including the bathroom—were 3 × 6 m^2, and cabin height was 2.20 m.

The cabin's four functional areas were furnished as follows:

- Entrance: wardrobe, minibar;
- Sleeping area: bed 1, bedside table 1;
- Living area: chair 1, desk 1, minibar 1.

The division of the spaces and the furniture organization correspond to the characteristics of the environment described in the ontology. The cabin was also equipped with networked devices able to monitor the environment and to provide adequate comfort metrics according to each passenger's preferences and to the activity he/she is performing.

Figure 13. Cabin environment. The Demo Cabin was provided by Fincantieri S.p.A.

6.1.3. Protocol

Each subject performs the test in the above-mentioned cabin environment. Each session started when the user was seated on the chair facing the desk. The user received the smartphone with the Smart Cabin Application. The user autonomously discovered the functions of the application. The test procedure ended with the questionnaire.

6.1.4. Measures

To evaluate the passenger's comfort, an ad hoc questionnaire was developed. The questionnaire provides two items aimed at investigating the knowledge and the use of smart devices and two items focused on the usefulness of self-regulation.

The questionnaire consisted of the following questions:

Q1 How much do you use IoT devices (e.g., Smart Home devices) in your daily life?
Q2 Do you feel comfortable with the smart devices in the cabin?
Q3 Do you find useful that environmental conditions adapt to the activity that you do?
Q4 Do you find pleasing the auto-regulation of the environment regarding your activities?

For all questions, the user had to indicate his/her level of agreement on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree).

6.1.5. Statistical Analyses and Results

Data resulting from the questionnaire were analyzed using one-way repeated measures ANOVA. Results of the questionnaires for the considered activity are reported in Table 3 and are graphically depicted in Figure 14. The results are presented taking into account the following categories: male, female, age below 40, age above 40, and all the sample (all in Table 3).

Table 3. Subjective test results. The mean value and the standard deviation of the level of agreement, ranging from 1 (strongly disagree) to 7 (strongly agree), has been computed for each question and for each category.

Question	Mean Value					Standard Deviation				
	Male	Female	Age < 40	Age > 40	ALL	Male	Female	Age < 40	Age > 40	ALL
Q1	2.00	2.18	2.25	1.94	2.04	1.10	0.40	1.13	0.72	1.50
Q2	4.89	5.27	5.08	5.00	5.04	1.10	0.90	0.90	1.13	1.62
Q3	4.94	5.27	5.17	5	5.04	1.13	0.90	0.94	1.14	1.62
Q4	6.41	5.91	6.25	6.22	6.29	0.96	0.83	1.14	0.81	1.24

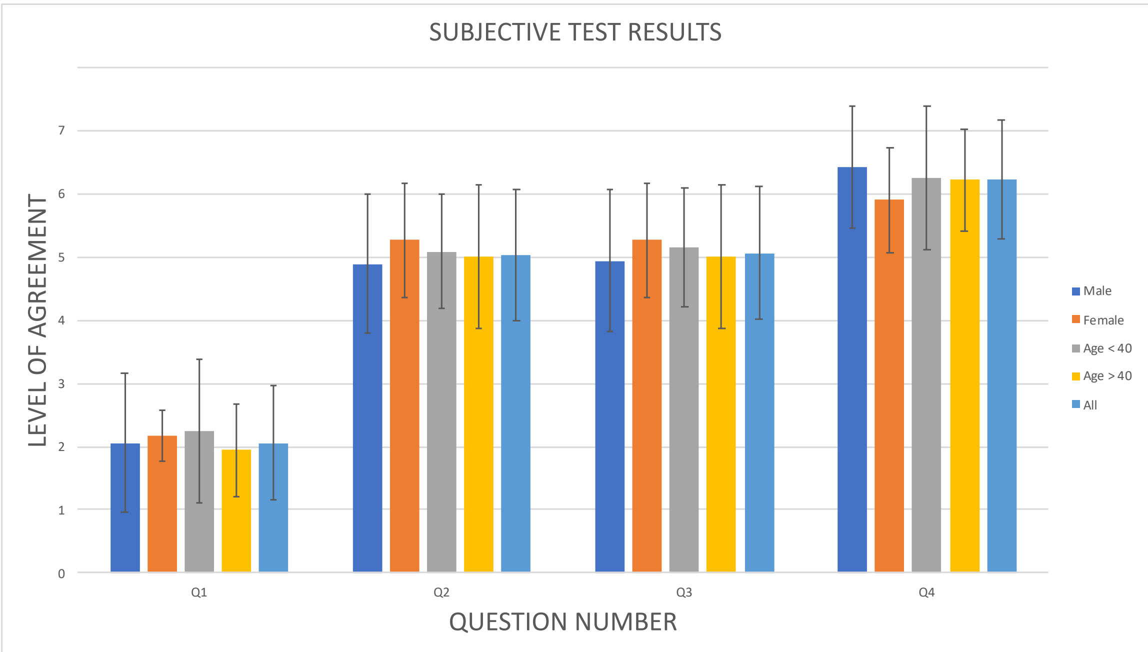

Figure 14. Subjective test results. The values reported in Table 3 are depicted in graphical format. The solid bars represent the mean value and the lines the standard deviation of the level of agreement (from 1 to 7) for the reply of the following five categories: male, female, age below 40, age above 40, all the persons in the sample.

6.2. Application Test

The application test presented in this research is based on the functionality and activities of the Smart Cabin Application described in Section 5. The aim of the Smart Cabin Application is to monitor, regulate and guarantee the best comfort performance (visual, acoustic and thermo-hygrometric) to the passenger during various activities carried out in the cruise cabin. The test has been done for testing the Use Case activities described in Section 4.

6.2.1. Participants

Three adult profiles—two males and one female—between 25 and 46 years old have been considered in the study. They all were in good general health status. Exclusion criteria were the same of the criteria described in Section 6.1.1.

6.2.2. Equipment

The test took place in the same Demo Cabin described in the Section 6.1.2 of the Subjective test.

6.2.3. Protocol

Each subject performs the tests in the above-mentioned cabin environment. The user received the smartphone with the Smart Cabin Application. Each session started after the user's log-in (the registration phase had already done). The user independently discovered the activities of the application and simulated the four Use Cases. The test procedure ended with the evaluation of the Use Cases, e.g., if the Use Case 1.1 was completed or not.

6.2.4. Measures

To evaluate the Use Case activities of the Smart Cabin Application, all three of the user performed the following Use Cases. Every user repeated the procedure a fixed number of times. For every repetition, the user had to indicate the success/failure of the process—for instance, if the environment changed considered his/her activity and characteristics.

6.2.5. Results

A total of 139 executions were carried out on Smart Cabin Application for testing the Use Case activities described in Section 4. All executions were successfully completed as shown in Table 4.

Table 4. Application test results. We have considered six different test cases, and in each of them we have tested the Application using three different user profiles, called Profile1, Profile2 and Profile3 in the table. Each user profile corresponds to a different configuration in the knowledge base. For each profile and each use case, two numbers are reported: the number of successful trials and the total number of trials for that test. The overall number of successful trials and the number of total trials for a given Use Case is finally reported in the Results column.

Use Case	Test			Results
	Profile1	Profile2	Profile3	
1.1.1—Start of the reading activity on the sofa	10/10	9/9	8/8	27/27
1.1.2—Start of the reading activity on the bed	8/8	10/10	8/8	26/26
2.1—Forced awakening due to a fixed commitment (ex: excursion)	10/10	10/10	10/10	30/30
3.1—Energy saving cabin settings after the exit of the passenger	10/10	9/9	9/9	28/28
3.2—Cabin environment restoration after the energy saving scenario and just before the passenger's entrance	10/10	9/9	9/9	28/28

6.3. Discussion of Test Results

The results of the two tests show that the tested users seldom use IoT smart devices different from the smartphone in their daily life. Although the IoT devices are rarely used, these users have a strong interest in spending time in cabins equipped with IoT devices. In the tested sample, there is no noticeable difference in the response between males and females, although men are a little more interested in using personalized comfort adjustment. Note that, although older people are slightly less accustomed to using IoT devices, they also have a considerable interest in customizing cabin comfort.

The three different Use Cases and the three different user profiles helped us in testing the Smart Cabin Application in different operational conditions. For each of the user profiles, the test was repeated several times, to check if the system response is repeatable. The Smart Cabin Application successfully fulfilled the tested Use Cases, showing that three different user profiles can be managed, and that personalized comfort configurations are inferred and then applied nearly in real time.

7. Conclusions and Future Works

In this paper, we presented a novel decision-making system capable of optimizing the cruise cabin comfort. This system leverages an ontology-based representation of the passengers and their health condition, indoor comfort metrics and sensors and actuators to provide tailored comfort adaptations to the passengers, exploiting reasoning techniques enabled by Semantic Web. The main novelty of the decision-making system relies on the definition of a new comfort metric domain ontology, mainly based on the concept of holistic comfort, which is able to reuse already defined and well-known person and IoT ontologies. In fact, exploiting semantic reasoning, the system can automatically adjust the comfort for a passenger, knowing his/her characteristics and taking into account the activity the person is performing in a particular area of the cruise cabin. A mobile-device application acts as an interface to allow the passenger to communicate with the decision-making system, so that he/she can select the activity he/she wants to perform, while hiding the complexity of the actuation performed in the cabin environment. Subjective results show a high acceptance rate of the automatic comfort optimization based on holistic comfort, while repeated tests show that the implemented demo scenarios are implemented in a reliable and affordable way.

Future works will consider a wider set of activities, extending the range of the use cases considered. New use cases will be drafted to consider other different IoT equipment and devices inside the cruise cabin. Among these activities, the possibility to provide personalized music to the passenger can also be evaluated; this would require a modification of the ontological framework to also encompass passengers' musical preferences. Another research line for the proposed framework is to investigate whether it could be adopted in different environments of the cruise ship, such as private areas inside restaurants, SPA areas, bars, etc. Moreover, the proposed decision-making system could be compared to the "Comfort as a Service" (CaaS) paradigm [56], which releases indoor environments' occupants from managing and operating with the comfort equipment with the aim of reducing energy wasting, increasing costs and uncomfortable indoor metrics. In relation to the presented framework, the IoT devices can enable the idea of CaaS.

Finally, in order to assess the passengers' acceptance for these kinds of technologies, the standard Technologies Acceptance Model (TAM) [57] and System Usability Scale (SUS) [58] can be adopted as tools to evaluate the system.

Author Contributions: M.N. developed the architecture and the application and contributed to the administration of the study, and supervised the writing of the first draft of this paper. D.S. developed the ontologies presented in this work, set the semantic repository, and contributed to the development of architecture. S.C. contributed to the enrolment of the participants and to the administration of the study, S.C. developed the study protocol, analyzed the outcomes, and wrote the study methods and results. R.B. contributed to the development of the application and the development of the architecture. M.S. contributed to administration and development of the study and revised the manuscript.

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Abbreviations

The following abbreviations are used in this manuscript:

AAL	Ambient Assisted Living
Ami	Ambient Intelligence
App	Application
BLE	Bluetooth Low Energy
CA	Context Awareness
DEHEMS	Digital Environment Home energy Management System
DMS	Decision Making System
ICF	International Classification of Functioning, Disability and Health
IoT	Internet of Things
JSON	JavaScript Object Notation
OWL	Ontology Web Language
RDF	Resource Description Framework
SSN	Semantic Sensor Network
SWRL	Semantic Web Rule Language
UML	Unified Modeling Language

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Cruise tourism: social media content and network structures

Flávio Tiago, João Couto, Sandra Faria and Teresa Borges-Tiago

Abstract

Purpose – *The purpose of this paper is to present knowledge acquired through examining three cruise lines' social media strategies over a three-year period, analyzing the network structures involved and demonstrating the value of the STAR (storytelling, triggers, amusement and reaction) model for enhancing social media activity.*

Design/methodology/approach – *This study gathered data from three cruise lines' official websites and Facebook and Twitter accounts, examining variables such as internet presence, engagement and fans/followers. Furthermore, the work also addresses several issues that researchers encounter when using the STAR model.*

Findings – *Digital activity was found to vary significantly between the three cruise lines' websites and Facebook and Twitter accounts, with the companies adopting different approaches and obtaining different results. Each company tended to have its own base of fans and followers, who shared a common language, reflected in the hashtags they used. The results show that cruise lines wishing to develop a content-oriented strategy that maximizes engagement in social media should share rich multimedia content that supports storytelling values and can be used on multiple platforms.*

Originality/value – *This work can be of interest to practitioners aiming to use a comparison and assessment tool for their digital activity. It could also assist future researchers focusing on cruise line activity, as few researchers have analyzed the online content strategies of cruise lines, particularly on Facebook and Twitter.*

Keywords *Cruise tourism, Social media, Content analysis, Facebook, Twitter, STAR model*

Paper type *Research paper*

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1. Introduction

The information-intensive nature of the tourism industry suggests the importance of information communication technologies (ICT) for tourism delivery systems. The main emphasis in this regard is on the internet, particularly social media (Zeng and Gerritsen, 2014).

Zeng and Gerritsen (2014) identified three domains of social media influence that merit consideration in regard to tourism:

1. ICT tools that rely on information technology and the digital marketing strategies of individual firms;
2. Channels that allow peer-to-peer communication, based on content creation, collaboration and exchanges of content between companies; and
3. The construction of virtual communities, which affects people's behavior.

Closely examining previous research in terms of the three abovementioned domains reveals that most studies have focused on the first sphere, mainly analyzing hotels and restaurants (Varkaris and Neuhofer, 2017; Kim and Park, 2017; Viglia *et al.*, 2016; Yang, 2017). Thus,

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few studies have explored other spheres of the tourism and hospitality industries, such as cruises and entertainment activities (Weeden *et al.*, 2011). Consequently, this study aims to describe the social media strategies used in the cruise industry. The approach involves analyzing the Facebook and Twitter activities of three cruise lines, analyzing the network structure of each cruise line and documenting the topics used (and the engagement and influence achieved) and transposing identified engagement drivers to the components of the STAR (storytelling, triggers, amusement and reaction) model.

2. Literature review

Recently, social media has become the focus of increasing attention among tourism and hospitality theorists (Varkaris and Neuhofer, 2017; Narangajavana *et al.*, 2017; Viglia *et al.*, 2016; Neuhofer *et al.*, 2014), and tourism and hospitality firms have themselves embraced social media, recognizing the potential for engagement and co-creation with consumers (Mistilis and Gretzel, 2014; Lee and Koo, 2012), and hoping to take advantage of the natural social bonding that occurs during most tourist experiences (Neuhofer *et al.*, 2014). However, regardless of the relevance of social media in cruise marketing, research in this field remains scarce (Park *et al.*, 2016; Gutberlet, 2016).

2.1 Cruise tourism agenda

According to statements made by cruise lines and trade associations (CLIA, 2016; FCCA, 2017), the worldwide cruise industry is the fastest-growing sector in the entire leisure market, boasting high levels of repurchase rates (Li and Petrick, 2008). Indeed, the number of people taking cruises has increased continually since the 1970s. A similar pattern of growth can be seen in cruise line revenues and numbers of ships. The greatest growth in this sector, however, is in the amount of information being shared, both by firms and by customers (CLIA, 2016).

Vogel and Oschmann (2012) questioned whether this phenomenon is truly promising, given that cruise prices have decreased in the past decade and competitors must continually reinvent themselves to offer memorable tourist experiences.

Despite the increasing relevance of the cruise industry to the tourism and hospitality sector, relatively little academic research has been conducted in this field (Brejla and Gilbert, 2014). Instead, most related works have focused on the economic (Brida and Zapata, 2009; Dwyer and Forsyth, 1996; McKee and Chase, 2003), socio-cultural (Lester and Weeden, 2004; Seidl *et al.*, 2006), and environmental (Johnson, 2002; Klein, 2011) impacts of cruise–ship activity, or on cruise–passenger behavior (Yarnal and Kerstetter, 2005; Petrick *et al.*, 2006; Li and Petrick, 2008; De Cantis *et al.*, 2016).

Papathanassis and Beckmann (2011) reinforced the notion that there is a lack of unifying theoretical perspectives in tourism theory, and particularly in cruise tourism. These authors identified 145 cruise-related academic publications published between 1983 and 2009. Acknowledging the relevance of the methodology and findings presented in their work, the authors conducted a similar procedure. Cruise-related academic publications were collected from Scopus for the period from 1999 until January 2018. In total, 386 references were retrieved (Figure 1).

When analyzing the fields of analysis, of the 386 references retrieved, only nine were within the field of business and economics. The remaining papers were in different research fields, such as engineering or environment.

To gain a better understanding of the fields, and taking into consideration that research can be cross-domain, we composed a graph with the major topics (Figure 2).

In an attempt to access the main fields behind the research, a cluster analysis was conducted; three clusters emerged (Figure 3).

Figure 1 Number of articles published

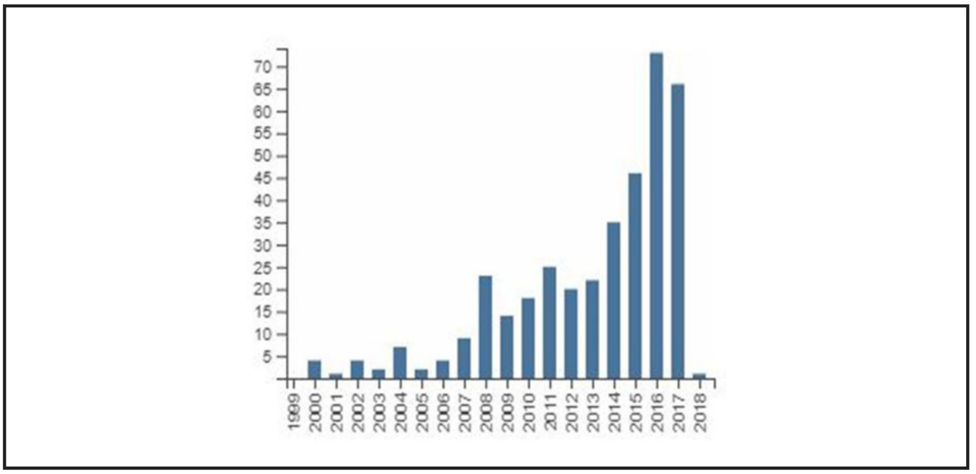
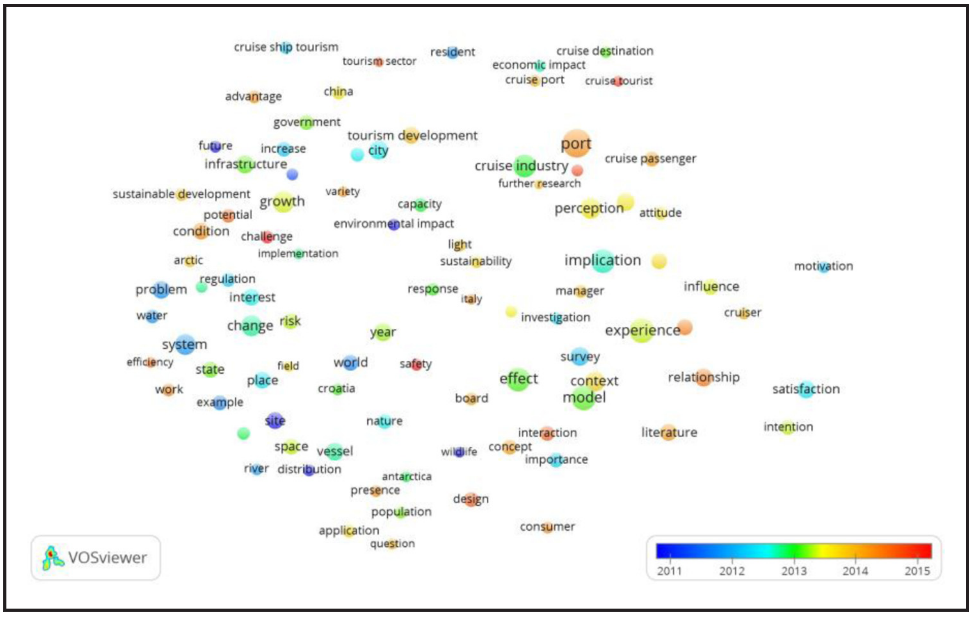


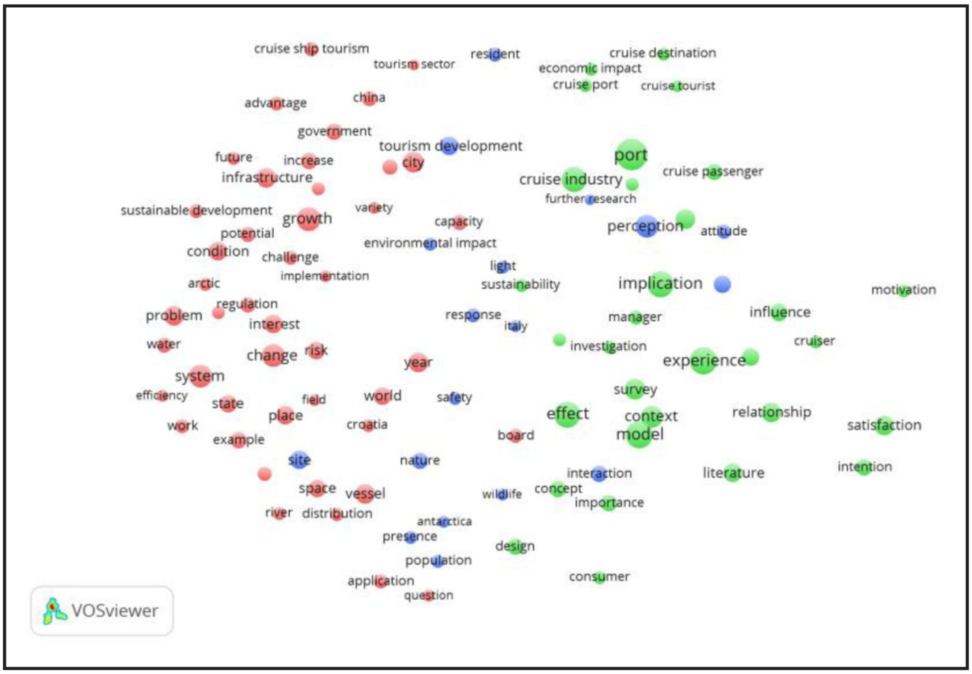
Figure 2 Main topics analyzed



Cluster 1 is the largest cluster, with 45 items related to cruise–ship systems. Cluster 2, with 31 items, focuses on cruise–industry models relating to customer experience. Cluster 3 aggregates 18 items, focusing on the impact of cruise tourism on local sustainability. In analyzing these graphs, the lack of studies integrating cruise lines and social media communication is noticeable.

Nevertheless, various factors have been found to influence tourists' intentions to take a cruise. Initial investigations have centered on economic, institutional and cultural environments (Vogel and Oschmann, 2012) leading to a definition of segments based on prices (Petrick *et al.*, 2006; Satta *et al.*, 2016) and destinations (Field *et al.*, 1985). Beyond this context, Hung and Petrick (2011) found that passengers' intentions to take cruises could be influenced by a wider set of personal and emotional factors, such as the

Figure 3 Cluster graph



opportunity to escape from their everyday environment, relax, improve relationships with family, engage in social interaction and enjoy novel and luxurious experiences (Huang and Hsu, 2009).

2.2 Technology: enhancing cruise experiences

The internet has redefined the tourism industry in a number of important ways (Buhalis and Zoge, 2007; Buhalis and Law, 2008; Leung *et al.*, 2013). However, this evolution is due not only to technological development but also because digital literacy has increased and social behavior has changed.

In the literature, we can find a wide range of works focusing on experience and technology adoption. These works established that the internet is used for planning holidays because:

- tourism produces intensive amounts of information and consumers use search engines (Sørensen and Jensen, 2015); and
- social media websites, where customers can post information about their experiences and expectations (Munar and Jacobsen, 2014), are considered to be more reliable information sources (Xiang *et al.*, 2015; Xiang and Gretzel, 2010).

Substantial research has been devoted to the social media usage of customers and firms (Leung *et al.*, 2013; Varkaris and Neuhofer, 2017; Wang, 2016; Atwood and Morosan, 2015; Amaro *et al.*, 2016; Baird and Parasnis, 2011; Berthon *et al.*, 2012; Buhalis and Foerste, 2015). These researchers have found that firms' strategies and degree of sophistication in terms of adopting social media can vary (Mistilis and Gretzel, 2014), and some have concluded that social media adoption is the final part of three sequential phases: static website, dynamic website and social media (Wang and Kim, 2017).

Although social media is a "megatrend" that has had a significant impact on the tourism system, hospitality and tourism firms have not fully exploited the potential of these networks

(Kim and Park, 2017; Berthon *et al.*, 2012; Baird and Parasnis, 2011). As noticed by Hudson and Thal (2013), firms have adopted approaches that reflect the level of their investment in social media in comparison to their overall marketing budget; however, not all communication is useful as a tool for communication, promotion or persuasion, and the same is true in the online context.

Online reviews can be classified in terms of quantity, valence and attributes, and when users share a common language and type of content, this facilitates the creation of online imagined communities around the subject (Kavoura and Borges, 2016). Review quantity refers to the number of posts concerning a product/service, which can indicate its popularity and can increase the credibility of the information; review valence concerns the type of comment, positive or negative; and review attributes refers to the nature of the information in the comment – if it is objective or subjective, or if it is attribute-centric or benefit-centric (Lee and Koo, 2012).

Yarnal and Kerstetter (2005) analyzed social interactions during a cruise and found an intersection between group vacation contexts and tourism experiences. If cruises are sources of social interactions in a specific physical space, social networking sites can be considered as the digital spaces of tourism experiences, allowing the sharing of past experiences and enabling the search for information regarding the experiences of others. Thus, two questions arise:

- *Q1.* To what extent does the shared content of tourists influence engagement level?
- *Q2.* What are the main types of content shared by cruise lines that promote high levels of engagement?

3. Method and results

This study investigates the online strategies adopted by cruise lines, particularly focusing on cruise lines' official websites and two of the most popular social media networks (Facebook and Twitter). After examining the ranks of cruiseline.com, Norwegian Cruise Line, Princess Cruises and Disney Cruise Line were chosen for analysis, as they appear in the top five of "Best Cruise Lines for First Timers." First timers tend to search and trust content shared by peers online (Liu and Park, 2015). The data were gathered directly from the companies' official social networking sites, using three traffic analysis tools available online. Data for November 2014-April 2015 were retrieved and weekly engagement levels were established. Then, in September 2017, using the same structural data forms, data were gathered to update and validate the initial considerations.

To examine the data, we used a mix of qualitative and quantitative analyses, starting with a descriptive analysis of traffic, volume and structure. The first level of analysis comprised a descriptive analysis approach, describing the overall results. The second phase interpreted assessments of STAR model dimensions. The STAR model focuses on message content, specifically, the ability to combine four dimensions: storytelling, triggers, amusement and reaction (Tiago *et al.*, 2016).

The storytelling dimension was measured by determining the existence (within the posted content) of stories with a sequence line or emotional flow; for triggering, we considered the number of shares or hyperlinks associated with a comment; amusement was examined by considering the average number of fan likes that each post received; and reaction was measured by considering active posts and comments created by fans. Then, based on the variables mentioned above, engagement and influence were measured. These metrics were also used to classify fans and followers on Facebook and Twitter, identifying key opinion makers.

The third stage involved analyzing user-generated content and transposing it to a dispersion tool, based on a graph analysis methodology. Using Gephi, social network analysis was performed to identify social data connectors and to map the cruise lines' networks. Furthermore, the centrality measure was used to establish how well the node was connected to the influence. After establishing the main network, a connected sub-graph, G (V, Σ), was created, in which G included all of the followers of each cruise line by country of origin, the cardinality of V was minimum influence and Σ NetWorth (vi ε V) was the maximum estimated value of influence. In addition, for each country, the most frequently used hashtags were retrieved to identify common words used in the network, and then the graphs showing countries were redrawn.

Given the network structure of the Norwegian, Disney and Princess Cruise Lines, in this study, a content analysis was combined with measurements of social media metrics, including engagement and influence scores (the influence score is a number between 1 and 100 that represents the influence of each user in a social media network).

We used variables related to website activity, such as the number of visitors, bounce rate, time online, geography, gender, access point and education. To analyze Facebook results, we considered the number of fans, likes, posts, shares and content posts. We also analyzed Twitter by examining the number of followers, tweets and retweets, in addition to the text of each piece of user-generated content.

3.1 Initial data analysis

These three companies all have a strong internet presence. Norwegian has the highest number of daily page views, with an average of 6.23; Princess is next, with an average of 4.72; and Disney is third, with an average of 5.52. The amount of time users spent decreased over the period of analysis. In regard to bounce rate, Disney is first at 27.2 per cent, then Norwegian at 25.6 per cent and Princess at 24.5 per cent.

Figure 4 shows that in 2014, more than 65 per cent of visitors to Princess' and Disney's sites, and 82.7 per cent of the visitors to Norwegian's site, came from the USA. The prevalence of US visitors was even higher in 2017: 79 per cent for Disney, 70 per cent for Norwegian and 66 per cent for Princess.

On all three sites, women comprised three-quarters of visitors. Visitors to Norwegian's and Princess' sites tended to be college educated, but those who visited the Disney site were not. This disparity can be associated with public perceptions of Disney; another salient aspect is the number of site visits that were made from schools to the Disney website, possibly reflecting the importance of children's opinions when choosing a cruise. This was a pattern that prevailed over the period of analysis.

Figure 4 Comparison of web page visitors

Norwegian Cruise Line

Metrics	Bounce rate	Daily Page views / visitor	Daily time on site
2014	21.4%	8.45	10:27
2017	24.5%↑	6.23↓	8:39↓

Princess Cruise Line

Metrics	Bounce rate	Daily Page views / visitor	Daily time on site
2014	20.8%	5.75	8:43
2017	25.6%↑	4.72↓	7:49↓

Disney Cruise Line

Metrics	Bounce rate	Daily Page views / visitor	Daily time on site
2014	36.0%	5.08	7:37
2017	27.2%↓	5.52↑	7:19↓

Although Norwegian gained first place in the website analytics, Facebook analytics differ. Evaluating fan bases on Facebook showed that Princess Cruises were the most popular, with 1.630 million fans, followed by Disney Cruise Lines, at 1.449 million fans, and Norwegian cruises, at 1.193 million fans. These numbers increased at a similar rate over the period 2014-2017.

The nationality of each firms' Facebook fans resembles the statistics for their official sites, but with an even higher concentration of people from the USA for all companies; second was Canada and third was the UK. Mexicans also appear on the Disney and Princess sites, whereas Puerto Ricans, a US territory, are present on all sites.

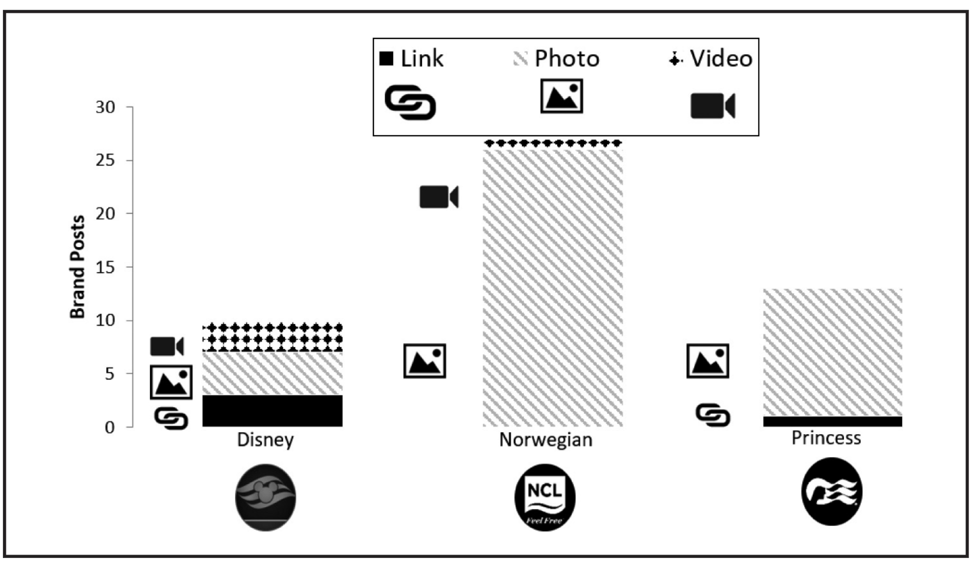
Among Princess visitors, Australians are the third-largest nationality; meanwhile, Germans appear only on Norwegian's site, Brazilians are strongly represented on Disney's site and Japanese are represented among Princess fans. Europeans are the most likely to be the fans of Norwegian's site.

In terms of level of engagement with fans, Disney had 11.4 per cent, Norwegian had 10.5 per cent and Princess had only 6.9 per cent. In other words, Disney has a 41 per cent share of fan engagement, Norwegian 31 per cent and Princess 28 per cent.

Although Norwegian has more posts per day than either Princess or Disney, this does not translate into higher total engagement in the initial period. This may be because Disney has the most diverse branded posts, with similar numbers of links, photos and videos; in contrast, Norwegian and Princess depend almost exclusively on photos (Figure 5).

Applying the STAR model structure to the three firms, it can be noticed that none of them apply to all four dimensions. Disney reaches higher engagement levels (11.4 per cent of total fans) using a multi-content strategy that allows them to explore the storytelling, amusement and reaction dimensions. With a smaller number of posts, Norwegian uses mostly photos and some videos to promote users' engagement, neglecting the storytelling behind it and focusing on the amusement and reaction dimensions. Therefore, the engagement levels achieved are small. Princess Cruise Line relies on social media communication in two types of contents: links and photos. These two elements promote amusement and triggers.

Figure 5 Each cruise line's relative share of engagement on Facebook



The situation on Twitter is very different. In 2014, Disney had 288,883 followers, compared with 87,497 followers for Princess and 78,827 followers for Norwegian. In 2017, Disney had 396,641 followers and Princess had 164,837. This difference between the number of Facebook fans and Twitter followers may reflect the fact that Facebook is stronger in Europe and Twitter is stronger in the USA (Table I).

In 2014, the majority of the cruise companies' Twitter followers were from the USA and Canada, with Europe a distant third. Updating these numbers for 2017, similar figures are found: Disney had the highest number of followers, whereas the influence score remains higher for Princess Cruise Lines. This is interesting, as all three companies attract similar national groups, suggesting that obtaining a greater number of followers than fans may be attributable to the companies' investment in Twitter rather than Facebook. Perhaps Disney focuses its strategy much more on Twitter than do Norwegian and Princess, integrating its Facebook and Twitter platforms with Instagram and YouTube.

By analyzing Twitter's customer service workflow, we observed that Norwegian has 1,039 brand mentions and Disney 1,063. Here, the average number of followers for Norwegian is 2,224.7 with 927 unique people, whereas for Disney, it is 4,722.5 with 1,292 unique people.

One relevant feature of social network analysis is the capability to identify sub-groups of individuals or entities that exhibit tight interconnectivity among the wider population. A Haren–Koren (HK) fast multiscale graph was composed for each of the cruise lines, featuring the 2,000 most recent Twitter posts that mentioned the companies' brand names or official hashtags, which were obtained using force-directed layout of vertices and edges based on the number of tweets and retweets from each contributor post. The graph produced for the cruise lines denoted that the Princess Cruise Lines and Norwegian Cruise Line communities are structured and have two main types of contributors: frequent contributors and those who tweet or retweet sporadically. Within the Princess and Norwegian networks, the nodes that presented higher intra- and inter-cluster links were from clients and travel agencies. Furthermore, in both network structures, a small community linked to employees could be found outside of the larger community (Figure 6).

Using the HK fast multiscale layout algorithm, Disney Cruise Lines presents a unique, unstructured network, denoting more spontaneous content creation. The Disney graph shows three pseudo-random networks with five clusters. Further filtering of the edges, to retain those who are more active inter- and intra-clusters, led to the finding that the two smaller pseudo-random networks represented travel channels and specialized cruise-travel agencies, whereas the largest reflects the main content creators.

Although these analyses reveal interesting facts concerning cruise line network cohesion and boundary spanners (represented by larger vertices), it was possible to explore additional facets of the data to gain further insights into the co-created communication; we used Gephi for such analysis. Consequently, content analysis associated with the graph analysis produced for Disney showed similarities in terms of hashtags used: "#new," "#dream," "#experiences" and "#family" were the most used words, regardless of the tweeters' countries of origin. The hashtags used in the USA and Canada showed minimal differences (Figure 7).

Table I Twitter followers

Indicators	*Norwegian Cruise Line*		*Disney Cruise Line*		*Princess Cruises*	
Year	2014	2017	2014	2017	2014	2017
Followers	78,827	135,780	286,883	396,646	87,497	164,838
Tweets	13,113	16,041	4,332	5,642	11,618	18,614
Influence score	80.5	81.2	83.3	88.1	87.7	88.3

Figure 6 Network graphs for the three cruise lines, obtained using the HK fast multiscale layout

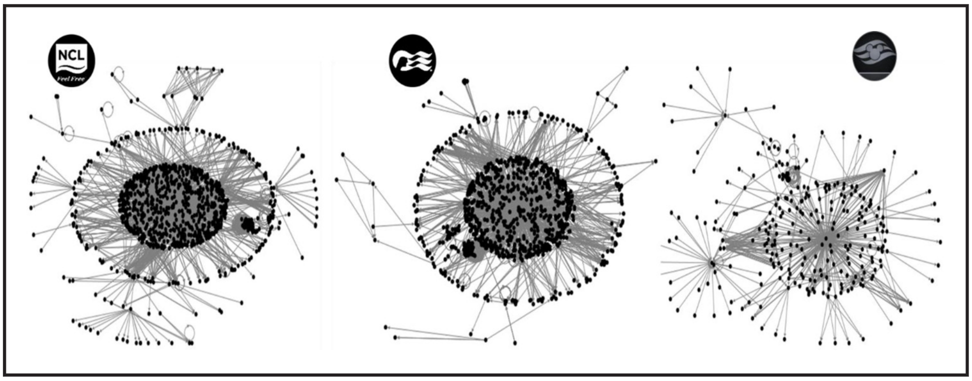
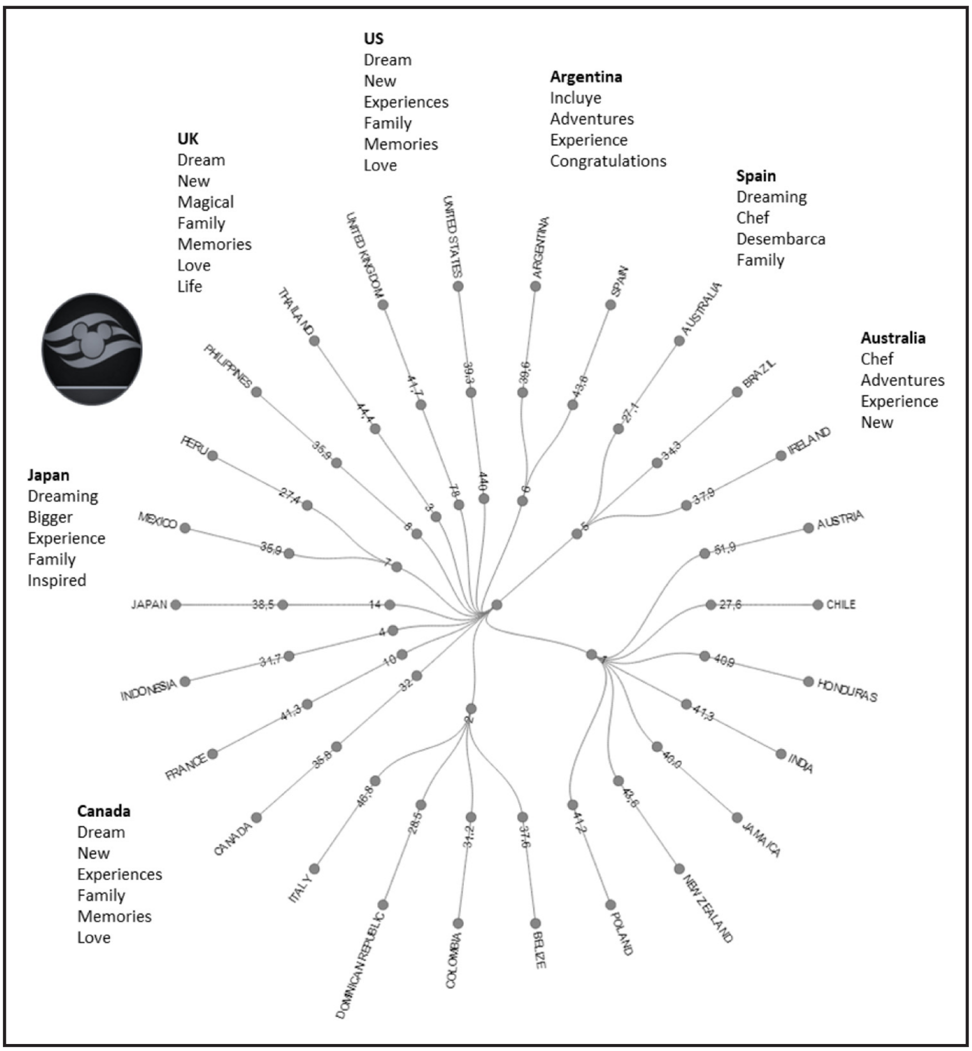


Figure 7 Graph analysis of Disney Cruise Line's Twitter



Countries at a greater cultural distance from the USA and Canada, such as Japan and Argentina, tended to adopt unique hashtags such as "#bigger" and "#incluye," respectively.

Lasswell's verbal classic formula of communication theory – "who says what, how, and to whom" (Chandler, 1994) – was used for the three cruise lines. Applying the Lasswell's formula randomly to one of the individuals from the USA who posted on Disney, the results were: a young mother (between 25 and 35 years old), with high educational level, social media manager, retweeted a Disney communication post with a personal added content related to the memories of a previous experience and the hashtags #girlstrip and #disneycruise. This content was shared on Twitter with 10.9 K followers and generated a clout of 65.1.

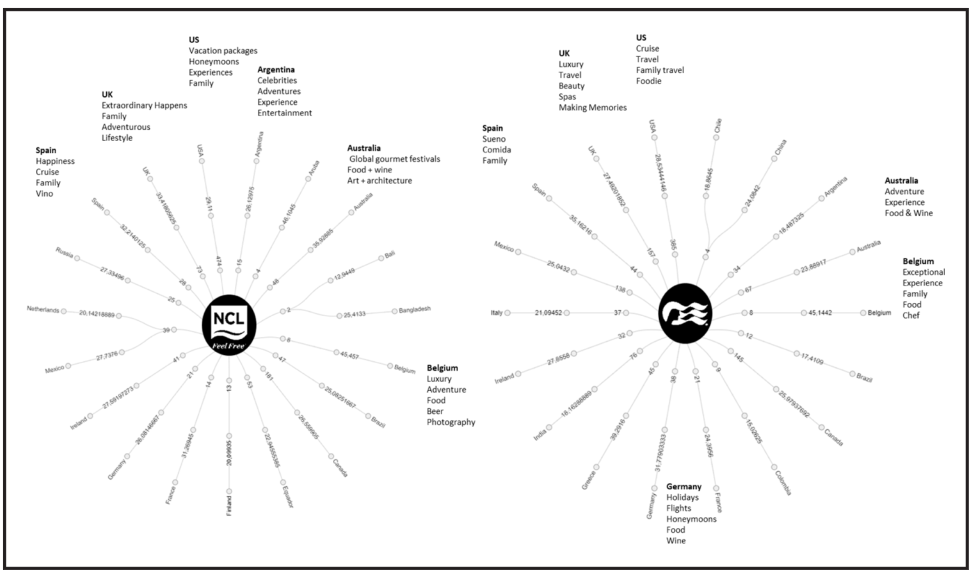
Examining the branches above shows that the number of members who post is not directly correlated with the average influence level; for instance, Figure 8 shows that, for Norwegian, four individuals from Aruba posted, but had an average influence of 46.10. The structures for the three cruise lines show that the keyword sets differ between each country. Such observations could not have been made using only the full graph visualization.

Applying Lasswell's formula randomly to one of the individuals from the USA who posted on Norwegian, the results were: a young girl (between 20 and 30 years old), with high educational level, fan of sports activities and pet lover, used the official Norwegian message and the hashtag "Out here, only the drinks are cold! #CruiseNorwegian" in a personal photo of her having fun while working in the cruise line. This content was shared on Twitter with 6,592 followers and generated a clout of 32.8.

In terms of analyzing the content of the comments from the users, we can highlight that "#family" is a regular hashtag in Disney comments, which is also used in the other networks, mainly by North Americans. Another hashtag with expressive use is related to "food&wine." "Experiences&adventures" are also key points used by users, regardless of the cruise line and country of origin.

In terms of interpretation, the contents that presented a higher use level by users can be used to enhance the companies' storytelling, reflecting unique bonds and experience

Figure 8 Graph analysis of Norwegian Cruise Line and Princess Cruise Lines' Twitter



promises. Furthermore, pieces of evidence point to the fact that employees also can be great marketers for the cruise line, as their posts can be seen as true storytelling.

One interesting finding concerns the average time to respond to users' posts (an indicator of the firms' interactive approach and engagement strategies). For Norwegian, this is approximately 5 h, with 5 p.m. Sunday being the most active time, whereas for Disney, the preferred time for engage with customers is approximately 3.30 p.m. Friday. This is important for firms to know so that they can post new content when people are most likely to see it, and supply customer service representatives when they are most needed. Adding to this, the bounce rate evolution, as well as the time spent on official websites, evidenced that customers are not willing to wait very long for feedback or update information.

4. Final considerations

The literature review shows that technology has transformed the tourism and hospitality industry (Leung *et al.*, 2013; Buhalis and Law, 2008); it allows firms to strengthen their relationships and communicate with customers, even as customers become more active in defining and communicating their tourism experiences (Baird and Parasnis, 2011). Users tend to buy experiences and to minimize their cognitive effort by listening to peers' comments and reviews on digital social networks (Neuhofer *et al.*, 2014).

In this context, social networking sites are becoming live-stream repositories of information – whiteboards on which tourists can post and search for information concerning travel (Liu and Park, 2015; Cheung and Lee, 2012). Tourism and hospitality firms have recognized the potential of social media, and have tried to adopt an active approach that enhances their customer orientation strategies. Despite significant research in this regard, however, few studies have analyzed the activity of cruise lines on social media (Park *et al.*, 2016; Gutberlet, 2016; Weeden *et al.*, 2011).

While exploratory in nature, this paper advances current knowledge regarding the presence of cruise lines in social media, by revealing the network structures and contents that are shared to promote and enhance the customer experience. Moreover, this is one of the first studies to explore experience co-creation from the cruise–tourism perspective and to identify related network structures, acknowledging the co-created content differences. Notably, in this work, we demonstrate the benefits garnered from an approach combining social network analysis with content analysis.

Furthermore, in terms of network structure, this study shows that social media communities and activities are not directly related to the traffic on official cruise line websites; the number of visitors is not proportional to the number of Facebook fans or Twitter followers. In addition, the number of fans cannot be considered as a reliable indicator of Facebook engagement – while Norwegian has the strongest Facebook presence, Disney has the most Twitter followers.

Moreover, considering the Twitter network structures of these companies, it can be seen that Norwegian and Princess display essentially the same intra-cluster structure; on the other hand, Disney has a less-structured network that features distinctive sub-groups. The Disney network structure also implies that using a combined storytelling and reaction-based communication strategy can lead individuals to co-create content, given that the Disney network exhibits a less-structured network, with thematic or content-driven sub-groups.

A fourth conclusion is that Facebook fans and Twitter followers belong to completely different communities, despite using some common hashtags, when the virtual community criterion from Patterson and O Malley (2006) described in the work of Kavoura and Borges (2016) is considered. Frequency analysis of words and hashtags presented some similarities with those reported by Park *et al.* (2016), reinforcing the conclusions of these authors.

Of the three companies, Disney has made the best use of the STAR model, adopting a multi-content brand-posting strategy and obtaining the highest levels of engagement with a relatively small number of posts. Moreover, their posts are being enhanced with personal content and shared by individuals with strong network connections.

The findings of the study show that cruise line social media posts, indeed, constitute a substantial part of the communication surrounding these firms on social media, thus playing an important role within this context. However, they do not produce all contents, leaving room open for tourists' own content creation. So, considering their network structure, marketers need to understand and produce contents targeting specific individuals to effectively compete with social media for tourists' attention, which by their network activity can enhance the communicational results.

Our results underline the need to adopt an active posture online, adapted for different markets to maximize customer engagement. Both Norwegian and Princess have relatively poor results in this regard because they concentrate on photos, which elicit few comments, tweets or retweets. In contrast, Disney has adopted a full STAR model strategy, also investing in movies and written content, and integrating different platforms.

In terms of managerial implications, cruise lines should place a higher value on co-creation and promote interconnectivity in their networks, taking advantage of the power of being trendsetters. In terms of contents to share, and considering the results found, developing short videos that become part of storytelling, and which can be shared across multiple platforms, would be helpful. The use of these media contents can enable cruise lines to expand their target markets into different countries, as these cruise lines are currently concentrated in the North American market.

Our results also show the need to offer content that appeals to specific target populations, especially women and children, as women constitute the clear majority of visitors to all of these websites. In the case of Disney, a large proportion of visitors access the site from schools; this suggests the need for a deeper analysis of posted content and viewer reactions. Therefore, further research should be conducted to uncover differences in the profiles of tourists within the cruise line community.

Considering the constant evolution of data across social media activity, these conclusions must be verified over time and analyzed using more systematic metrics.

Furthermore, social media and web-driven strategies must be closely monitored. Special attention should be given to the development of a hashtag–engagement dictionary that companies can use to generate automatically personalized responses. In particular, considering that, in some markets, Facebook and Twitter are relatively minor in the social network field, future research should consider social networks such as Badoo.

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Exploring the development of Malaysian seaports as a hub for tourism activities

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Abstract

Purpose – The purpose of this paper is to explore the prospects of Malaysian seaports as hubs for seaport tourism. This symbiosis nexus between seaports and tourism needs to be explored to provide a luxury economic growth. Combinations of these two segments are expected to explore a new market in Malaysian tourism industry.

Design/methodology/approach – A thorough case study consists of five major seaports in Malaysia including Penang Port, Port Klang, Port of Tanjung Pelepas, Kuantan Port, Bintulu Port and Kota Kinabalu; these seaports have been selected to reveal their opportunities for the prospect of Malaysian seaport tourism via spatial interaction model.

Findings – Four main components including cruise activities, support from intra-region and inter-region economic corridors and the seaport regionalisation can be integrated to reveal the capacity of Malaysian seaport to be hub for seaport tourism.

Originality/value – This paper incorporates tourism sector as one of the streams in the fifth-generation seaports. Seaports and tourism are two economic generators in Malaysia and infusion of these components is expected to enhance the economic prospect, diversify the function of seaports and reduce the over-dependence on conventional tourism activities.

Keywords Case study, Malaysia, Seaports, Tourism

Paper type Case study

Malaysian seaport systems

The location of Malaysia in the heart of Southern Asia, immediate borders with Singapore, Thailand and Indonesia, the exposure more than three quarters of it land mainly to the South China Sea Malacca Strait, surplus geo-economic advantages especially on nations resources, spatial, temporal, capital and market significantly emphasise the importance of seaports in the trade activities in this specific region. This has been further evidenced by the growth of the volume in trade by 1.5 per cent in this region from 1.463tn in 2015 to 1.485tn in 2016 (Malaysian External Trade Statistics, 2017). Malaysia is a focal location for international investment hub especially for international shipping companies such as China Shipping Group Company, Maersk Line and Evergreen. These mega carries corporations

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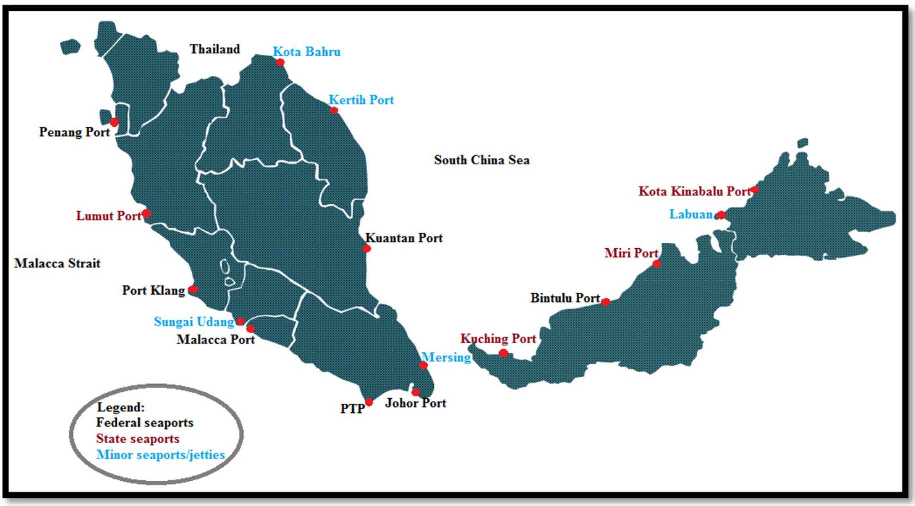
have and planning to invest in Malaysian main seaports including West Port (operator of Port Klang) as well as Port of Tanjung Pelepas (operator of Johor Port). This specific advantage determines the high dependency of its national trade and economy on maritime business. For example, volume of container freight handled in all main container seaports in 2013 was 329.9 million tonnes compared to 179.0 million tonnes in 2010 which shows the magnificent growth and dependency of seaports on sea-based freight (MOT, 2014).

In Malaysia, seaports are classified as federal seaports and state seaports. Port Klang, Penang Port, Johor Port, Kuantan Port, Bintulu Port and Malacca Port are categorised as federal seaports, while Lumut Port, Kota Kinabalu Port, Kuching Port and Miri Port are examples of state seaports (MIMA, 2014). In addition to federal and state seaports, there are also secondary seaports and jetties under the jurisdiction of the Marine Department and managed under the Merchant Shipping Act 1952 and owned and operated by oil companies, tourism sectors and fisheries sectors as indicated in Figure 1 (MIMA, 2014).

From the administration perspective, all federal seaports are governed by the Ministry of Transport (MOT) under the supervision of the Maritime Division. The state seaports are under the jurisdiction of the State Ministry (MIMA, 2015). Each federal seaport is assisted by terminal operators. For example, Port Klang Authority is assisted by West Port and North Port; Johor Port and Port of Tanjung Pelepas (PTP) are the operators for Johor Port Authority; there are two operators each assisting Penang Port Commission, Malacca Port Authority and Kuantan Port Authority respectively and one operator for Bintulu Port Authority. Seaport authorities play the role of regulator, supervisor and facilitator for the seaport operators' activities.

Tourism industry in Malaysia

In the current challenging lifestyle, stress has been emerged especially from the continues demand to meet basic needs, accelerating demand in the place of work as well as difficulties



Source: Adapted from MIMA (2014)

Figure 1. Location of various seaports in Malaysia

in the personnel relationships. According to Berno and Ward (2005) the development of tourism activities has been initiated to understand and attempted to reduce significant impact from the catastrophic demand in human life. In general, tourism can be defined as activities of people travelling to and staying in places outside their usual environment for leisure, business or other purposes for not more than one consecutive year (Tourism Society, 2017). Therefore, tourism has become a competitive and dynamic sector that entails the capacity of adaptability towards the changes in customers' demand, the level of satisfaction, availability of safety procedures and variations of enjoyment level among the tourist (Tourism Society, 2017).

Malaysia offers a wide range of cultural activities, natural heritage and leisure activity. As indicated in the Table I, based on the statistics from EPU (2016), total value of Malaysian Gross Domestic Product (GDP) showcases an increasing trend from 2007 (841.36bn) to 2015 (1,287.97bn). In general, however, the contribution of tourism industry in Malaysian GDP indicates the opposite trend compared to the value of the total GDP. In detail, the contribution of tourism industry in Malaysian GDP elicits the declining trend from 1.94 per cent in 2007 to 1.48 per cent in 2015. The contribution of tourism sectors has been encountered positive development especially in 2009, 2013 and 2015. On the other hand, changes of this industry have faced downfall especially on 2008, 2010, 2011, 2012, and 2014. In nutshell, the contribution of tourism sector in this region is not significant by the average contribution of this business is about 1.23 per cent every year.

Momentous innovation is required in tourism industry to ensure the contribution of this sector is equivalent compared to other industry such as mining and quarrying (MYR 98.2bn in 2016), agriculture (MYR 93.6bn in 2016), manufacturing (MYR 254.2bn in 2016), construction (MYR 50.4bn in 2016) and other services by MYR 594.0bn in 2016 (EPU, 2016). In comparison, total of tourist embarking and disembarking in Europeans seaports are more than 400m in 2016 (Eurostat 2017). However, in Malaysia, almost 6,841,493 passengers have been recorded at Malaysian seaports in 2016 (Malaysian Marine Department, 2017). Unfortunately, the trend of tourist handled in Malaysian terminals has been reduced substantially. For example, the number of tourist/passengers handled in 2010 was 18,968,152, then the volume started to decrease, fluctuate and drop significantly to 7,257,803 in 2015 (Malaysian Marine Department, 2017). Based on these circumstances, seaport tourism has been proposed as a new cluster in maritime business via this paper by revealing

Year (s)	Total gross domestic product (MYR billion)	GDP of tourism (MYR million)	Contribution of tourism in GDP (%)	Changes of the tourism in GDP (%)
2007	841.36	16.4	1.94	–
2008	1,003.33	12.7	1.26	−0.68
2009	879.22	13.4	1.52	+0.26
2010	1,108.57	13.1	1.18	−0.34
2011	1,295.18	12.7	0.98	−0.2
2012	1,366.58	13.0	0.95	−0.3
2013	1,405.26	13.7	0.97	+0.2
2014	1,687.07	14.2	0.84	−0.13
2015	1,287.92	13.5	1.04	+0.64
2016	1,211.94	13.8	1.13	+0.09
2017	1,285.51	13.4	1.04	−0.09

Source: Adapted from EPU (2018)

Table I.
Total revenue of Malaysian tourism industry (2007-2017)

the prospective in this region to enhance the contribution in the national GDP. Further, this paper will explore the opportunity to assimilate seaport and tourism sectors for a collective benefit to the nation.

Methodological approach

A thorough multiple case study will be employed as the research approach and content analysis will be executed among major seaports in Malaysia including Penang port, Port Klang, Kuantan Port and PTP in peninsular Malaysia and Bintulu and port of Kota Kinabalu in east Malaysia which have been selected for this research. Owing the capability to explore new phenomenon and reveal comprehensive descriptions on certain case and its analysis (Starman, 2013), a multiple case study approach has been employed in this paper. Multiple case study approach has been adopted in this paper to produce clear understanding on the phenomena. Further the application of this specific method is important to analyse the data within each situation and across the situation (Gustafsson, 2017). In this paper, the current understanding on Malaysian seaports needs to be explained and the potential of these nodes transforming onto tourism hub need to be explored. On the other hand, content analysis was used as tool for data analysis because of its ability to categorised, counted or measured any elements in text. For example, presence of certain words or expression, metaphors, arguments or the frequency of particular phenomenon is referred to (Boréus and Bergström, 2017). Hence, secondary data as well as primary data from face-to-face interview sessions will be used to extract themes to answer the research question about the potential of Malaysian seaport tourism in this paper. Participants for this paper have been selected from seaport authority (SA), Malaysian Marine Department (MD) and Ministry of Transportation (MOT). Interview sessions among these key players in Malaysian seaports and cruise industry were undertaken between 12 and 15 April 2017. Each interview session took between 90 and 120 min.

Nexus between seaports and tourism

The role of seaports has changed due to a globalised and deregulated environment (Robinson, 2002). Technological changes such as containerisation and the development of intermodal logistic have made seaports a node in the supply chain network. As a result, seaports have become a network-based entity (Hall, 2002). The network concept has pushed seaports to develop their relationship with their hinterlands and regions for a collective benefit. Further, European Commission (2009) indicates that climate attraction, culture, portscape and variation in seaport functions in seaports develop a mutualistic nexus between seaports and tourism.

The location of Malaysia in the equatorial region and covered by tropical rainforest climate become main reasons on the existence of hot and humid throughout the year. Port Klang and Penang Port which located in the west coast of peninsular Malaysia are exposed to typical tropical condition; hot, sunny and humid with showers all year round. The coastal zone is a major focus for recreation and additional economic activity (Sachs *et al.*, 2001). In contrast, Kuantan Port and PTP own wonderful beaches along the east coast with continue sunshine. In addition, the existence of several islands such as Redang and the Perhentian Islands increase the demand of cruise activities at these seaports.

All Malaysian festivals and celebrations have their own tradition culture every religion kept for future generations. Tourists, passenger and crew of vessel who berth at seaports especially at Port Klang, Penang Port, PTP, Kuantan Port and Bintulu Port can take this opportunity to explore and enjoy new culture exist in this region.

Portscape is defined as the ’overall visual impression of the built environment and nature scenery at seaports’ (Kato, 2014, p. 105). Therefore, the seaport and harbours in this region can be used as a marketing/promoting tool for boosting the regional economic development. This strategy provides tourist, passenger or the vessel crews access to the seaports especially to enjoy the view of waterfront.

The variation of seaports function as river and barter trade seaport in Malaysia indicates the ability of this node for multitasking. River port is used for facilities that handle river traffic especially at Rajang River at east Malaysia (Kader, 2014). The flow of this river crossing Brunei, Sabah, Sarawak and Indonesian enhances the attractiveness for freight and tourist accessibility. On the other hand, barter trade generally refers to trade activities between opposite shores of the Straits of Malacca. Barter trade recorded 84,000 vessels in Malacca straits from 2004 until 2010, contributing approximately 18-24 per cent of the total trade in Malaysia (Jeevan *et al.*, 2015). In addition to Port Klang, Penang Port and PTP, Malaysian minor ports such as Port Dickson, Muar seaport and federal seaports such as Malacca port are involved in barter trade between Thailand, the Philippines and Indonesia (Rusli, 2012). Hence, the variation of seaports functions in the river freight activities and barter trade can be used for passenger or tourist handling terminal to boost the tourism sector in the nation.

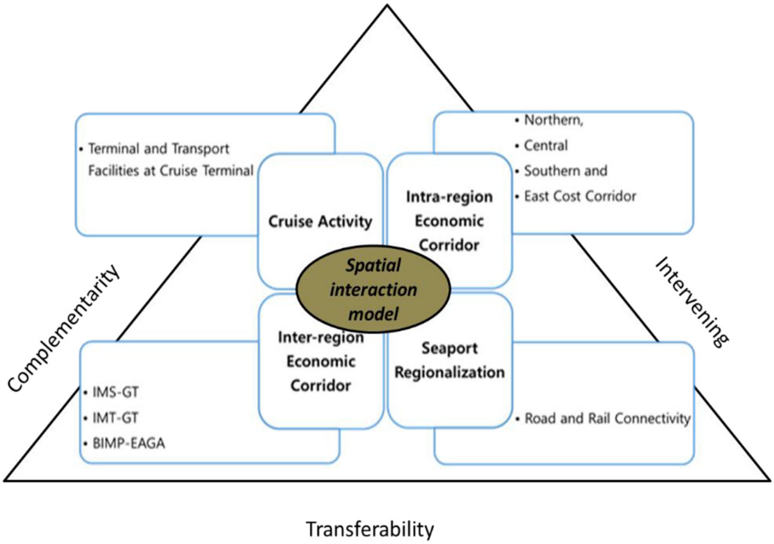
Spatial interaction model in Malaysian seaport tourism: an evaluation of the prospect

Seaport tourism is referred to tourism activities in specialised seaports (Jugovic, 2006). The respective seaports need to be equipped with modern built, customs and immigrations procedures, organised facilities, equipment and activities for accommodation, location and maintenance of craft for nautical tourism, updated facilities with the purpose of providing relevant services to tourist in various activities and leisure navigation on sea, excursion activities to surrounding prominent and distinguish locations and restaurants to be involved in the seaport tourism.

The spatial interaction model is a model that normally applied in various fields including trade, leisure activities and tourism. According to Rodrigue (2017), a spatial interaction is a realised movement of people, freight or information between an origin and a destination. This model focuses on tourism flow between or within the regions (Khadaroo and Seetanah, 2008). The potential of each seaport to become a hub for seaports tourism are revealed according by incorporating spatial interaction model between cruise activities, economic corridors and penetration of seaport via seaport regionalisation (Figure 2). This figure depicts the potential opportunities own by Malaysia seaport tourism especially for commuting the tourist within and between the countries.

Spatial interaction model is effective to explore, analyse and explain flows of people, goods or information over space. Therefore, it has been widely used to analyse migration flows, freight transport flows and trade flows (Kerkman *et al.*, 2017). In addition, this model may analyse the influence of spatial characteristics and characteristics of the transport network simultaneously (Bates, 2000). In general, spatial interaction models are formulated to predict flows of goods, information or person between zones. In this paper, the application of this model will be used to predict the movement of tourist from point of origin to point of destination. There are there main components involved in spatial interaction model including complementary, transferability and intervening (Rodrigue, 2017).

These three main pillars will be used to determine the efficiency of this model in Malaysian seaport system by including distance of the location (complementary), travelling cost (transferability) and accessibility (intervening). Hence, in this paper, all these



Source: Authors

Figure 2. Mapping the prospect of Malaysian seaport tourism via spatial interaction model

components will be integrated in Malaysian seaports to explore the possibilities the emergence of seaport tourism.

Based on the requirements for seaport tourism activities, it can be concluded that seaport activities are not limited to the sea-based activities but extended towards the inland. Therefore, the prospect of Malaysian seaports to transform into tourist-based seaports will be evaluated from four main scope including cruise activities, support from intra-region and inter-region economic corridors as well as the evolution of seaport regionalisation. Although Malaysia has developed its own cruise seaport, this paper will evaluate the prospect of Malaysian seaport to become a hub for seaport tourism. This because, the limitation at cruise seaports encourages the cooperation of this cruise seaports with Malaysian container seaports to develop as major hub for seaport tourism. In detail, this paper reveals the limitation of Malaysian cruise terminals and discloses the prospect of Malaysian container seaports to be tourism hub. The following section reveals all components that has been proposed in spatial interaction model to boost seaport tourism in Malaysia. These components are including cooperation with cruise activities, inter/intra-regions economic corridors and seaport regionalisation.

Cooperation with cruise activities

Maritime Division also coordinates the development of cruise tourism, especially in the development of cruise infrastructure at each destination in Malaysia to achieve international standards as outlined in the Cruise and Ferry Integrated Seaport Infrastructure Blueprint for Malaysia (MOT, 2017). Cruise Tourism is one of the National Key Economic Area (NKEA) with the aim to increase the number of tourists to Malaysia. Currently, there are only a few dedicated cruise terminals located in Penang, Langkawi, Port Klang, Malacca, Sabah and Sarawak. In Penang terminal, there are four berths actively operated with 10.5-meter draft and total 730 metres length. The trend of passenger cruise in Penang terminal is increasing from 132 in 2013 to 145 in 2015 (Table II).

In the Tenth Malaysia Plan (2011/2015), the Malaysian government decided to invest a massive amount of money to upgrade the capacity of seaports. This important decision has been made because Malaysian seaports will face tremendous constraint in terms of their capabilities in handling surplus containers from 2016 onwards (Containerization, 2016). However, the utilisation of vessels in berth in Port Klang, Johor, Kuantan and PTP are underutilised. For example, the difference between berth capacity and ships call per day at Port Klang, Johor seaport, Kuantan seaport and PTP are six, three, seven and four vessels respectively. On the other hand, Penang seaport has recorded overcapacity at its berth whereby the number of ships call was higher than berth capacity (Table III).

Table II.
Description and statistics of passenger cruise in Malaysia (2013-2015)
T- terminal

No.	Location	No. of berths	Draft (metre)	Berth length (metre)	Year 2013	Year 2014	Year 2015
1	Swettenham Pier Cruise Terminal, Penang	4	10.5	T1-220 T2-190 T3-180 T4-140	132	137	145
2	Langkawi, Kedah	2	11	T1-178 T2-145	58	43	80
3	Boustead Cruise Centre, Port Klang	3	14	T1-438 T2-195 T3-210	102	97	137
4	Kuching, Sarawak	6	8.5	T1-100 T2-100 T3-100 T4-100 T5-100 T6-100	6	8	6
5	Malacca	2	3	T1-40 T2-40	45	46	49
6	Kota Kinabalu, Sabah	12	9.6	Average between 120-350	16	25	31

Source: MOT (2017)

Table III.
Utilisation of berth capacity in Malaysian seaports

Malaysian sea ports	Average ship calls per year (2010-2015)	Average ship calls per day (A)	Berth length (meter)	Berth capacity ship/day (B)	Berth utilisation (A-B)
Port Klang	17,031	47	15,600	53	−6(underutilised)
Penang	6,505	18	16,200	6	+12(overutilized)
Johor	4,350	12	4,474	15	−3(underutilised)
Kuantan	2,384	7	4,013	14	−7(underutilised)
PTP	4,812	13	5,040	17	−4(underutilised)

Source: Adapted from Othman *et al.* (2016)

Although berth capacity has outgrown the number of ships calls per day and become a major obstacle in Malaysian seaport performance, this situation can be converted to improve the berth utilisation by allocating the berth in those seaports for cruise and passenger vessels. Therefore, the tourism sectors especially at the seaport area and the utilisation of the berth in those seaports can be amplified significantly. Despite of leaving berth at seaports remaining underutilised, it will be appropriate to integrate the seaport tourism with seaports in order promote this upcoming industry as well as enhancing berth utilisation at seaports.

To improve the utilisation of seaports, one of the participants (SA), emphasised that "seaport authorities need to improve the seaport marketing strategy". This participant also added that, "seaport marketing is crucial to improve seaport tourism activities". Further, this participant also said that the "involvement of ministry of tourism at seaports is essential to promote tourism activities at this area as well as increasing the berth utilisation at these seaports". Currently, there are many passenger vessels berth at Port Klang, however, the passenger in those vessels face many difficulties and due to the delay caused by the immigration's clearance procedure. In norm, the participant (MD) mentioned that:

> [. . .] cruise vessel only berths one day at the seaports. The delay caused by the immigration procedures restricting the pleasure that tourists supposed to enjoy in the seaport area as well as in the inland. As a consequence, the passenger needs to return to the jetty by 7 pm for the departure.

This indicates that delay in the documentation clearance affecting their pleasure and shortening the time that they have to adore the great scene, food and entertainment in inland of port of call.

To improve the immigration procedures, a participant (SA), has suggested that:

> [. . .] the immigration procedure shall take place in the vessels rather than at port of call. This procedure improves the efficiency of immigration clearance as well as enhancing the satisfaction of the passenger at the port of call.

Although, these two participants provide substantial strategies to improve seaport tourism in Malaysia, one of the participants (MOT) declared that "Malaysian seaports are not suitable to be transformed into tourism hub". This participant is very vigilant towards the safety aspect at the seaport terminals in which the environment surrounded with large and dangerous equipment and exposure to high-risk environment reducing the potential of Malaysian seaports to be hub for seaport tourism. Hence, this participant added the:

> [. . .] preparation of local seaports with specialised passenger terminal which away from cargo handling equipment, separate passenger enter/exit gate and guided by highly trained workforce will reduce the risk among the passenger at seaports and enhancing the potential of these venue to be hub for tourism activities.

The content in Table IV indicates the overview of present cruise terminal in Malaysia. Based on this table, all five cruise terminals are well connected to the major place of interest. Moreover, cruise terminals at Klang and Penang are filled by sufficient terminal facilities. On the other hand, cruise terminals at Kuantan, Bintulu and Kota Kinabalu are not fulfilled by complete terminal facilities. In addition, in term of transport facilities, all cruise terminals need to be provided prior notice before berthing and no berthing facility provided in Bintulu cruise terminal. These conditions limit the marketability of Malaysian tourism industry in selective area. Therefore, all the underutilised seaports as shown in Table III can be used for the berthing of cruise vessels and at the same time enhance the popularity of those places for tourism activities.

Table IV.
Overview of Malaysian terminal and transport facilities at cruise terminals

Cruise seaports	Klang	Kuantan	Penang	Bintulu	Kota kinabalu
Place of interest	Petronas Twin Towers, National Museum, Merdeka Square, KL Tower, KL Bird Park, Kuala Lumpur Craft Complex, Royal Selangor Visitor Centre, Putrajaya, Carey Island, Batu Caves, Little India and Klang	Lake Chini, Teluk Chempedak and The Great Mines of Sungai Lembing	Penang Hill, Cheong Fatt Tze Mansion, Fort Cornwallis, Pinang Peranakan Mansion and Penang National Park	Pantai Tanjung Batu, Similajau National Park, Kuan Yin Tong Temple, Kampung Jepak and Longhouse and Council Negeri Monument -The Birth Place of the Sarawak Legislative Council	Tunku Abdul Rahman Park, Kota Kinabalu, Poring Hot Springs, Ranau, Kinabalu Park, Kundasang, Mari Cultural Village Inanam and Gaya Street (Sunday Market)
Terminals facilities at cruise seaports					
Terminal building	Yes	No	Yes	No	Yes
Covered walkway	Yes	No	Yes	No	No
Tourist information centre	Yes	No	Yes	No	No
Transport facilities at cruise seaports					
Distance from pier to nearest town centre	Port Klang-13km and Klang - 20 km	28 km	1 km, located in George Town itself	10 km	1 km
Walking distance to Town	No	No	Yes	No	Yes
Shuttle buses required to access town	Yes	No	No	Yes	No
Distance from ship to bus pick-up point	200 m	100 m	200 m	100 m	100 m

(*continued*)

Cruise seaports	Klang	Kuantan	Penang	Bintulu	Kota kinabalu
Name of nearest airport	KLIA and KLIA 2	Sultan Ahmad Shah Airport	Penang International Airport	Bintulu Airport	Kota Kinabalu International Airport
Distance to airport	75 km	36 km	20 km	28 km	Terminal 1 - 8 km Terminal 2 - 7 km
Approximate travelling time to airport (without traffic)	60 min	40 min	40 min	30 min	15 min
Guaranteed berthing for cruise ships	Yes, prior notice	Yes, prior notice	Yes, prior notice	No	Yes, prior notice

Sources: Ministry of Tourism and Culture (2016); Compiled by Authors

Table IV.

Support from intra-regional economic corridors

There are four major freight corridors in peninsular Malaysia, namely Northern, Central, Southern and East coast freight corridors. Each freight corridor incorporates several economic development plans initiated by the Malaysian government. Each development plan is designed for a specific region, i.e. North, Central, South and the East coast of peninsular Malaysia (Table V).

In the North corridor, Penang Port is the main gateway to serving all regions of northern peninsular Malaysia, including Southern Thailand. To connect these hinterlands, there are two main dry ports involved, namely, Padang Besar Cargo Terminal (PBCT) and Ipoh Cargo Terminal (ICT), which are located 150 km and 181 km from Penang Port, respectively (Chen *et al.*, 2015). This corridor uses multimodal transportation connecting different transport nodes and hinterlands, including road and rail, in particular the Malaysian Thailand land bridge (MTL), thereby providing substantial benefits in freight transportation efficiency (Ngah, 2010). Rail links in this freight corridor contribute almost 80 per cent of the container transportation in the nation (Malaysian Railway, 2016). However, because of having no railway linkage of passenger jetty at Kuala Kedah, this has limited the potential of Kuala Kedah to develop as significant tourism seaport hub. In addition, the northern freight corridor also includes Penang Island. Other than by ferry, the link connecting Penang Port to Penang Island is the Penang Bridges. With the opening of the

Economic corridors	Northern corridor	Central corridor	Southern corridor	East coast corridor
Regional development plan	Northern Corridor Economic Region (NCER)	Central Corridor	Iskandar Malaysia (IM)	East Coast Economic Region (ECER)
Government authority	Northern Corridor Implementation Authority (NCIA)	Government of Malaysia	Iskandar Region Development Authority (IRDA)	East Coast Economic Region Development Council (ECERDC)
Started (year)	2007	1991	2006	2007
Objective (s)	World-class economic region	Equitable growth and economic development	Sustainable metropolis of international standard	A developed region-distinctive dynamic and competitive
Radius of coverage	17,816 square kilometres	15,033 square kilometres	22,874 square kilometres	66,736 square kilometres
State of coverage	Penang, Kedah, Perlis and Perak	Negeri Sembilan, Selangor and Kuala Lumpur	Johor and Malacca	Pahang, Kelantan and Terengganu
Focus industry	Agriculture, human capital, infrastructure, manufacturing, logistic and tourism	Human capital, infrastructure, manufacturing, service sector, agriculture	Educati on, financial health care, ICT, creative industries, logistic , and tourism	Agriculture, education, manufacturing, oil, gas, petrochemical, and tourism
Expected employment (million)	3.1	9.8	1.4	1.9
Expected investment (USD billion)	55	559	118	35

Source: Adapted from Jeevan (2017)

Table V.
An overview of intra-region corridors in Malaysia

second Penang Bridge in 2014 and the expansion of lanes for the first bridge from four to six has improved the connectivity for the northern freight corridor as well as improve the number of tourists to and from Penang Island. Therefore, the development rail linkage, introduction of second bridge in Penang Island has great possibility to enhance the seaport tourism especially in Kuala Kedah and Penang Port.

The Central Corridor which has developed significantly following the introduction of the New Economic Development Policy in 1991 is the key economic development region for Malaysia (EYGM, 2014). It has been equipped with well-developed industrial parks, highways and rail infrastructure which are opportunities for effective operations of the seaports. This freight corridor is supported by the development plans NCER, East Coast Economic Region (ECER) and the Indonesia-Malaysia-Thailand-Growth Triangle (IMT-GT) which generate more freight for this corridor. Some of the attractive places at the central region such as Petronas Twin Towers, National Museum, Merdeka Square and many other places are central for tourist. Central corridor is equipped with a major seaport, Port Klang, as well as dry ports and inland clearance depots, and multimodal transportation to undertake the freight task are well equipped with road and rail transportation. Hence, all passengers from Port Klang can use these transport facilities to enjoy the view at the above-mentioned venue.

In the Southern freight corridor, the seaport PTP is the main gateway to serving all regions in southern peninsular Malaysia including Singapore. PTP is connected by three main dry ports including ICT, Segamat Inland Port (SIP) and Nilai Inland Port (NIP), with their locations ranging from 188 kilometres to 551 kilometres from this seaport (Chen *et al.*, 2015). Road and rail networks are used to undertake the freight task along this freight corridor (Humphries, 2004; Ngah, 2010). This freight corridor is connected by rail links to all hinterlands except Malacca and Singapore because there is no rail link to these regions (Chen *et al.*, 2015). Additionally, this freight corridor is equipped with the North-South Expressway which connects all states in west coast peninsular Malaysia with Singapore (PLUS, 2011). Therefore, the availability of PTP at this corridor enhances the tourist to travel from Malaysia to Singapore and vice-versa. In that case, the availability of sufficient road and rail network in southern economic corridor enhances the number of passengers from Malaysia have a great opportunity to travel to Singapore and enjoy their holidays in these two different nations.

In the Eastern Corridor, there locates some of the attractive tourist venues including Lake Chini, Teluk Chempedak and The Great Mines of Sungai Lembing, Cameron Highlands. Although extensive road connectivity is available along this corridor, the absent of rail link limits potential venues to be explored especially in Terengganu and Kelantan which are main tourist spot in this corridor. According to participants from MOT and SA:

> [. . .] the poor coverage of rail links in this corridor left cruise terminal in Kuantan are underutilised as well as reducing the profits to this particular seaport and hindering the tourism industry to contribute significantly to Malaysian GDP. However, the development of East Coast Rail Link (ECRL) which connects all states in east coast region including Port Klang may enhance the prosperity of tourism sector in this region.

Support from inter-regional corridors

The strategic location of Malaysia presents an opportunity for involving neighbouring countries in freight corridors to amplify its economic progress. There are three (3) inter-regional freight corridors involving Malaysia, Thailand, Singapore, Indonesia and Brunei. These include the Indonesia-Malaysia-Thailand Growth Triangle (IMT-GT), Indonesia-

Malaysia-Singapore Growth Triangle (IMS-GT) and Brunei-Indonesia-Malaysia-Philippines-East Asian Growth Area (BIMP-EAGA).

IMT-GT is a sub-regional economic development plan established in 1993. Its intention is to facilitate and promote trade among the members, strengthen the infrastructure linkages to support the integration of IMT-GT sub-regions, develop human resource competencies and enhance public-private sector collaboration (IMT-GT, 2012). Almost US$5,218m has been invested in these three countries for main sectors such as transportation, trade, agriculture, food, tourism and human resource development (Rahim *et al.*, 2014). Malaysia and Thailand use the Malaysia-Thailand Land bridge which operates two trips every two months (Chen *et al.*, 2015). As well as the land bridge system, manufacturers from Thailand also use the highway network from Padang Besar–Bukit Kayu Hitam–Penang Port–Port Klang. In Malaysia, this IMT-GT has potential to improve cross border tourist movement between Malaysia, Thailand and Indonesia. The cooperation with Thailand and Indonesia provides transport facilitation for passenger mobility across those regions. The northern region of Malaysia has strong potential to generate a high volume of tourist from this network which will be beneficial for Malaysian GDP because of its location adjacent to the southern Thailand and Indonesia. Therefore, the seaports available in this sector especially Penang Port and Port Klang have a great advantage and manage to provide significant connection for the leisure activities to the tourist in the future.

IMS-GT was initiated by Singapore in 1990 to enhance cooperation between Indonesia, Malaysia and Singapore. This collaboration has invested almost US$27.7m in these three countries, especially for the development of transportation equipment (Sparke *et al.*, 2004). This cooperation has generated more investment in southern Malaysia whereby many investors invest in industrial estates, improving industrial facilities, and encouraging the dispersal of new industries to rural areas. Moreover, the establishment of IMS-GT has improved the availability of quality labour by developing a new training institute, increased transport infrastructure, enhancing tourist activities, and streamlined the customs procedures for freight transportation between these three regions (Humphries, 2004). Currently, Malaysia and Singapore are connected via the North-South Highway First Link and the Malaysia-Singapore Second Link respectively (PTP, 2015). In future, the development of the Singapore-Kunming Rail Link will be the pioneer project which will improve rail freight connectivity between Malaysia and Singapore (ASEAN, 2011). IMS-GT attempts to harmonise and simplify the rules and regulations relating to land laws, labour market policies, cross border procedures and other formalities to improve and increase the attractiveness of these regions to foreign investors (Humphries, 2004; Sparke *et al.*, 2004). In addition, seaport such as PTP and Port Klang including Kuantan Port may take a great advantage to improve their tourism services in their particular seaports.

BIMP-EAGA is the current collaboration between Brunei, Indonesia, Malaysia and the Philippines which was initiated by the Philippines in 1992 (Annuar, 1994). The main focus of this collaboration is on transport and shipping services, tourism and fisheries cooperation (Annuar, 1994). Therefore, the mechanism for the BIMP-GT implementation is by facilitating free movement of goods within the participating countries, sharing common facilities and implementing appropriate economic development activities in each region (Ishak and Kasim, 2004). Moreover, the availability of Pantai Tanjung Batu, Similajau National Park, Kuan Yin Tong Temple and many other places (Ministry of Tourism and Culture, 2016) at Bintulu and Kota Kinabalu provide attractions for domestic and international tourist. In that case, seaports at east Malaysia including Bintulu and Kota Kinabalu seaports may take additional advantages from this economy growth to improve the tourism sectors in east Malaysia. A participant from MD indicates that “the availability of attractive places will be a great boost for the emergence of seaport tourism activity and increasing fascinating roles of seaports in our country".

Connections between Anyport model, seaport regionalisation and tourism

The Anyport Model indicates three major stages of seaport development including setting, expansion and specialisation (Bird, 1984). At the setting stage, a seaport depends mostly on geographical factors. It is a key element of urban centrality and is classified as operating in isolation and performing as an interface between hinterland and foreland (Notteboom, 2000). During seaport expansion, the hinterland connection starts to develop to ease the proportional growth in maritime traffic. The integration of rail links with the seaport terminals are required to enable the seaport to access the inland area (Bird, 1984). During seaport specialisation, numerous opportunities are created for other users to use the seaport's facilities such as housing and commercial development (Bird, 1984). The outcomes from global containerisation and intermodalism result in seaports becoming dynamic leading nodes in distribution networks. Notteboom and Rodrigue (2005) added an additional stage "regionalisation" into the Anyport Model, and it has attracted the role of inland terminals in seaport development (Monios and Wilmsmeier, 2011). Seaport regionalisation is the development of a seaport incorporating the support of a freight distribution centre, and it ultimately leads to the formation of a regional load centre network.

Seaport regionalisation represents a different dimension in seaport development whereby the efficiency of a seaport system is determined by the integration of the inland freight distribution system. Since a seaport represented a physical and functional link between the logistics and transportation networks, it needs to meet certain requirements in intermodal and landside links such as to access infrastructure and connectivity with the economic system of the hinterland (Sanchez and Tuchel, 2005). The existence of a intermodalism via dry port provided infrastructure and connectivity from seaports to hinterlands. It also improved the physical and functional link between transportation networks in various locations. The evolution of Anyport model and regionalisation indicated the intermodalism is the key component which distinguishes between these two stages. Moreover, the availability of intermodalism also encourages the development of multimodal transportation along the economic corridor. However, in this region, the level of regionalisation is not even compared to east and west coast of peninsular Malaysia. This has been evident by the absence of interstate and intrastate railway linkages in peninsular and east Malaysia. Therefore, the limited coverage of seaport regionalisation prevents the land transportation options to the passenger/tourist to enjoy the beauty of Malaysia. In addition to that, a participant from SA reveals that "limited access to the inland from seaports limit the progress of tourism sectors and preventing the development of seaport tourism industry in Malaysia". Based on this statement, it is understandable that limited transport connectivity between inter and intra states affecting the complementary, transferability and intervening during the accessibility from seaport towards inland and vice versa.

In general, seaport regionalisation comprises six main themes including innovative, accessible, safe, sustainable, workable and enterprising (Notteboom, 2006). In that case, introduction of tourism activity in seaports enhances the concept of sustainability, innovative and enterprising concept during its operation. However, the limitation of Malaysian seaport especially on railway and road connectivity to and from seaport and hinterland reduces the impact of Malaysian seaport tourism activities on these three main themes. Hence, to ensure the effectiveness of seaport regionalisation on each theme, the connectivity to and from seaports need to be improved.

Implication and conclusion

This paper has revealed the potential capacity of Malaysian seaports to become hub for tourism activity. Therefore, four main components including cruise activities, support from intra-region and inter-region economic corridors as well as the evolution of seaport regionalisation have been selected to evaluate the capacity of Malaysian seaport to be hub for seaport tourism. Firstly, underutilised condition of Malaysian seaports provides a great potential to channel the cruise activity towards the seaports. Through the inter-port cooperation between commercial seaport and cruise terminals as emphasised in the Malaysian Port Authorities Act (2006), the seaport capacity, space as well as the facilities can be optimised to increase the number of cruise passenger in each terminal. Secondly, the existence of intra-region economic corridor which consists of northern, central, central and east coast economic corridor provided linkages of seaports to and from hinterland in each corridor. Therefore, the capacity of seaports to include another function in their cluster which is tourism can be executed via the linkages of seaport and hinterlands.

There are significant advantages and disadvantages gained by incorporating tourism in the seaport system. Firstly, this incorporation may improve the efficiency of the underutilised berths in Port Klang, Johor, Kuantan or PTP port in Malaysia. Seaports can raise funds by charging for berths in ports or at regulated anchorages or providing services for the cruises and passengers. In wider terms, it can be said that with the assist of tourism activities, there will be more opportunities for finding employability and making the profit in the areas nearby the ports. Hence, the innovation of seaport adapting the tourism via spatial interaction model may increase the profitability of the seaports as well as the attraction of these seaports among their clients from either inland or foreland.

However, on the contrary, tourism also can bring some predicaments for seaports. First, negative influence is reflected in excessive crowds caused by many unregulated vessels on the water side or unregulated vehicles on the land side. Consequently, the quality of environment around and inside the seaports could be affected and polluted. The pollution can be generated from unusually crowds in the ports and the waste amount will be increased if the tourists are unaware. In addition, the noise pollution will be high due to the unusual appearance of the visitors. Another effect is that while the port has huge space with containing many bulky equipment and dangerous operating activities requiring high safety attention, the appearance of the tourists may compromise the maintenance and safety at the port. Therefore, to overcome the disadvantages that affect the incorporate the tourism in the seaports, the government should develop specific, detailed policies focussing on tourism.

Currently, the contribution of tourism activities on Malaysian GDP is not significant. Hence, the infusion of tourism in the seaport operation may provide a great contribution on Malaysian revenue. Therefore, the introduction of seaport tourism as a new cluster in Malaysian maritime sector may develop a new insight for our economic development. As a platform for future research, the impact of seaport tourism in Malaysian economy and the preparation of Malaysian seaports to develop a new cluster which labelled as seaport tourism are worth to be explored. In conclusion, the incorporation of tourism in seaport activities may provide a new dimension of development especially in regional, seaport, infrastructure, connectivity development which will be channelled to the national economic growth.

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Sentiment analysis for cruises in Saudi Arabia on social media platforms using machine learning algorithms

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Abstract

Social media has great importance in the community for discussing many events and sharing them with others. The primary goal of this research is to study the quality of the sentiment analysis (SA) of impressions about Saudi cruises, as a first event, by creating datasets from three selected social media platforms (Instagram, Snapchat, and Twitter). The outcome of this study will help in understanding opinions of passengers and viewers about their first Saudi cruise experiences by analyzing their feelings from social media posts. After cleaning, this experiment contains 1200 samples. The data was classified into positive or negative classes using the choice of machine learning algorithms, such as multilayer perceptron (MLP), naıve bayes (NB), random forest (RF), support vector machine (SVM), and voting. The results show the highest classification accuracy for the RF algorithm, as it achieved 100% accuracy with over-sampled data from Snapchat using both test options. The algorithms were compared among the three different datasets. All algorithms achieved a high level of accuracy. Hence, the results show that 80% of the sentiments were positive while 20% were negative.

Keywords: Sentiment analysis, Social media, Machine learning, Artificial intelligence, Cruise, Tourism

Introduction

Social media has undergone significant development in recent years; thus, a huge amount of information is in circulation. Various websites have been developed through which users can express their opinions and share their content. This is especially the case with the expansion of social networks (blogs, forums, and social media) in which the content is usually subjective and loaded with opinions and ratings. This kind of information can be very useful for recommending products or brands [1]. First, there is Twitter, which is a microblogging service that allows small blog posts called Tweets to be sent and received [2]. Second, Snapchat is a mobile messaging app for sharing temporary photos and videos called Snaps that disappear after viewing [3]. One of Snapchat's most important features is the Snap Map that displays a real-time location for anyone who submits a snap to the map. The third platform is Instagram, which is commonly used to post photos and videos in order to share them with followers who can comment on or 'like' these posts. Social media provides an enormous amount of data. As a result, there is a need for data mining, which enables analysis of social media data and user sentiments by seeking their opinions on specific topics Saudi Arabia presented plans to change the course of its tourism sector through the development of Vision 2030 that was announced on 25 April 2016 by Crown Prince Mohammad bin Salman [4]. One of these plans is to invest in tourism by launching various events to attract visitors. Some of these events are unprecedented for the Saudi population, as they have been offered for the first time. For the first time, by offering tourist visas, Saudi Arabia was opening its doors to visitors from many countries. Saudi Arabia received 24,000 international visitors during the first ten days of applications for immediate tourist visas [5]. This study aims to analyze passengers' and viewers' opinions to see if the pandemic effects on the economy about cruise entertainment, which is the first of its kind in the Kingdom of Saudi Arabia [6, 7]. The sentiment analysis (SA) process is the systematic identification, extraction and quantification of affective states and subjective information using natural language processing [8]. It was made by starting with the collection of opinions as textual data from several social media platforms. The platforms used are Instagram, Snapchat and Twitter, because of their popularity in Saudi Arabia [9].

The opinions of this Red Sea Saudi cruise were analyzed and classified into negative and positive classes. To the best of our knowledge, this research is one of the few studies that classifies emotions by applying machine learning (ML) algorithms to Arabic datasets. This is because of the difficulty of finding logical results and the need for longer pre-processing steps. Furthermore, this study was launched during the Covid-19 pandemic. We study the quality of the sentiment analysis by various ML algorithms for the three selected social media platforms. Five of the most popular ML algorithms were applied: multilayer perceptron (MLP), Naıve Bayes (NB), random forest (RF), support vector machine (SVM), and the voting ensemble algorithm. These algorithms were used to classify opinions about the cruise. Each algorithm relies on a unique method for making predictions. Likewise, ML algorithms were chosen due to the size of the dataset. Finally, a comparison is made to evaluate the efficiency of these models in classifying textual data in the Arabic language.

The remaining of this paper is divided into five sections: "Literature review" section covers related work on SA in tourism. Next, the proposed techniques in this paper are presented, followed by the empirical and experimental studies, after which the results are discussed. Finally, the conclusion is presented along with ideas for potential for future work.

Literature review

In this section, a literature review of the relevant research is provided. The research is summarized and classified based on the platform type used.

Instagram

In [10], the authors searched for a study of criteria for expressing feelings on social media, especially on Facebook, Twitter, Instagram and WhatsApp, and compared their efficacy for expressing six separate feelings. Through the analysis of the samples and the procedures, the results for expressing negative feelings show WhatsApp to be most suitable, followed by Facebook, Twitter, and Instagram. In order to ex- press positive feelings, perceived suitability was highest for WhatsApp, followed by Instagram, Facebook and Twitter. The system only provides a comparative analysis among these four platforms. In another study [11], the authors addressed the problem of predicting the success of music albums by investigating various data sources from social media to mainstream American newspapers. The principal technique applied was the RF approach, which predicted results with an accuracy of 94%. There are limitations regarding the shortness of the data collection period, which is only one month. In [12], the authors explored the use of Instagram to promote tourism destinations in Indonesia. By exploring users' perceptions using in-depth conversations and interviews with visual styles and image-induction techniques, they tried to describe the potential value of Instagram for promoting tourism sites in Indonesia. They found everyone tried to promote their own cities in their own ways, with Instagram providing complete communication facilities from tourism brands to allow user-generated photographic content. The search was limited only to the Instagram platform's contribution to the development of tourist destinations.

Snapchat

In recent research [13], the authors investigated data posted to our story on the Snap Map. They collected photos and videos, and applied statistical and deep learning techniques to SA. The data were gathered during three events in Riyadh Tourist Season. Their results indicated the capacity for SA through Snapchat. The authors of [14] analyzed combined data from a questionnaire, Snapchat, and Google Maps. They looked into lexicon-based and ML approaches. The research results revealed that celebrities on Snapchat impact people's choices of restaurants. In [3], the authors researched how US media uses Snapchat to reach young audiences. The chief technique applied was interviews and content analysis. The principal result showed that publishers on Snapchat Discover are embracing the capabilities of Snapchat, and adapting media types and story themes using visuals. Results also showed that the media retains its own character in judging the news. The system only dealt with the use of Snapchat Discover. Piwek and Joinson [15] ran an online survey using the memory sampling method to inquire into details of a recent photo sent by every Snapchat participant. Results showed that they already share 'avatars' and 'creative logo graphics', and often use them at home mainly as an easier and more fun way of reaching friends. In [8], the authors performed SA on social media textual data as a rich source of opinions. These textual views were classified into four categories based on their level of extremeness: low, high, moderate and neutral. To classify the data, multinomial NB and linear SVM classifier algorithms were used. The results showed that the SVM algorithm was the most accurate classifier with an accuracy of 82%.

Twitter

In [16], the authors analyzed tweets collected in the Arabic language and compared different algorithms using SA with different n-grams as a method for feature extraction. The performance of the algorithms was evaluated by measuring accuracy, precision, recall, and f-measure. The result showed a 99.96% accuracy with unigram.

Also, Heikal et al. [17] explored a deep learning model for application to Arabic data in order to improve the accuracy of Arabic SA. The fundamental techniques were CNN and long-term memory models. The major result of this study was that the model achieved an F1 score of 64.46%, which outperformed the modern deep learning model's F1 score of 53.6% for the Arabic sentiment dataset. The system was limited to analyzing sentiments from Twitter data only. In [18], the authors conducted an SA of social media. They applied the NB method and Google Prediction API. The accuracy achieved and the macro-F-measure were 90.21% and 89.98%, respectively. The main finding evaluated the classification performance by comparing it with predictions of the winner of the 2016 US election. However, only Twitter data were used. Furthermore, the authors looked at and discussed social media analysis using Twitter data relating to cruises, representing it in three categories of user group: commercial, news/blogs, and private [19]. Block analysis was the key method used after using three distinct techniques: word repetition, content analysis, and network analysis. Results showed tourists are less influential than celebrities, and celebrity influence is one of the marketing strategies that is relied upon nowadays. The data collection period was short, and sadly, the analysis remains mainly exploratory for this reason. In [20], the authors proposed hybrid algorithms to discover people's opinions from their Twitter posts. The primary technique, the polarity classification algorithm, contained three stages for classifying 2,116 tweets into positive, negative, or natural groups. The central finding was that this achieved a greater accuracy than other algorithms for the same dataset. The paper evaluated the algorithm by using different metrics, although the authors did not indicate the keywords or the data collection period. In [21], the authors conducted SA of tweets to understand of the effect of the COVID-19 pandemic on the cruise industry, and mined semantic time-series data from social media. They computed the adjusted sentiment score for each tweet posted between 1 February and 18 June 2020. The main finding was that there are two groups, with the first suffering from quarantine and limits on travel because of COVID-19, making them even more eager to travel and explore, and the second, interested in cruise tourism possibly shifting from mass cruises to niche cruises.

Other social networks

In a recent paper [22], the authors analyzed reviews on the TripAdvisor website. They applied multi-classification to get high performance of the SVM algorithm, NB oversampling, Word2vec, and Knowledge Graph. The best result achieved was a recall of 0.901. As for places, the Tower of London was the best. Banati et al., [23] analyzed the emotions expressed by users about their experiences while traveling. Opinion mining was applied to reviews from the TripAdvisor website which were extracted using a web crawler in Python. The extracted reviews were classified as positive or negative at different levels: document level, sentence level, and feature/entity level. Classification for multiple entities at the document level could not be linked under the same category. In addition, they evaluated the performance of seven ML algorithms, such as RF, RT, NB, and OneR. The best accuracy achieved was for RF at 88.25%, while OneR provided the lowest result, with an accuracy of 68.1%. In addition [24], the authors considered the problem of the glut of information on the Internet discovered while mining reviews from travel blogs. They applied NB and SVM, with the main finding being that the SVM model with N- gram achieved excellent results. However, the system only dealt with the use of sentiment classification for reviews.

Brida et al. [25] considered the experiences of passengers on cruises and their features. The main technique applied was a decision tree (DT), with the authors analyzing data from 1361 responses collected through a questionnaire over three months in 2009. The main finding for the applied DT was an accuracy of 67.6%. However, the authors observed that the lower the characteristics were, the more accurate was the prediction. The paper does not consider different types of evalu-ation nor comparison of algorithms. In study [26], the authors focused on the SA of multilingual textual data from social media to discover the intensity of the sentiments for extremism. They proposed a manual method that effectively found extreme sentiment from multilingual data by creating a new multilingual lexicon or dictionary. Experiments were performed for supervised and unsupervised algorithms. The greatest accuracy achieved for SVM supervised was 82%, while for KNN unsupervised, the best accuracy was 26%.

In [27], the authors presented a data-driven approach to analyze data about trips from location-based social networks (LBSN). The study aimed to discover the mobility pattern for how tourists would travel the world. Moreover, they presented two applications to use the data from each trip. First, travelers were clustered in terms of the Twitter and Foursquare datasets, which obtained three clusters for Twitter and six for Foursquare. The second application area was the spatial clustering of destinations throughout the world. They identified 942 regions as destinations that can be directly used in a regional model for a destination recommender system. However, the results might have been affected by travelers' continuously location- sharing their LBSNs, resulting in out-of-date datasets from Foursquare and Flickr. Table 1 shows a summary of the relevant studies. It is clear from the literature review that there are many studies in the SA field that have reported useful results. Nevertheless, the literature lacks comparative studies that use different social media platforms to analyze tourist impressions of new tourism events. A comparison of the performance of ML algorithms is made among several popular algorithms, such as MLP, SVM, RF, NB, and Voting based upon their accuracy rates. The experiment is tested using 10-fold cross-validation with the 70% split test option.

Description of proposed techniques

This section is concerned of with describing the implemented algorithms MLP, SVM, RF, NB and Voting.

Multilayer perceptron

The MLP algorithm was introduced by M. Minsky and S. Pappert in 1969. This algorithm consists of a neural network that contains multiple layers of nodes. The layers are subdivided into three categories: input layer, hidden layers, and output layer. Furthermore, this algorithm processes data by passing it from the input layer to the hidden layers, and up to the output layer to obtain the classification results [28]. Figure 1 shows the grid configuration of the algorithm, explaining the connections and nodes between the layers.

The input data is fed into the input layer and the extracted data is delivered to the output layer. The hidden layers are layers of nodes between the input and output

Table 1 Summary of previous studies

References	Data source	Method	Domain	Language	Size of data
[10]	Instagram, Twitter, Facebook, WhatsApp	Analysis and procedure	Emotion	Dutch	1201
[11]	Instagram, Twitter, Facebook	RF	Music	English	86 albums
[12]	Instagram	Dialogues, interviews	Tourists	English	–
[13]	Snapchat	Deep learning	Tourists	Arabic	–
[14]	Snapchat	Lexicon, ML	Economic	Arabic	1435 restaurant-goers
[3]	Snapchat	Content, Interviews	News	English	726 snaps
[15]	Snapchat	memory sampling	SA	English	online survey
[8]	Snapchat	NB, SVM	SA	English	textual data
[16]	Twitter	ML	SA	Arabic	151,500 tweets
[17]	Twitter	CNN, LSTM	SA	Arabic	–
[18]	Twitter	NB, Google prediction API	SA	English	120,000 tweets
[19]	Twitter	Word frequency	Tourists	English	42,785 tweets
[20]	Twitter	PCA	SA	English	2116 tweets
[21]	Twitter	lexicons	Tourists	English	53,546 tweets
[22]	TripAdvisor	SVM	Tourists	English	Reviews
[23]	TripAdvisor	ML	Tourists	English	2116 tweets
[24]	Online reviews	ML	Tourists	English	–
[25]	Questionnaire	DT	Tourists	English	1361 responses
[26]	Social media	NB, SVM	SA	English	2500 web pages
[27]	Social media	ML	Tourists	English	942 Regions

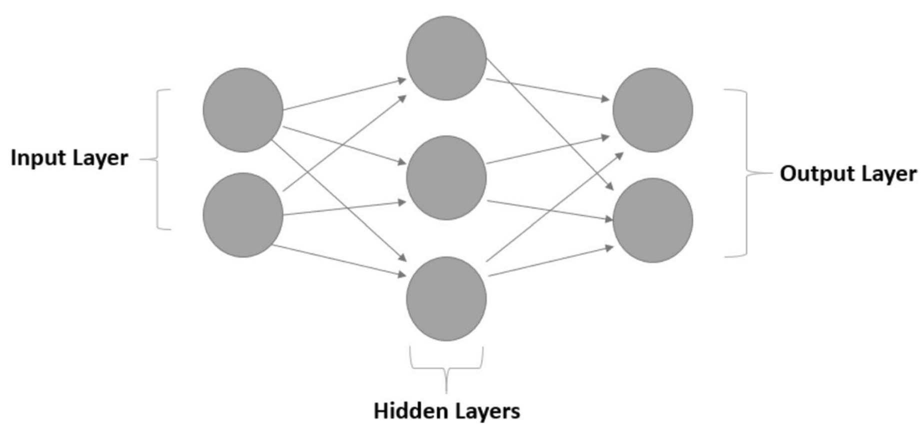

Fig. 1 MLP Algorithm flowchart

layers, and there may be one or more of these layers, which perform non- linear transformations on the inputs entered into the network. They are layers of mathematical functions, each designed to produce an output specific to an intended result. The connections between the layers are called weights (W), which are normally defined between 0 and 1. The output value of each neuron is calculated in two subsequent stages as follows. In the first stage, the weighted summation of the input values is calculated using the following Eq. (1):

$$\forall l \in \{1,2,\ldots,j\}, h_l = \sum_{i=1}^{m} W_{il}^{H} Ii + \beta_l^{H} \quad (1)$$

where Ii is the input variable i, W_l^H. Is the connection weight between i input neuron and the hidden neuron l, m is the total number of inputs and β_l^H is the bias of the *lth* hidden neuron. In the second stage, the output value of each neuron in the hidden layer is calculated based on the weighted summation using an activation function, as in Eq. (2):

$$\forall l \in \{1,2,\ldots,j\}, H_l = sigmoid(h_l) = \frac{1}{1+e^{-hl}} \quad (2)$$

The final output is calculated as in Eqs. (3) and (4) [29]:

$$\forall k \in \{1,2,\ldots,n\}, o_k = \sum_{i=1}^{l} W_{ik}^{o} Hl + \beta_k^{o} \quad (3)$$

$$\forall k \in \{1,2,\ldots,n\}, o_k = sigmoid(o_k) = \frac{1}{1+e^{-o_k}} \quad (4)$$

Naive Bayes

NB is a method that uses knowledge of statistics and probabilities and depends on the implementation of Bayes theory. Figure 2 shows how the probabilistic model provides the probability distribution of an instance over a set of classes. In addition, C is the instance where X1…Xn are the classes, and each probability should be calculated with all classes. This model is the opposite of the deterministic model that only outputs whether or not an instance belongs to positive or negative classes [30].

The mathematical expression for Bayes' theorem [30] is as follows in Eq. (5):

$$P(A|B) = \frac{P(B|A)\cdot P(A)}{P(B)} \quad (5)$$

is given in Eq. (5) above. In the NB classifier, all attributes are separated to provide the value of the class variable (depending on independence), as in Eq. (6):

$$P(F|C) = P(f_1,f_2\ldots f_a|c)_i^n \pi P(f_i|c) \quad (6)$$

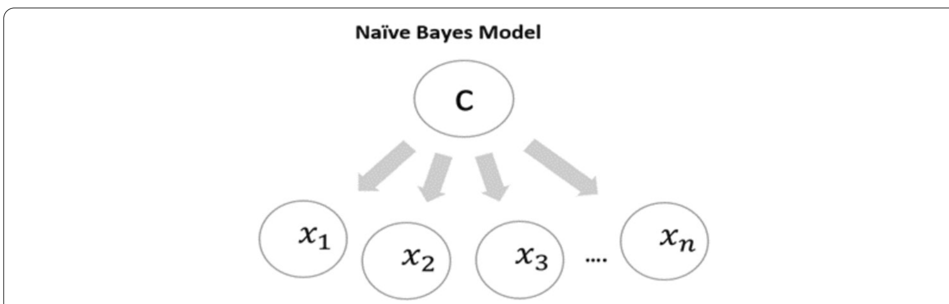

Fig. 2 NB Algorithm flowchart

This algorithm is the easiest and fastest of the Bayesian models [30]. It matches the estimation of the kernel density where it can attain higher levels of accuracy. It works by assuming that all the attributes are independent and affect the results separately [31]. However, this classifier is highly scalpel, requiring several linear parameters for the variables.

Random forest

RF is an ensemble classification method. It is designed as a series of classifiers that take a vote on their forecasts in order to classify the data [32]. These classifiers are tree-structured and randomly divide each node between the subsets of the predictors by taking the best-case scenario [33]. In addition, the trees grow using a random set of features. Figure 3 shows the structure of a RF. The trees run in parallel with no interaction between them. During training time, the algorithm immediately constructs several decision trees, picking a random point k from the training set of data points. After that, the first and second steps are repeated by selecting the number of trees, N, that are needed. Ultimately, each of the N-tree trees predicts the value of the output, y, for the data points.

The process is repeated with new data points, then the average value is taken and assigned as the predicted value, y.

Support vector machines

SVM is a supervised learning algorithm that is mathematically well-founded [32] and is similar to logistic regression. Figure 4 shows how the algorithm works by dividing the

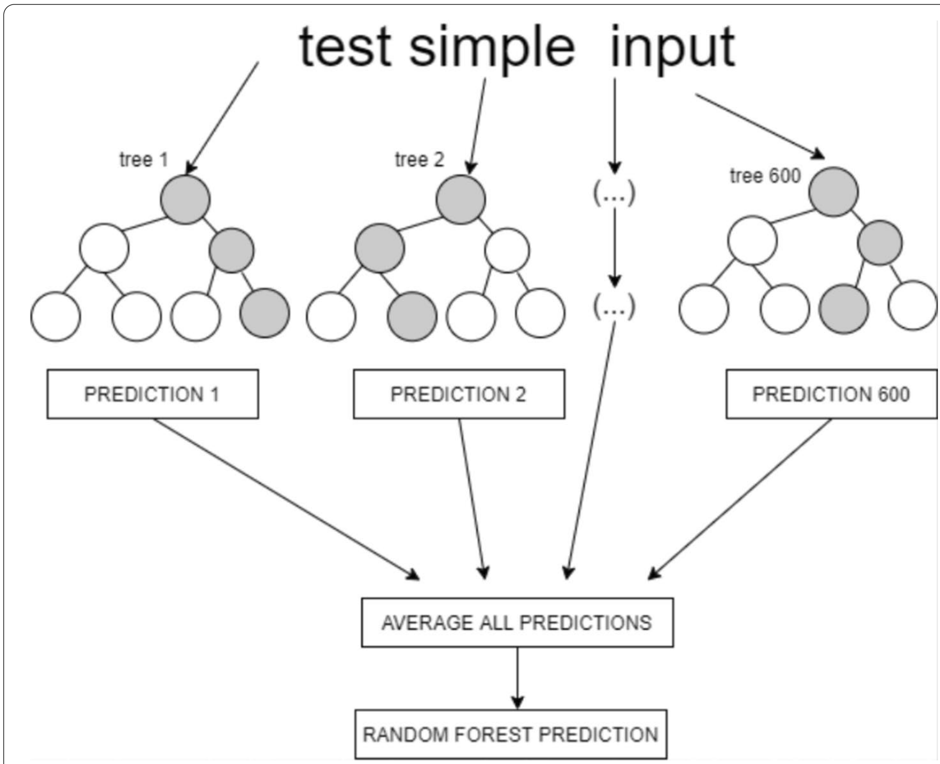

Fig. 3 RF Algorithm flowchart

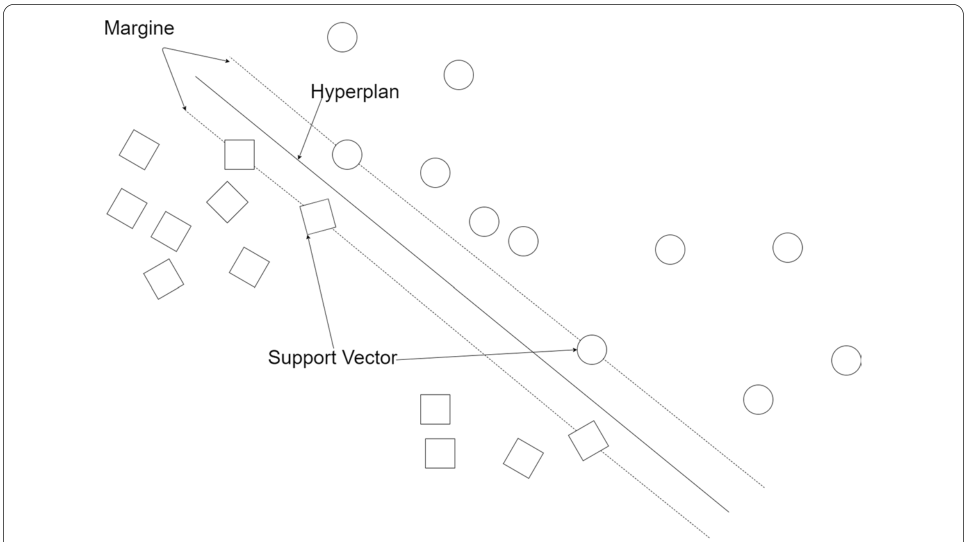

Fig. 4 SVM Algorithm flowchart

sample into two classes by separating the hyper-plane. Furthermore, the few samples at the margin call, support vectors. The distance between the hyper-plane and all training points is called the margin. SVM is recommended to be used in linear model problems. However, one type of SVM, kernel theory, is used to solve nonlinear problems. Linear, polynomial, radial basis function kernels are given in Eqs. (7), (8) and (9) respectively. Linear kernel:

$$k\left(x_i, x_j\right) = x_i^T x_j \tag{7}$$

Polynomial kernel:

$$k\left(x_i, x_j\right) = \left(1 + x_i^T x_j\right)^p \tag{8}$$

Radial Basis Function kernel:

$$k\left(x_i, x_j\right) = e^{-\frac{\left\|x_i - x_j\right\|^2}{2\delta^2}} \tag{9}$$

Voting

Ensembling is a method that uses multi-label algorithms together to classify and predict classes. This method is used to optimize the performance obtained from each learning algorithm separately [34]. Furthermore, there are many types of ensemble learning, such as bagging, bootstrapping, stacking and voting [35]. Ensemble voting is used by meta-classifiers to combine ML algorithms by summing the predictions or averaging the predictions made by regression models [36]. Moreover, this classifier is used to aggregate the classes of weak algorithms [37, 38]. Figure 5 shows how this technique sums each classifier with its predicted probabilities to be combined with other classifiers, taking the average for better results.

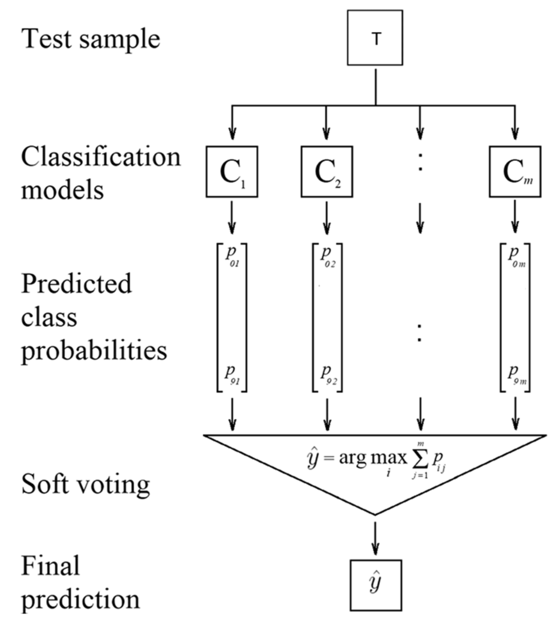

Fig. 5 Voting Algorithm flowchart

Finally, the Voting algorithm follows the principle given in Eq. (10) [34],

$$\hat{y} = \arg\max i \sum_{j=1}^{m} w_j p_{ij} \tag{10}$$

where w_j is the weight to be assigned to the j classifier.

For binary classification task with class labels, example i $∈ $0, 1

Methodology

This section presents the methods and tools used for data collection and mining from the social networks Instagram, Snapchat, and Twitter. Figure 6 shows the framework for the data mining process, beginning with collecting data from the three platforms, then extracting it, and finishing with the classifying and predicting process.

Description of dataset

After collecting the data, several features were selected to create a database: gender, text, and class. Table 2 shows the type and utility of each property. The features were chosen according to the content available on each social media platform, in order to compare them.

Experimental setup

In this study, the performance of the implemented ML algorithms is experimentally assessed experimentally, and a comparison is made between five ML algorithms: SVM, RF, NB, MLB, and Voting. The algorithms are applied to the extracted textual data, which is written in Arabic. In addition, the algorithms are tested using the Waikato Environment for Knowledge Analysis (WEKA), applying 10-fold cross-validation and a 70%

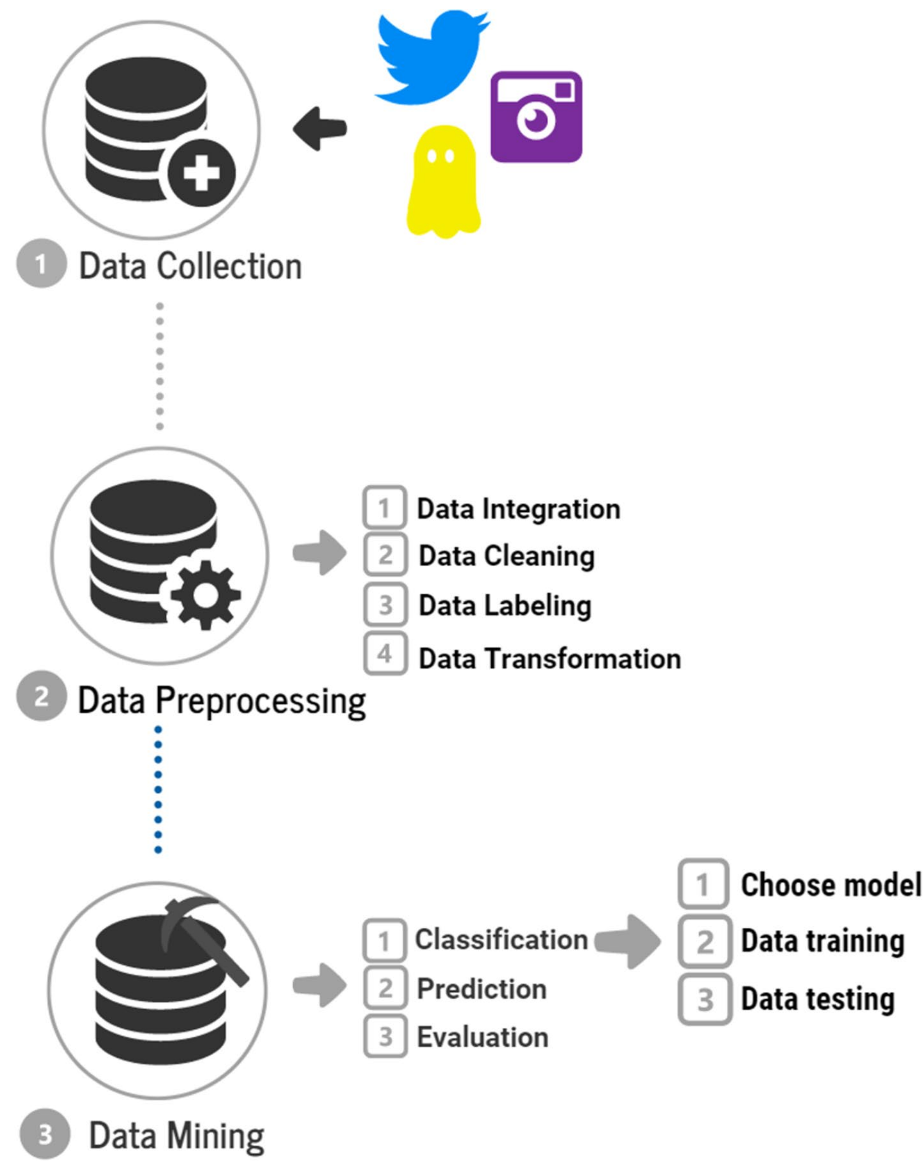

Fig. 6 The data mining process framework

Table 2 Describe each feature

Feature	Type	Description
Gender	Nominal	This column contains a classification of user gender. It contains the two values "F" for a female and "M" for a male. The value is obtained by noting the account name, image displayed, or from the textual data in the contents of the posts
Text	Nominal	This attribute holds values made of strings that have been filtered and converted into vector words. The content of the column is useful for classifying opinions as positive and negative terms are inferred to arrive at the classification decision, whether negative or positive
Class	Nominal	This column is concerned with the results of the instance classification. Class is represented by two nominal values: positive rating and negative rating. The classification result is inferred by analyzing the words and expressions used in the text column

split as evaluation measures on all imbalance sampled, over-sampled and under-sampled data [39].

Cross-validation is a method for evaluating predictive models that divide the original sample into a training set and a test set for training and evaluating the model. Figure 7 depicts the data partitioning in ten folds, which implies that the entire data was randomly partitioned into ten parts, nine of which were used to train the model and one used for testing. After that, the process was repeated ten times, with the error being determined each time. The mean of the errors created in each iteration will be the model's total error [39]. Another way to split the dataset is directly in this research adopted 70% as training dataset and the rest of dataset to testing.

Data collection

We collected data from different platforms: Instagram, Snapchat and Twitter, from the start of September to the end of October. These platforms were chosen because of their diversity. Through Snapchat, we track the status of tourists in real time, and analyze their feelings by sharing their snaps in Snap Map. Twitter and Instagram were chosen to analyze the comments of tourists and non-tourists by watching the event, and also to compare these different platforms in Sentiment Analysis using ML algorithms. Also, these three applications are the most used in Saudi Arabia, according to what was published by the global media insight [9].

We collected snaps from Snap Map API. The data collection was a real-time process during each trip. The process started with downloading snaps, both pictures and videos, using Python source code. After that, we separated each snap into three layers: textual data, visual content and audio files. The audio files were converted into text using the speech-to-text Python library. The extracted data were recorded in a database file containing snap data from specified map locations in order to build the dataset. On the

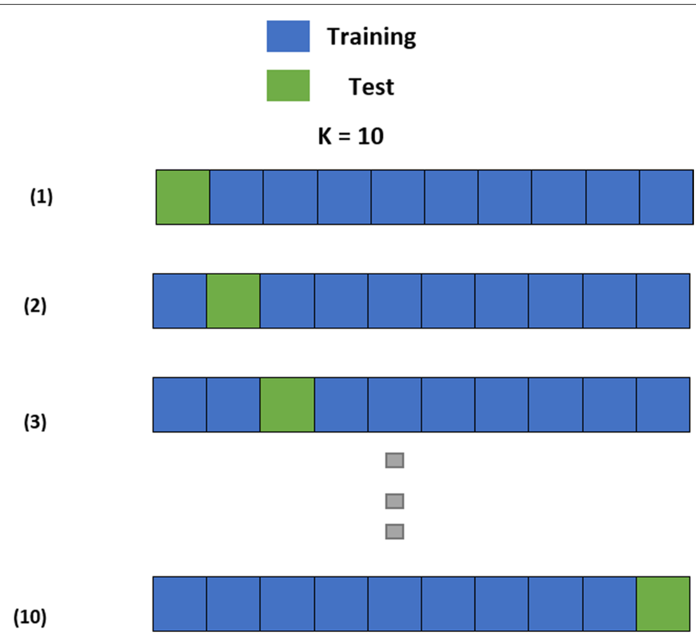

Fig. 7 K-fold Cross-Validation

Table 3 Number of datasets before and after pre-processing stage

Platform	Before	After
Instagram	7538	514
Snapchat	1932	284
Twitter	1452	462

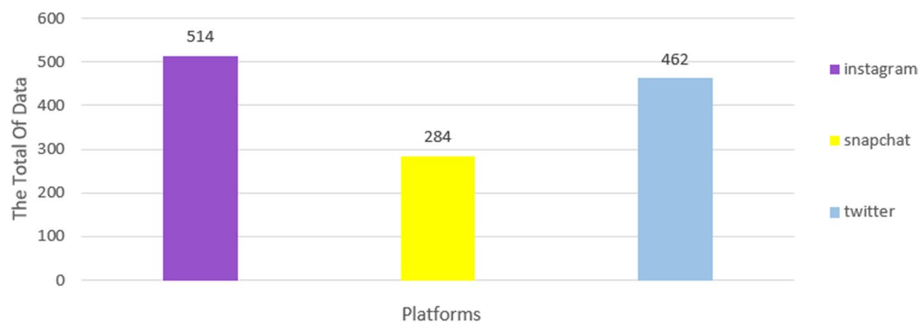

Fig. 8 The total of dataset

Twitter platform, we collected the relevant tweets using the Rapid Miner tool to pull out data using keywords. On the Instagram platform, we collected all posts that were either pictures or videos and their comments using hashtags and place tags with the Instaloader tool. Textual data was then manually extracted from these pictures and videos. The keywords used to gather data from Twitter and Instagram were: 'cruises', 'Red Sea', 'trip', 'prices', and 'tourism'.

Pre-processing

After collecting the data, pre-processing was applied to clean the data of noise. This is the most important factor that can make a difference between a good ML model and a poor one. It attempts to fill in missing values and to smooth out the noise in data. Table 3 contains the sample in the dataset before cleaning and after for each platform.

One of most interesting findings was that interaction on the platforms was highest on Instagram, followed by Twitter, then Snapchat as presented in Fig. 8.

Missing data

- Ignore the attribute: ignore the attribute such as nationality, because it contains several rows with null values
- Fill in a missing value manually: in the case of the categorical feature column, we consider missing data as a new category in itself by replacing the missing values with 'NA' or 'Unknown' or some other relevant term such as gender column.

Noise

Noise is slightly erroneous data observations that do not comply with the trend or distribution of the rest of the data. Though each error may be small, noisy data collectively results in a poor ML model. Noise in data can be minimized or smoothed out by removing the items listed below:

- Arabic diacritics.
- Repeated letters such as "Noooo".
- Any irrelevant data.
- Numbers such as "123".
- Elongation.
- Punctuation marks such as $". ! ?-_*[]:;/() "$.
- Focusing on Arabic data and deleting any other language.

Labeling

This section describes the data, called annotation or tagging. This is the process of preparing labeled datasets for ML. Data samples were detected and tagged to establish a foundation for reliable learning patterns. ML systems often require massive amounts of data based on data features that help the model organize the data into patterns that provide an answer. We conducted SA on the sample and labeled it manually as 'y', referring to positive sentiment, and 'x' referring to negative sentiment. After collecting data from the three platforms, Instagram, Snapchat and Twitter, we configured a separate dataset for each. A total of 10,922 instances were obtained from all platforms and reduced to 1200 after cleaning. In addition, data analysis results show that most of the sample opinions studied were positive about the Saudi Cruise experience. The numbers of positive opinions totaled 342 out of 514 for Instagram users, 256 out of 284 for Snapchat users and 260 out of 462 for Twitter users. This represents 858 positive opinions from the total for all platforms. Figure 9 illustrates the variation of opinions on the three platforms. The results from the data analysis show that the majority of passengers' opinions were positive about their cruise experience.

Feature extraction

The n-grams applied by using WEKA refer to a neighboring sequence of n words in a text string, with particular words known to be unigrams (1-g), and n- grams of higher order corresponding to all possible contiguous substrings of length n words that can be constructed from a string. Because of their inherent simplicity, n-grams are a desirable option. An n-gram model can capture more context simply by increasing n.

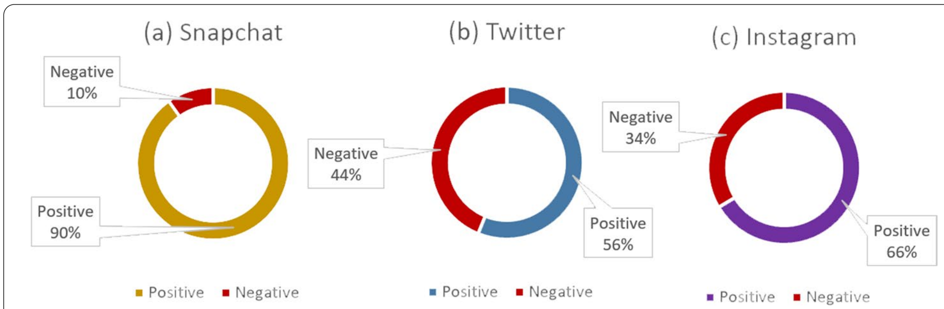

Fig. 9 The percentage of positive against negative opinions in all platforms

Table 4 Number of positive and negative sentiment when data re-sampling

Platforms		Number of positive (y)	Number of negative (x)
Instagram	Imbalance	342	172
	Over-sampling	342	342
	Under-sampling	170	170
Snapchat	Imbalance	256	28
	Over-sampling	256	256
	Under-sampling	28	28
Twitter	Imbalance	260	202
	Over-sampling	260	260
	Under-sampling	200	202

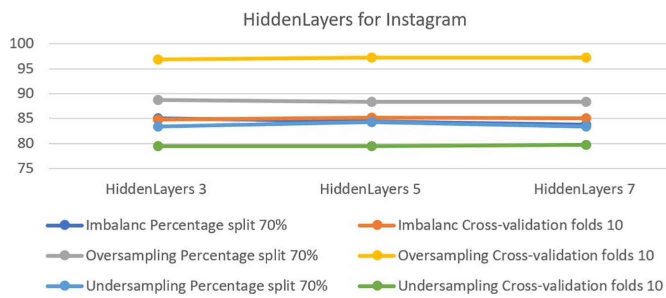

Fig. 10 The accuracy of hidden layers for MLP in Instagram

We hypothesized that the addition of n-gram characteristics would allow a classifier to learn richer representations of the underlying text data, and contribute to a concomitant improvement in the output of classification and useful analysis of sentiment.

Data transformation to address imbalance in datasets

Imbalances in data are one of the common problems in classification. This phenomenon is increasing in importance since it is faced in natural data domains when the number of samples is unequally distributed between classes by a large ratio. In order to solve such imbalances, a dataset needs to be re-sampled using under- sampling and over-sampling. Under-sampling focuses on the majority class by re- moving samples in order to balance with another class. Conversely, adding samples to the minority class is called over-sampling [40]. Table 4 shows the number of positive (y) and negative (x) opinions in the dataset in terms of imbalance, under- sampling, and over-sampling for all platforms.

Optimization strategy

Multilayer perceptron

In the MLP model, there is a parameter that allows some changes in the hidden layers when changed to 3, 5 and 7. Moreover, the accuracy changes in some datasets. As shown in Fig. 10, which compares hidden layers in the Instagram dataset, the effect of increasing the number of layers is to improve the accuracy. It achieved 85.21 in hidden layer 5 in the dataset with imbalance and cross-validation, which was higher than in hidden layer 3. Also in the over-sampled dataset with cross- validation, it achieved 97.22 in

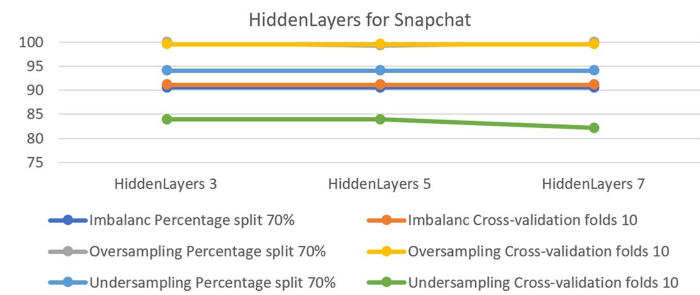

Fig. 11 The accuracy of hidden layers for MLP Snapchat

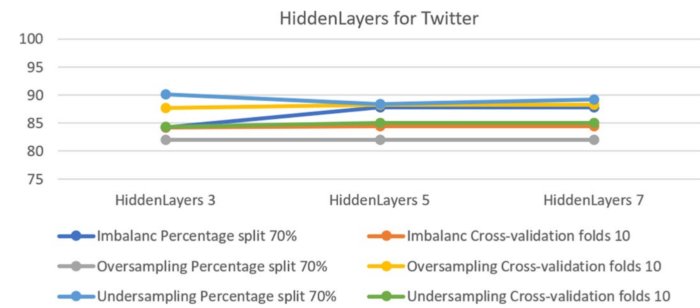

Fig. 12 The accuracy of hidden layers for MLP Twitter

hidden layers 5 and 7, the best accuracy for this algorithm. For the under-sampled dataset, meanwhile, with percentage 70% split, the best result was in hidden layer 5, achieving an accuracy of 84.31%.

On another platform, Snapchat, there was no change in the imbalance in both tests; all results were equal. However, for the over-sampled dataset hidden layers 3 and 7 gave the best accuracy of 100% with 70% split. In the under-sampled dataset the results were equal except in hidden layer 7, which achieved 82.14% in cross- validation. Figure 11 shows the results obtained from the experiment.

The next platform is Twitter. Figure 12 shows that the best results for the dataset with imbalance are 87.77% in both hidden layers 5 and 7 with percentage 70% split. For the over-sampled dataset, the cross-validation test achieved 88.27% in both hidden layers 5 and 7. For the under-sampled dataset, the best accuracy of 90.08% was in hidden layer 3 with a 70% split.

In the MLP model, some parameters did not enable the model to operate properly. These parameters are 'nominal to binary filter', 'normalize attributes' and 'normalize numeric class'. Changing the setting from true to false allowed the model function correctly. Table 5 summarizes the optimal parameters for both 10-fold cross-validation and a 70% split.

Naive Bayes

In the NB model, the parameter that makes changes is useKernalEstimator, when it is changed from 'false' to 'true'. Moreover, the accuracy changes in some datasets. Figure 13 compares the experimental parameter using the Instagram dataset and shows

Table 5 Optimal parameter for MLP model

Parameter	Platform	Under-sampling		Over-sampling		Imbalance	
		Fold 10	70%	Fold 10	70%	Fold 10	70%
HiddenLayers	Instagram	7	5	5	3	5	3
	Snapchat	3	3	3	3	3	3
	Twitter	5	3	5	3	5	5

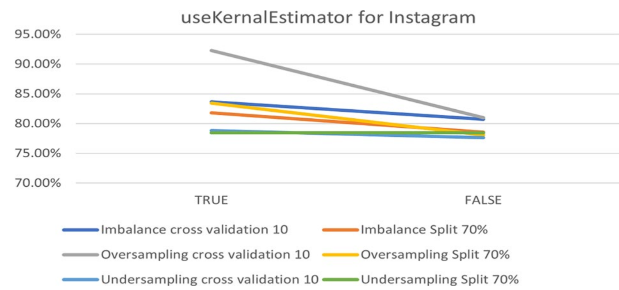

Fig. 13 The accuracy of useKernalEstimator for NB in Instagram

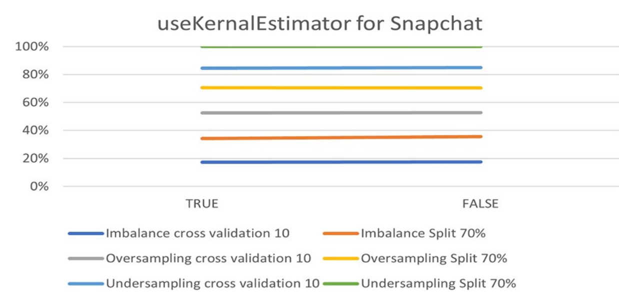

Fig. 14 The accuracy of useKernalEstimator for NB in Snapchat

that changing the value from 'true' to 'false' leads to 77.64% accuracy in under-sampling with 10-fold cross-validation. It can be illustrated that the best accuracy is related to the default parameters in over-sampling with 10-fold cross- validation.

The parameter adjustment was beneficial to under-sampling of the Snapchat platform. However, the default parameters were the best in over-sampling, especially in the 10-fold cross-validation, which achieved 98.04%. Figure 14 shows the results obtained from the experiment.

The next platform is Twitter. Figure 15 presents an overview of the impact of the parameter on accuracy. The best accuracy is 90.08% for under-sampling with a 70% split.

To summarize the optimal parameters, the default was preserve filters. Such a filter type was normalized through training data, except for the useKernalEstimator parameter. Table 6 summarizes the optimal parameters for both 10-fold cross- validation and a 70% split.

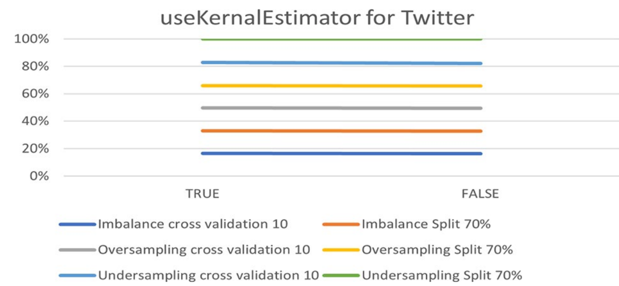

Fig. 15 The accuracy of useKernalEstimator for NB in Twitter

Table 6 Optimal parameter for Naive Bayes model

Parameter	Platform	Under-sampling		Over-sampling		Imbalance	
		Fold 10	70%	Fold 10	70%	Fold 10	70%
useKernalEstimator	Instagram	True	True	True	True	True	True
	Snapchat	True	True	True	True	False	True
	Twitter	True	True	True	True	True	True

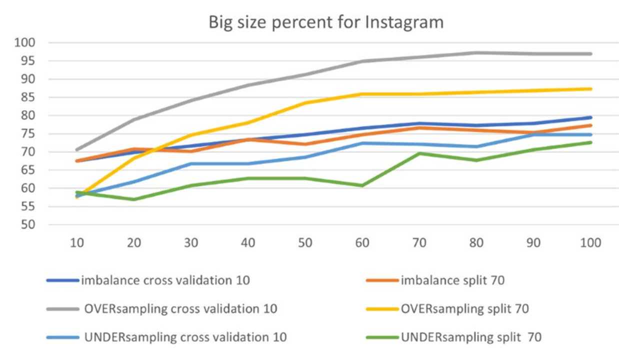

Fig. 16 The accuracy of BigSizePercent for RF in Instagram

Random forest

In the RF model, we changed one parameter, the BigSizePercent, from the de- fault values, with accuracy improving or worsening depending on each option in the dataset. Figure 16 presents the comparison between the parameters for the Instagram dataset. The figure shows that changing the value from 100 to 80 leads to 97.22% accuracy in over-sampling with 10-fold cross-validation. From the chart, we can observe that the best accuracy is for the default parameters in over-sampling with 10-fold cross-validation.

The parameter adjustment was useful for imbalance sampling of the Snapchat platform. However, the default parameters performed best in over-sampling, especially with both 10-fold cross-validation and a 70% split, achieving 100%. Figure 17 shows the results obtained from the experiment.

The next platform is Twitter. Figure 18 presents an overview of the parameter's impact on accuracy, with the best accuracy being 87.30% for over-sampling with 10-fold cross-validation.

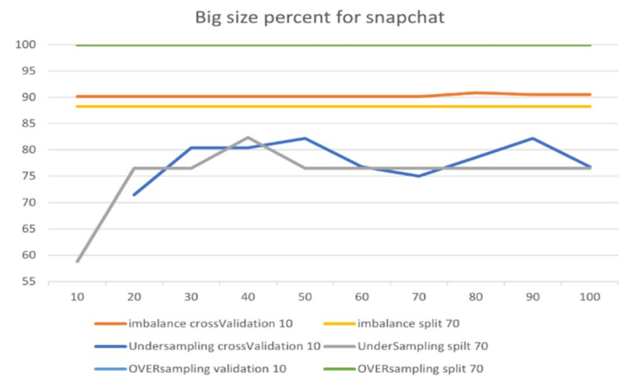

Fig. 17 The accuracy of BigSizePercent for RF in Snapchat

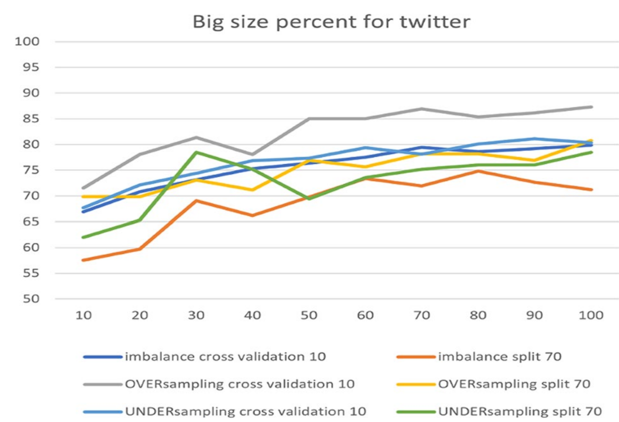

Fig. 18 The accuracy of BigSizePercent for RF in Twitter

Table 7 Optimal parameter for BigSizePercent

Parameter	BigSizePercent			
	Platform	**Instagram**	**Snapchat**	**Twitter**
Under-sampling	10-fold	100	90	90
	70%	100	40	100
Over-sampling	10-fold	80	100	100
	70%	100	100	100
Imbalance	10-fold	100	80	100
	70%	100	100	80

Table 7 summarizes the optimal parameters for both 10-fold cross-validation and 70% split.

Support vector machine

In the SVM model, the only parameter that makes changes is checksTurned Off, when it is changed from 'false' to 'true'. Accuracy changes in some datasets. Figure 19 compares the experimental parameter for the Instagram dataset and shows that changing the value

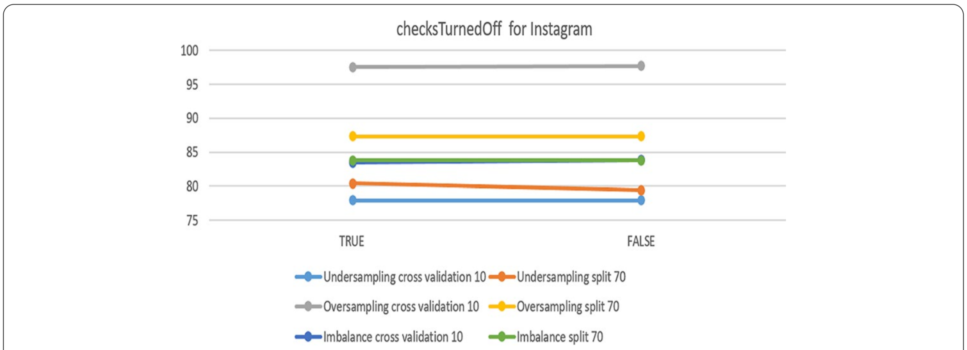

Fig. 19 The accuracy of checksTurnedOff for SVM in Instagram

from 'true' to 'false' leads to 80.39% accuracy in under-sampling with 10-fold cross-validation. From the chart, it can be shown that the best accuracy is related to the default parameters in over-sampling with 10-fold cross-validation.

For the Snapchat platform, parameter change was helpful with under-sampling. However, the default parameters were best in over-sampling, especially 70% split, which achieved 100%. Figure 20 show the results obtained from the experiment.

The next platform is Twitter. Figure 21 presents an overview of the impact of the parameter on accuracy. It had no effect on imbalanced data nor on over-sampling with a 70% split, while the best accuracy was 89.26% in the case of under-sampling with a 70% split.

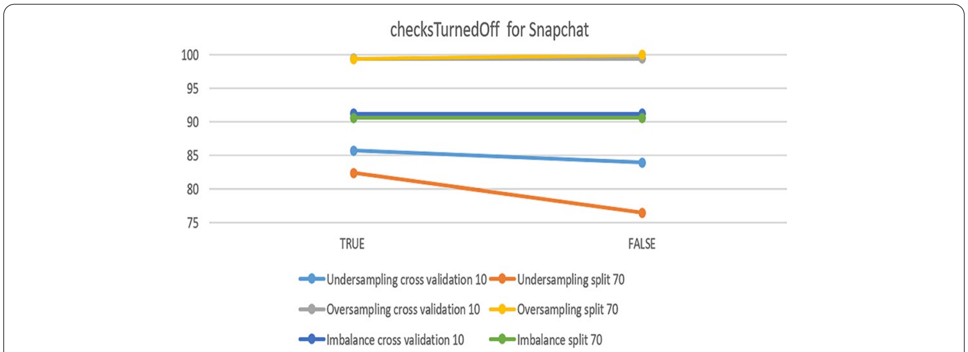

Fig. 20 The accuracy of checksTurnedOff for SVM in Snapchat

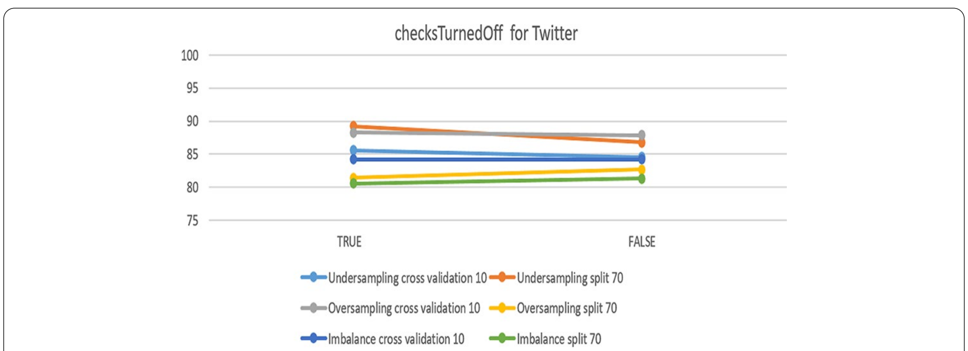

Fig. 21 The accuracy of checksTurnedOff for SVM in Twitter

Table 8 Optimal parameter for the SVM model

Parameter	checksTurnedOff			
	Platform	Instagram	Snapchat	Twitter
Under-sampling	10-fold	True	False	True
	70%	True	True	True
Over-sampling	10-fold	False	False	True
	70%	False	False	False
Imbalance	10-fold	False	False	False
	70%	False	False	False

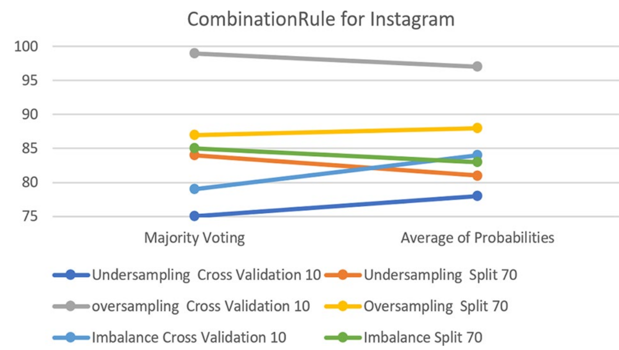

Fig. 22 The accuracy of CombinationRule for the Voting Classifier in Instagram

To summarize the optimal parameters, the default was preserved, the filter type was normalized training data, and the kernel was PolyKernel and others, except for checksTurnedOff. Table 8 summarizes the optimal parameters for both 10-fold cross-validation and 70% split.

Voting

For the Voting classifier, CombinationRule is the only parameter that affects the algorithm accuracy results. Furthermore, the changes are almost negligible, with the maximum accuracy change being almost 3% for all datasets. Figure 22 compares the experimental parameter for the Instagram dataset. The results show that the biggest difference is between Average of Probabilities (AoP) and Majority Voting (MV) in oversampling, with a 3% change in 10-fold cross-validation, which is the default parameter with the best accuracy from among all the options.

For the Snapchat and Twitter platforms, the results show that keeping the default parameter generates greater classification accuracy in all cases for both platforms.

Figure 23 shows that over-sampling has almost the same accuracy before and after sampling, with 100% before and 99% after in Snapchat with the over-sampling cross-validation option. Moreover, it shows that most of the samples have greater accuracy with the parameter set to the default. Finally, Fig. 24 shows the accuracy change for the Twitter Platform which clarifies the similarly of the impact of changing the parameter on both platforms.

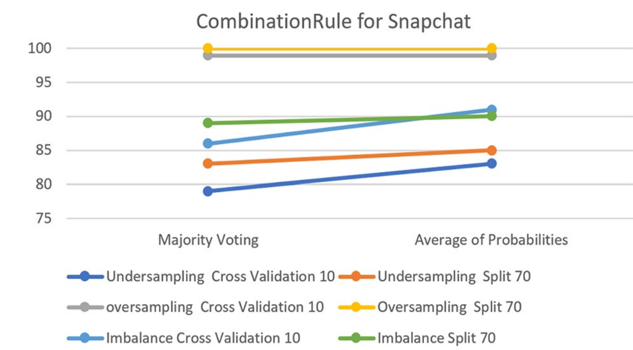

Fig. 23 The accuracy of CombinationRule for the Voting Classifier in Snapchat

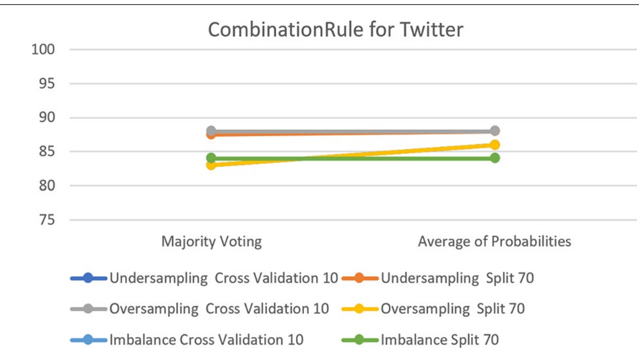

Fig. 24 The accuracy of CombinationRule for the Voting Classifier in Twitter

Table 9 Optimal parameter for the Voting model

Parameter	**CombinationRule**			
	Platform	**Instagram**	**Snapchat**	**Twitter**
Under-sampling	10-fold	AoP	AoP	AoP
	70%	AoP	AoP	AoP
Over-sampling	10-fold	MV	AoP	AoP
	70%	AoP	AoP	AoP
Imbalance	10-fold	AoP	AoP	AoP
	70%	AoP	AoP	AoP

Table 9 summarizes the optimal parameters for both 10-fold cross- validation and 70% split.

Result and discussion

This section presents an overview of the various empirical findings. After applying the algorithms to the datasets, there was a marked difference in terms of their accuracy on each platform. Table 10 shows the results of applying the algorithms on the Instagram platform with split 70% and 10-fold cross-validation test options on imbalanced, over-sampled and under-sampled data. The results show that the SVM algorithm achieved the best accuracy of 97.66%.

Table 10 Result of Instagram platform

Instagram							
Algorithm	**Metrics**	**Imbalance**		**Over-sampling**		**Under-sampling**	
		70%	**Fold 10**	**70%**	**Fold 10**	**70%**	**Fold 10**
MLP	Accuracy	84.41%	85.21%	88.29%	97.22%	84.31%	79.41%
	MAE	1.19	0.18	0.14	0.48	0.21	0.23
	Precision	0.85	0.85	0.89	0.97	0.85	0.8
	Recall	0.84	0.85	0.88	0.97	0.84	0.79
	F-Measure	0.84	0.85	0.88	0.97	0.84	0.79
SVM	Accuracy	83.77%	83.85%	87.32%	97.66%	80.39%	77.94%
	MAE	0.16	0.16	0.12	0.02	0.19	0.22
	Precision	0.85	0.84	0.89	0.98	0.81	0.80
	Recall	0.84	0.84	0.87	0.98	0.80	0.87
	F-Measure	0.83	0.83	0.87	0.98	0.80	0.78
RF	Accuracy	77.27%	79.38%	87.32%	97.22%	72.55%	74.71%
	MAE	0.29	0.28	0.28	0.21	0.38	0.37
	Precision	0.81	0.83	0.88	0.97	0.76	0.79
	Recall	0.77	0.79	0.86	0.97	0.72	0.74
	F-Measure	0.73	0.76	0.86	0.97	0.72	0.74
NB	Accuracy	81.82%	83.66%	83.41%	92.25%	87.43%	78.82%
	MAE	0.20	0.19	0.18	0.11	0.22	0.23
	Precision	0.82	0.85	0.86	0.92	0.79	0.79
	Recall	0.82	0.84	0.83	0.92	0.78	0.79
	F-Measure	0.81	0.83	0.83	0.92	0.78	0.79
Voting	Accuracy	85.06%	84.44%	88.29%	97.22%	81.37%	78.82%
	MAE	0.21	0.20	0.17	0.09	0.26	0.26
	Precision	0.86	0.85	0.89	0.97	0.82	0.8
	Recall	0.85	0.84	0.88	0.97	0.81	0.79
	F-Measure	0.84	0.84	0.88	0.97	0.81	0.79

Table 11 shows the results of applying the algorithms on the Snapchat platform with the same settings. The results show that the SVM, MLP, RF and Voting algorithms achieved the best accuracy of 100%.

Table 12 shows the results of applying the algorithms on the Twitter platform with the same settings. The results show that the MLP and NB algorithms achieved the best accuracy of 90.08%.

Next, the ROC values are presented in Table 13 for the best results.

Further discussions

Interaction by women and men

The research sample was separated based on the users' gender into females, males and unknown. Each of the three categories were compared to identify the most interactive participants. Figure 25 shows that most Instagram users were females representing over 60% of the sample. However, for the other platforms more than half of the participants were men.

Table 11 Result of Snapchat platform

Snapchat							
Algorithm	**Metrics**	**Imbalance**		**Over-sampling**		**Under-sampling**	
		70%	**Fold 10**	**70%**	**Fold 10**	**70%**	**Fold 10**
MLP	Accuracy	90.59%	91.19%	100%	99.61%	94.12%	83.93%
	MAE	1.10	0.10	0.01	0.01	0.18	0.21
	Precision	0.92	0.90	1.00	1.00	0.95	0.84
	Recall	0.91	0.91	1.00	1.00	0.94	0.84
	F-Measure	0.88	0.89	1.00	1.00	0.94	0.84
SVM	Accuracy	90.59%	91.20%	100%	99.41%	82.35%	85.71%
	MAE	0.09	0.09	0.00	0.01	0.18	0.16
	Precision	0.91	0.90	1.00	0.99	0.87	0.84
	Recall	0.91	0.91	1.00	0.99	0.82	0.84
	F-Measure	0.89	0.89	1.00	0.99	0.82	0.84
RF	Accuracy	88.24%	90.85%	100%	100%	82.35%	82.14%
	MAE	0.12	0.12	0.04	0.03	0.39	0.34
	Precision	0.88	0.92	1.00	1.00	0.87	0.82
	Recall	1.0	0.91	1.00	1.00	0.82	0.82
	F-Measure	0.94	0.87	1.00	1.00	0.82	0.82
NB	Accuracy	89.41%	92.61%	97.40%	98.05%	82.35%	75%
	MAE	0.10	0.09	0.05	0.05	0.25	0.25
	Precision	0.91	0.93	0.98	0.98	0.83	0.76
	Recall	0.89	0.93	0.97	0.98	0.82	0.75
	F-Measure	0.85	0.91	0.97	0.98	0.82	0.75
Voting	Accuracy	90.59%	91.55%	100%	99.41%	85.71%	82.35%
	MAE	0.10	0.10	0.028	0.03	0.25	0.23
	Precision	0.92	0.91	1.00	0.99	0.87	0.86
	Recall	0.91	0.92	1.00	0.99	0.82	0.86
	F-Measure	0.88	0.89	1.00	0.99	0.82	0.86

Most used words

In this section, the common words on the three platforms, Instagram, Snapchat and Twitter, are discussed. Figure 26 represents the most used words on Instagram, which were 'beach', 'Sindalah Island' and 'sunset'. In addition, for Snapchat the most used words are shown in Fig. 26b; these were sea, cruise and island. Finally, Fig. 26c presents the most popular words on Twitter, such as 'October', 'cruise' and 'summer'. In general, most words are positive and the word 'cruise' is often mentioned.

Conclusion and recommendation

In this study, SA was applied to the feelings of passengers and viewers of the Saudi Cruise, the first cruise in the Kingdom of Saudi Arabia. The sample was collected from three social media platforms, Snapchat, Twitter and Instagram. Separate datasets for each platform were created, and we obtained 10,922 instances, which were reduced to 1200 after cleaning. The results showed that most opinions, 80%, were positive across all three platforms. Furthermore, the ML algorithms, MLP, SVM, NB, RF and Voting, were applied to each dataset in order to classify and predict the opinions of passengers and

Table 12 Result of Twitter platform

Twitter							
Algorithm	**Metrics**	**Imbalance**		**Over-sampling**		**Under-sampling**	
		70%	**Fold 10**	**70%**	**Fold 10**	**70%**	**Fold 10**
MLP	Accuracy	84.17%	84.19%	82.05%	87.69%	90.08%	84.33%
	MAE	0.20	0.18	0.20	0.14	0.14	0.17
	Precision	0.85	0.84	0.84	0.88	0.91	0.85
	Recall	0.85	0.84	0.84	0.88	0.90	0.84
	F-Measure	0.84	0.84	0.82	0.88	0.90	0.84
SVM	Accuracy	81.30%	84.20%	82.69%	88.27%	89.26%	85.57%
	MAE	0.19	0.16	0.17	0.11	0.11	0.14
	Precision	0.82	0.85	0.84	0.89	0.90	0.87
	Recall	0.81	0.84	0.83	0.88	0.89	0.86
	F-Measure	0.81	0.84	0.83	0.88	0.89	0.86
RF	Accuracy	74.82%	79.87%	80.77%	87.31%	78.51%	81.09%
	MAE	0.82	0.83	0.86	0.89	0.85	0.85
	Precision	0.82	0.83	0.86	0.89	0.85	0.85
	Recall	0.75	0.80	0.81	0.87	0.79	0.81
	F-Measure	0.73	0.79	0.80	0.87	0.77	0.81
NB	Accuracy	84.89%	87.45%	85.26%	88.08%	90.08%	88.31%
	MAE	0.17	0.15	0.15	0.13	0.12	0.14
	Precision	0.85	0.87	0.85	0.88	0.90	0.89
	Recall	0.85	0.87	0.85	0.88	0.90	0.88
	F-Measure	0.85	0.87	0.85	0.88	0.90	0.88
Voting	Accuracy	84.17%	84.89%	84.44%	88.65%	88.43%	86.07%
	MAE	0.22	0.17	0.20	0.17	0.18	0.20
	Precision	0.84	0.85	0.85	0.88	0.89	0.87
	Recall	0.84	0.85	0.84	0.88	0.98	0.86
	F-Measure	0.84	0.85	0.83	0.88	0.88	0.86

Table 13 ROC values for the best results

	Algorithm ROC		
	Instagram	**Snapchat**	**Twitter**
MLP	0.99	1.00	0.97
RF	0.99	1.00	0.94
NB	0.98	1.00	0.96
SVM	0.98	1.00	0.89
Voting	0.97	1.00	0.97

viewers. The results show that the algorithms, RF, SVM and Voting, are the best when applied to the Snapchat platform, while the RF, SVM and Voting algorithms are best for Instagram, and NB and MLP for Twitter.

In addition, the dataset analysis showed that the most used words were 'cruise', 'Saudi' and 'Allah'. These words may be explained by the fact that' cruise' relates to the kind of trip,' Saudi' relates to the location of the trip. As for the word 'Allah', it is an Arabic word that means 'God'. The word 'Allah' stands for the surprising, the beautiful, the amazing,

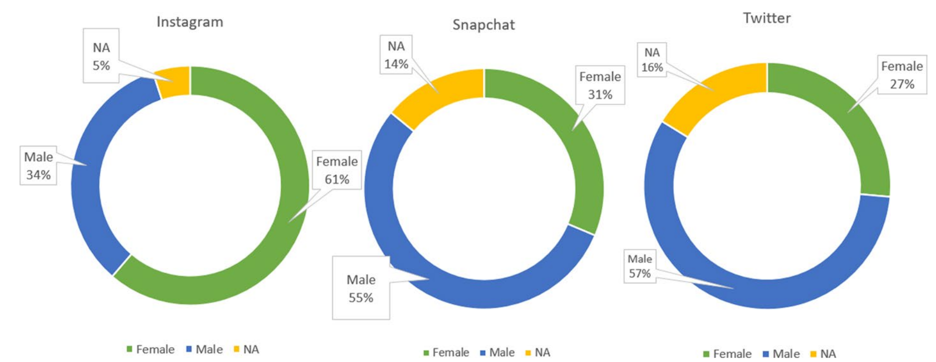

Fig. 25 The percentage of gender in all platforms

Fig. 26 The word clouds of the platforms

etc. Also, 80% of those who shared their experience were men. The difference between the gender of passengers who published their experiences is attributed to different circumstances that led to a decrease in women's participation on social media platforms, including the conservative culture of Saudi society.

This study responds to this need. The starting point for the study was to monitor the interactions between people on social media during the first cruises in Saudi Arabia during the COVID-19 pandemic as a unique experiment. Hence, the SA perspective should be the first step in any attempt to examine public opinion on any development or change. Thus, ML models were designed and developed to improve the process parameters in predicting feelings in the future that will help the decision-maker. Also, performance analysis enhanced models so that they achieved 100% accuracy. In addition, the social media platforms were compared in order to detect feelings, which is innovative.

This study has potential limitations. The data considered were from three popular social media platforms, Instagram, Twitter and Snapchat. Also, the period for data collection was long compared to the amount of data in the dataset. Because of Covid-19 and social distancing, the number of passengers on trips was reduced. Furthermore, there were places where taking pictures or videos was not allowed in order to protect the privacy of passengers.

A natural progression from this work is to compare more algorithms. These findings provide the following insights for future research: data in different formats, such as visual and audio data, could be analyzed; further research might explore more platforms for data comparison; development of a hybrid algorithm from the algorithms used in this study is recommended. Ultimately, the study could be applied to a wider area of entertainment in Saudi Arabia. And it is recommended that the scope of the study be expanded to other regions and countries by adding other data sets, to include demographics and not be limited to Saudi Arabia.

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Authors' contributions
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Availability of data and materials
The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Not applicable. This research does not involve any human participants, human data, or human tissue. Data is obtained from Instagram, Snapchat, and Twitter. The data is extracted using Python script.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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Smart cruising: smart technology applications and their diffusion in cruise tourism

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Abstract

Purpose – This paper aims to explore and discuss the impact of digital innovations from a business eco-systemic perspective. Key smart technology application themes in the cruise industry are extracted and synthesised in a "Smart Cruise Ecosystem" (SCE) framework.

Design/methodology/approach – Information communication technologies (ICTs) advancements and smart tools revolutionise interactions and affect all transactions, transforming the cruise experience. Gradually a Smart Cruise Ecosystem emerges by incorporating all technologies available and involving cruise passengers, who as smart actors interact dynamically with stakeholders, creating value before, during and after the cruising experience. The COVID-19 pandemic outbreak stressed the need for touchless and digital interactions as well as real-time information, fast-tracking the deployment of smart technologies. The diffusion of ICTs in the cruise industry is multi-faceted and dynamic, resulting in a number of smart-technology use-cases.

Findings – Smart technology constitutes a comprehensive smart ecosystem to manage all actors, controls, devises and systems to optimise ship operations and management, while co-creating value for guests and crew in an effective way. The multiplex SCE proposed is enabled by digital technologies collecting, storing, accessing and processing big data dynamically, including: object detection, Internet of Things, Internet of Everything, satellite communications, Big Data, automation, robotics, Artificial Intelligence and Machine Learnin, Cloud Computing, Augmented, Virtual and Mixed Reality. A range of interoperable and interconnected supporting systems form the basis of the smart ecosystem.

Originality/value – The proposed framework offers a holistic perspective of the smart-cruising domain, highlighting innovations, interfaces, dependencies, along with the corresponding key limitations and challenges. The synthesis and conceptual structure provided serves as a topology for guiding and connecting further research in smart cruising.

Keywords Experience, Tourism, Technology, Smart, Cruise

Paper type Research paper

摘要

智能巡航：智能技术应用及其在邮轮旅游中的传播

研究目的 – 本文从商业生态系统的角度探索和讨论了数字创新的影响。在"智能邮轮生态系统"框架中提取和综合邮轮行业的关键智能技术应用主题

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研究方法论/方法/途径 – 信息通信技术 (ICT) 的进步和智能工具彻底改变了交互并影响所有交易, 从而改变了邮轮体验。通过整合所有可用技术并让邮轮乘客参与其中, 智能邮轮生态系统逐渐出现, 他们作为聪明的参与者与利益相关者动态互动, 在巡航体验之前、期间和之后创造价值。 COVID19 大流行的爆发强调了对非接触式和数字化交互以及实时信息的需求, 以快速跟踪智能技术的部署。信息通信技术在邮轮行业的传播是多方面的和动态的, 产生了许多智能技术用例

研究发现 – 智能技术构成了一个全面的智能生态系统, 用于管理所有参与者、控制、设计和系统, 以优化船舶运营和管理, 同时以有效的方式与用户和船员共同创造价值。提出的多元智能巡航生态系统（SCE）由数字技术实现, 包括物体检测、物联网、卫星通信、大数据、自动化、机器人、人工智能、云计算、AR、VR, 动态收集、访问和处理大数据。一系列可互操作和互连的支持系统构成了智能生态系统的基础。

研究原创性/价值 – 本研究提议的理论框架提供了智能巡航领域的整体视角, 突出了创新、接口和依赖关系, 以及相应的关键限制和挑战。所提供的综合和概念结构用于指导和连接智能领域的进一步研究提供划分类型。

关键词 – 智能, 游轮; 旅游, 信息技术, 船舶, 创新

文章类型 – 研究型论文

Introduction

Cruising has been dramatically gaining popularity as a leisure and travel activity. Up to the COVID-19 pandemic crisis, the global cruise sector grew from 21.3 million passengers in 2013 to 28.5 million in 2018, reaching the 30 million mark in 2019 (CLIA, 2018, 2019; 2020a). The ocean cruise capacity reached 537,000 passengers, carried by 314 vessels and, by 2020, 37 new-builds were planned, adding 99,895 lower berths to the worldwide passenger capacity and $11.7bn in annual revenue to the ocean cruise industry. The three major competitors that dominate the global cruise industry include the Carnival Corporation and Plc. (CCL), Royal Caribbean Cruises Ltd (RCCL) and Norwegian Cruise Line Holdings Ltd. (Cruisemarketwatch, 2018). Although the threat to these corporations from new entrants is limited, competition within the market is intense (Lester and Weeden, 2004). The cruise sector continues to grow, particularly in Asia. In 2017, there were more than 50 mega cruise ships operating in Asia, indicating a growth of around 25% per year. By 2030, China was predicted before COVID-19 to become the world's second-largest cruise market after the US (Allianz, 2021). The Chinese cruise market is emerging rapidly, seeking quality and pursuing luxury experiences (Hung *et al.*, 2020).

At the core of the cruising experience is a new, dynamic and demanding customer base demanding the transformation of cruising to a safer, more sustainable and transformative experience. The emergence of a younger, increasingly active and connected clientele (Generation Y and Z) calls for the adaptation of marketing strategies as well as the reengineering of the products and services offered on board. Demographic-based segmentation requires appropriate tools for targeting specific groups of cruisers. An evolving consumption culture and demographic structure is calling for innovations, digitalisation and a more activity-focused experience portfolio and a close coordination between multiple stakeholders, before, during and after the actual cruise. This includes the port and the destinations; local, regional and national governments; cruise companies; ground handlers; suppliers; cruise travel agents and distributors (Di Vaio, *et al.*, 2018; CLIA, 2018). Papathanassis (2022) illustrates the "bright side" of cruise tourism (growth and the emergence of "floating destinations"), the "dark side" (sustainability and corporate social responsibility) and the "grey side" (regulations, health and safety and working conditions).

Resuming sailings in the post-COVID-19 era confronts the cruise sector with radically transformed regulatory-, demand- and operational environments. This new context acts as a catalyst for the accelerated adoption of smart technologies, which in turn is a key enabler for the business continuity of the sector (Papathanassis, 2017a, p. 115). Smart tourism accelerates the development of technology empowered business ecosystems (Buhalis *et al.*, 2019; Assiouras *et al.*, 2019). Smart tourism poses a paradigmatic challenge for tourism scholarship (Buhalis, 2020) and can benefit from "practical research" and from adopting a wider, supplier-focused perspective (i.e. beyond destination-specific cases) (Mehraliyev *et al.*, 2020, p. 88). This paper aims at exploring the application and potential of smart technologies in the cruising industry. It aims to derive a conceptual framework to synthesise current smart-technology applications and their interdependencies. The paper maps smart cruising developments and inspires innovations in the cruise tourism domain.

Cruise tourism as a complex system and "smart-technology" potential

"Cruise tourism is a socio-economic system generated by the interaction between human, organizational and geographical entities, aimed at producing maritime-transportation-enabled leisure experiences" (Papathanassis and Beckmann, 2011). This combines socio-psychological and business perspectives, while incorporating research and paradigms from the humanities, environmental studies, maritime transportation, hospitality and tourism. Managing an information-intensive cruise experience and coordinating the corresponding supply chain implies considerable information and communication challenges.

Managing an evolving cruise customer experience and supply-chain ecosystem value creation

The UN (2010) defines cruise passengers as "tourists or overnight visitors" on-board and "same-day visitors or excursionists" on-land (i.e. ports of call), exposing the challenging nature and fluid competitive boundaries of the cruise market. Market maturity is evident in the concentration of the industry and the accompanying investment in ever-larger all-inclusive ships, offering an extensive range of facilities and on-board sports, health and wellness amenities (Weeden *et al.*, 2011). Intense competition in the cruise sector has highlighted the need for highly sophisticated and information-intensive marketing practices, aimed at dealing with the challenges of:

- information intensity of on-board and ashore revenue management;
- diversity of consumption profiles;
- reliability of demand forecasting; and
- impact assessment of competitive pricing and sales promotions.

The cruise industry's growth calls for a modernisation of the sector's image (Papathanassis, 2020, 2022). The cruise guest demographic and consumption profiles are evolving. First-time cruisers tend to be younger and prefer a resort style cruising. They differ in terms of their expectations related to the duration of cruise vacation, the composition of the cruise itinerary, distance of destination attractions from cruise ports and the influence of cruise online reviews and environmental friendliness of cruise lines on their booking decision (Bahja *et al.*, 2019). Cruise guests' participation is critical in the co-creation of positive experiences (Fan *et al.*, 2020; Kang, 2020; Risitano *et al.*, 2020; Wu *et al.*, 2021). The relationship between passengers and crew determine the perceived value attributed to a cruise experience (Jeong and Hyun, 2019). Personalisation and multilingual interaction between tourists and crew enable passenger participation and engagement, resulting to more satisfying cruise experiences. Domènech and Gutiérrez (2020) illustrate that the extent of cruise tourists' port activity and expenditure depend on a range of factors, such as the travel party, the age of the visitors, the length of stay and the tourists' activities in the city, ultimately reflecting their satisfaction with the visit. Aside from the negative global publicity attributed to the cruise sector's crisis management during the onset of the pandemic, other health and safety issues, such as norovirus outbreaks (accidents [Papathanassis, 2016] and crime at sea [Klein, 2016, 2019; Klein and Poulston, 2011; Wittlinger and Papathanassis, 2019]), have long existed. Cruise passengers also need protection from becoming victims of criminal activities aboard a cruise ship or suffer from illness or medical conditions either on board or related to landside excursions (Vogler, 2022). Experiential value and value co-creation determine the brand prestige and loyalty for cruisers (Kang, 2020).

For destinations/ports, the direct economic impacts of cruise tourism are determined by: the total number of cruise tourists and crewmembers embarking/disembarking, the average expenditure per cruise line and passenger and the number of cruise lines attracted (Chen *et al.*, 2019). Ecological concerns, particularly in fragile and insular environments, are also a key issue (Lamers *et al.*, 2015; Van Bets *et al.*, 2017). However, harsh economic realities, supply chain power struggles and the sheer diversity of ports and islands, all render stakeholder coordination for sustainability planning and regulation control highly complex (Lester and Weeden, 2004). Many shore excursions and attractions are highly dependent on cruise lines. Sustainability aspects, ranging from environmental impacts to overcrowding, have been reluctantly accepted as the price local communities have to pay to economically benefit from cruises (Thurau *et al.*, 2013; Larsen and Wolff, 2019; Navarro-Ruiz *et al.*, 2020).

Cruise passengers can possibly return and spend a longer holiday at a port once having "sampled it" through a cruise (Klein, 2009; Larsen *et al.*, 2013; MacNeill and Wozniak, 2018; Larsen and Wolff, 2019). The macro-economic contribution of cruise tourism varies greatly amongst ports, being significantly lower for visiting ports of call (compared to turnaround/home ports) (Chen *et al.*, 2019). A closer look at the annual CLIA's reports on the sector's economic impact reveals that shipbuilding and cruise line purchases account for approximately 70% of the cruise sector's economic contribution (Papathanassis, 2019a). Such activities primarily benefit the economies of passenger-sourcing countries, rather than smaller destination economies. Engaging customers with information on shore activities and ports can generate benefits (Thyne *et al.*, 2015). Using smart solutions enhances customer experience and supports citizen behaviour (Fan *et al.*, 2019; Assiouras *et al.*, 2019). Informational-, behavioural-familiarity and visit arrangement (organised excursion vs. independent visit), determine the length of stay ashore as well as satisfaction and cruise tourist behaviour (Sanz-Blas *et al.*, 2019). Satta and Vitellaro (2022) suggest that "the success of cruise-port destinations and the sustainability of cruise tourism are expected to benefit from the involvement of public, private and hybrid entities in the development of cruise port and related tourist activities".

Smart-technologies for cruise tourism

The multidimensionality characterising a cruise experience requires ICT-diffusion and the digitalisation of both business and consumer processes (Buhalis, 2020). This poses challenges to establishing a fertile ground for the effective application of "smart technologies" in the cruise sector. Technological disruptions revolutionise and transform service industries (Buhalis *et al.*, 2019). The adoption of innovative technologies (smartphones, tablets, computers, laptops, gadgets, wearables) empowers end-consumers by enabling real-time decision-making and by enriching experiences (Buhalis and Sinarta, 2019; Buhalis and Foerste, 2015; Buhalis and Inversini, 2014). ICTs can support cruise businesses and operators towards achieving their key goals, namely, cultivate loyalty, raise customer value, innovate for competitive differentiation and foster collaboration in new ecosystems. Technology is a key driver for cost reductions, management-effectiveness, sustainability, safety improvements and market penetration. "Smartness" includes customer experience, business ecosystems and destination (Buhalis and Amaranggana, 2014; Gretzel *et al.*, 2015a; Gretzel *et al.*, 2015b). “Smartness” in hospitality places tourists in the middle of the ecosystem (Buhalis and Leung, 2018). Different ICTs systems (or hard smartness), including the Internet of Things (IoT), Cloud Computing and End-User Internet Service Systems, orchestrate the co-creation of customer experiences (Buhalis *et al.*, 2019; Zhang *et al.*, 2012; Wang *et al.*, 2013). The combination of “soft smartness” (i.e. application-innovation, human and social capital employment) and leadership within a “Service Dominant” logic ecosystem structures, result in value co-creation for the wider network of stakeholders (Neuhofer *et al.*, 2014, 2015).

Combing all systems, through ambient intelligence and ensuring interoperability and interconnectivity, empowers smart digital ecosystems and ambient intelligence (Buhalis, 2020). Interoperability refers to the ability of data, information and knowledge-sharing between disparate systems (Maheshwari and Janssen, 2014). Interconnectivity and dynamic interaction, rather than individual technological advances, assist the co-creation of experiences through optimisation of subsystems and operational and marketing practices (Buhalis and Leung, 2018; Höjer and Wangel, 2015; Gretzel *et al.*, 2015b). Digital technologies on board raise new opportunities and challenges for customers, cruise companies and stakeholders. Operational efficiency and control as well as reliable information and transparency regarding passengers’ movements and activities determine health, safety and disease-control on board. Connectivity and real-time information are key-enablers for managing the cruise vessel’s interface with ports and attractions. Failure to manage these interfaces may undermine the safety on board and ultimately jeopardises a complete cruise holiday experience (i.e. with land excursions and port visits) (Vogler, 2022).

Research methodology: thematic analysis of cruise-related smart technology application

A literature search on smart tourism addressing the cruise domain revealed a potential research gap. Conducting an advanced bibliographical search for literature containing the keywords: “smart”, “cruise” and “tourism” in their title, abstract and/or keyword list, yielded no results. The absence of a conceptualisation for smart-technology diffusion in the cruise tourism underlines the relevance and need for a thematic framework to facilitate the mapping and scoping future research efforts. This qualitative approach involved the thematic analysis of secondary sources (i.e. professional and sector publications) and searched for keywords: “innovation”, “smartness”, “smart”, “information and communication technologies (ICTs)”, “big data”, “internet of things”, “value co-creation”, “future (s)”, “trends”, in conjunction/combined with: “cruise (s)”, “maritime, “cruise ships”, “tourism”, “destination”. Each search result was reviewed and selected sources informed the thematic analysis.

In addition a comprehensive search was undertaken on the homepages, statements, social media and published reports including:

- Cruise and hospitality associations: the annual publications of the Cruise Lines International Association (CLIA) as well as HORWATH’s reports;
- Smart technology suppliers: three leading organisations (ACCENTURE, WARTSILA, XEVO), plus the annual reports of ALLIANZ (2021), to summarise the current smart services offered in the marketplace; and
- Smart Applications Analysis of Cruise operators: comprising a coverage of the top six cruise corporations amounting to 13 cruise brands (i.e. Carnival Cruises, Princess Cruises, Holland America Lines, Costa Cruises, Aida Cruises, Cunard Seaburn,

Royal Caribbean Intl, Celebrity Cruises, Norwegian Cruise Line, Regent Seven Seas Cruises, Disney Cruise Line, Crystal Cruises and MSC Cruises).

The analysis of reports and use cases revealed commonalities, differences as well as interconnections (Yin, 2016) between current and anticipated developments in cruising. Key themes extracted, including trends, risks, challenges and best practices were grouped based on their demand- and supply- related 'smartness' potential.

Results and discussion

"Smart-Cruisers": cruise-demand trends and smart technology potential

Tourism demand is rapidly moving towards smart tourists that engage with a range of technologies to maximise their value (Femenia-Serra *et al.*, 2019; Fan *et al.*, 2019; Gajdošík *et al.*, 2020). An analysis of the reports illustrate key trends and demand-driven motivators for change. Table 1 summarises these future trends, namely, customer segment diversity: experience-innovation; service digitalisation; value-based consumption illustrating the "Cruise Management – Smart Technology" potential.

Customer segment diversity drives service diversification and digitalisation. Cruising has become more affordable and accessible than ever before, offering excellent value for money and a diversity of destination experiences. This democratisation of cruises as a holiday form has rendered cruising accessible to a wider, less affluent consumer base. The "Silver-Ager" segment, loosely defined as the total economic activity of the 50+ population is expanding rapidly (Zsarnoczky, 2016). They tend to be experienced travellers and often travel in larger, multi-generational family groups (e.g. with their grandchildren). A relatively younger generation of cruisers is also emerging, including "Working Nomads" who combine work with leisure time; "Going Solo", who travel alone either by choice or by necessity; Gen Y (born between 1982 and 1998), who seek interaction and exploration; Gen Z (born between 1996 and 2010) who prefer authentic experiences over material items (McCrindle and Wolfinger, 2014).

Different market segments with different needs, expectations, requirements and critical satisfaction paths, experience cruise holidays differently and yet often share the same vessel and itinerary. This heterogeneity of customers traveling on a cruise, especially for cruise ships carrying 1,000 passengers or more, implies a need for increased operational flexibility and tailor-made services in a large scale. Mass customisation and personalisation of services at this scale is only possible by context-based digitalisation (Buhalis and Foerste, 2015). The need for customisation and personalisation of services is greater than ever. Under this premise, conventional loyalty schemes (e.g. loyalty cards and points, discounts) are expected to decline. Loyalty will increasingly be based on value co-creation, enabled by digitalisation and technology-enriched experiences, facilitated by mobile apps, online portals, gamification and other data-based innovations (Neuhofer *et al.*, 2015; Xu *et al.*, 2017).

Seeking experiences drives innovation and value-based consumption. CLIA expects that the next evolution of cruise travellers will be one dominated by a focus on healthy lifestyle and the demand for "transformational experiences". Consumers engage with people and places seeking transformational value and emotional involvement, rather than material things. They have an active role in shaping their vacation, preferring to co-create experiences rather than being passive recipients of pre-fabricated animation and entertainment activities. Story-telling, content crowdsourcing and enrichment support co-creation add value to the entire ecosystem. Cruise companies acknowledge a shift from "storytelling" to "individual discovery". They offer itineraries where tourists can engage in authentic experiences, deeply rooted in the local context. Providing targeted information,

Table 1. Future trends in tourism and in cruise industry

Key Theme	10 Tourism Megatrends (HORWATH HTL, 2015)	Cruise travel report 2018 (CLIA, 2018)	Cruise trends and industry outlook 2019 (CLIA, 2018)	Cruise Management – Smart Tech Potential
Customer Segment Diversity	• Growing middle class	• All budgets will cruise	• Female-centred cruising	• Granular segmentation
	• Silver Hair Tourists	• Skip-gen cruising: grandparents with grand-children	• Singles Segment,	• Individualisation of marketing measures
	• Generation Y and • Generation Z	• Millennials (Gen Y) and River cruising	• "Going Solo"	• Provision of customised services
			• Working-Digital nomads	• Improved preference and behavioural tracking
			• Gen Z (iGen) and Sea Cruises	
Experience innovation	• Emerging destinations (Middle East and Asia)	• Travelers warm to chilly destinations (Canada, Alaska, and Antarctica)	• Off-peak adventures, including once-in-a-lifetime experiences during the colder months	• Story-telling and content enrichment
	• Political issues and terrorism. Risk for destinations	• Transformational cruise experiences (cultural immersion, voluntourism, extreme adventures)	• Achievement over Experience	• Targeted information
			• Access is the new luxury, for unreachable destinations by plane	• Location and context based services • Experience co-creation • Safety and security targeted information
Service Digitalisation	• Technological (r)evolution (SoMo – Social and Mobile)	• Smart travel technology (wearables for seamless and personalised experience on-board)	• On board with Smart Tech	• Digitally-enabled process and data-integration
		• Steady demand for travel agent services	• Instagrammable cruise travel	

(*continued*)

Key Theme	10 Tourism Megatrends (HORWATH HTL, 2015)	Cruise travel report 2018 (CLIA, 2018)	Cruise trends and industry outlook 2019 (CLIA, 2018)	Cruise Management – Smart Tech Potential
	• Dominance of digital distribution channels • Loyalty V.X.0 (digital integration of loyalty programmes into the overall tourists' journey)			• Usability and seamless technology Individualisation of marketing measures • Contextualisation of information
Value-based Consumption	• Sustainability (Socio-cultural, environmental)	• Sustainability (Sustainable practices on and off board from recycling and waste management to popular voluntourism initiatives)	• Conscious travel, by implementing innovations that decrease the environmental footprint of cruise travel	• Content reliability and transparency
	Health and healthy lifestyle	Healthy doses (health and wellness services)	Total restoration offering the latest in fitness innovations	Responsible digital engagement Adoption of Social responsibility related to ports and destinations

Source: Based on HORWATH HTL and CLIA

Table 1.

based on location and context-based services, allows passengers to build their own unique experience throughout their itinerary. While in the past, a standardised itinerary would be sufficient, there is a drive for facilitation of individualised and personalised experiences on board and ashore.

Cruise ship size drives smart logistics: passenger and hospitality supply management

Digitalisation is also reinforced by the size and capacity of cruise ships. The sheer volume of passengers and crew on board, as well as the coordination of all logistics from both customers and supply chains force digitalisation. At least 50 mega-ships with capacity over 4,000 passengers, plus crew, put pressure on port authorities to expand their infrastructure to accommodate larger cruise ships, as well as to ensure safety, health and security to the cruisers (Papathanassis, 2017a and 2022; Cheng *et al.*, 2016). At least 10 ships carrying nearly 10,000 passengers were stranded at sea after having been turned away from their destination ports (McCormick, 2020; Bennett *et al.*, 2020). At this scale, raising hospitality service standards on board and satisfying an increasingly demanding guest-base, stumbles on logistics and crowd-management. For example, offering quality excursion experiences for 6,000 passengers, who must board and disembark efficiently and safely within a limited timeframe, needs precise orchestration and choreography, allowing practically no room for error. Not only does the organisation of the cruise ship adhere to a tight schedule, but each passenger needs to follow this schedule quasi-religiously, especially during port visits, to avoid delays. Delays result in missing flight connections, missing passengers, and disturbances leading to dissatisfaction, compensation, financial loss and reputation damage (Vogler, 2022). The quest for uniqueness and novelty extends to all the components of the cruise bundle, from the vessel itself to the ports-of-call.

Safety and security also drive digitalisation. The establishment of new cruising regions and the emergence of novel port-destinations are highly susceptible to political-volatility and safety-related risks (e.g. terrorism). Unexpectedly, COVID-19 brought at the forefront the safety and security as several cruise ships were held in quarantine or stranded at sea, highlighting the health risk perceptions in ocean cruising (Holland, 2020). Assuring the safety and security of such amounts of people in a rather confined area, also reinforces the strategic use of technology as a means to detect and deter internal and external threats (Vogler, 2022).

Food and beverage operations and supply chain management are crucial for the operations and guest satisfaction. Providing hospitality services at sea is a considerable logistical challenge. Smart hotel management technology (Buhalis and Leung, 2018) need to support the hospitality aspects of the cruise ship operations and to integrate its supply chain. To illustrate the magnitude of this challenge, Symphony of the Seas procurement requirements and waste management outlines the procurement and waste volumes of the Symphony of the Seas catering for 6,680 passengers, accommodated in 2,759 cabins and 2,200 crew members:

(1) Operator: Royal Caribbean Year of entry into service: 2018;
(2) Number of staterooms: 2,759; Gross tonnage: 228,081;
(3) Number of guests (max.): 6,680; Number of crew (approx.): 2,200;
(4) Food and Beverage Facilities: 23 restaurants and 36 kitchens;
(5) Food and Beverage Consumption:

11 million meals per year prepared by 1,085 Food and Beverage professionals;

479,314 gallons of fresh water are consumed each day on the ship;
110,000 lbs of ice cubes are made each day;
60,000 eggs consumed per week;
9,700 pounds of chicken per week;
15,000 pounds of beef per week;
700 pounds of ice-cream per week;
20,000 pounds of potatoes per week;
12,600 pounds of flour per week;
2,500 pounds of salmon per week;
2,100 pounds of lobster tails per week;
5,000 pounds of French fries per week;
5,300 pounds of bacon per week;
12,000 pounds of flour tortillas;
2,000 pounds of chicken wings;
1,500 pounds of coffee per week;
40 different varieties of fruit;
80 varieties of vegetables;
450 cases of Champagne per week;
3,200 slices of pizza per hour; and
479,314 gallons of drinking water per day.

Waste Generated

A ship with 6,000 people on board generates approximately:
2,100 tons of waste water;
24 tons of wet waste (food waste and bio sludge from wastewater treatment plants); and
14 tons of dry waste per day (solid burnable waste, plastic, glass, tins and cans).
Source: Ros (2019)

Many port destinations struggle to deal with the disembarkation of so many passengers simultaneously, heading for the same attractions and tourism honeypots. Ports are also unable to provide the quantity and quality of supplies required. Environmental regulations are very strict and the quality standard are very high. Thus, very complex and sophisticated planning process and adaptive operational plans are required. Cruise ships are very susceptible to their external environment, including weather, tornados, safety and security and political situations. Adaptive and resilient plans constantly need to be updated with real-time contextual information to reduce disruptions and ensure business continuity.

Smart cruise ships: cruise-supply trends and smart technology potential for service

Cruise ships become more sophisticated and technologically empowered. The concept of "Smart Cruise ship" provides a constant digital insight into the physical status of a vessel and fully supports its functionality. It consists of multiple layers, such as the product hardware itself, embedded software, connectivity, the product cloud with software services, security tools and end-to-end integration with existing enterprise systems (Uhlemann *et al.*, 2017). Digital experiences, content co-creation and seamless process integration are essential to effectively addressing a more diverse, competitive and demanding cruise market. The digitalisation and enrichment of co-created holiday content, as well as the electronic integration of company with customer processes, enable a seamless flow of information between cruise operators, customers and other stakeholders such as suppliers and port immigration and security authorities. Contextualising and personalising experiences support destination management and carrying capacity management.

Smart ship and energy management and navigation. As generic shipping, smart cruise ships consist of four main features, which are translated into requirements for the various hardware positioning systems on the ship (Van Dijk *et al.*, 2018), namely:

(1) navigation: receiving data from various sensors, which are combined with a Situation Awareness (SA) and a software-based system to create and assess an image of the real world;
(2) guidance to chart the ship's path;
(3) physical ship management to support software-based decision-making; and
(4) control or motion controller that steers the ship in the right direction.

Ship management innovations include Augmented Reality (AR) that assists navigation and manoeuvring under extreme ambient conditions, as well as energy savings systems, exhaust gas cleaning systems (ECGS) and waste management.

Sustainability has emerged as a top priority for the cruise industry, fuelling investments in new technologies and cleaner fuels, to reduce air emissions and achieve greater energy efficiencies, as well as to address regulatory pressures (CLIA, 2020a). For instance, the "Harmony of the Seas" has all her lighting provided by low-energy LED or fluorescents and motion sensors. The ship is also equipped with an Advanced Emission Purification (AEP) system, which remove about 98% of sulphur dioxide from the engines' exhaust. Improvements in energy efficiency, navigational and general safety ultimately reduce operational costs for cruise operators. Yet, the primary driver of technological innovation – after comparing a mega-ship with a smart ship – is enhancing customer's holiday experience and not for the human-related cost-reduction (Papathanassis, 2017b).

Smart hospitality on-board. From a hospitality perspective, a cruise ship is comparable to a resort, offering accommodation, catering and entertainment services at sea. For the post-panamax, mega cruise ships, the term "floating city" would be more accurate than "floating resort", and they are subject to unprecedented management challenges. "Smart Cruising" is critical for developing a critical path analysis and dynamically updating plans with contextual data, to maximise resilience and business continuity. Both leading companies, Royal Caribbean and Carnival Corporation, aim at optimising front-office service operations, by improving efficiency and customer service for guests. By reducing the time wasted queuing, waiting for check in, bags to arrive, ordering food, booking activities and all other activities, before boarding, on-board and ashore, they practically increase the guests' holiday duration. Failure to manage these processes efficiently will results to dissatisfaction, complains and compensations. Smartness is critical for larger vessels, as it helps manage passengers efficiently.

According to Jay Schneider, Senior vice president of Royal Caribbean Cruise Line, "Waiting is time stolen from their time off, wasted effort and wasted energy". The company has deployed a range of technologies aimed at increasing efficiency, such as: RFID Tags (e.g. WOW Band electronic bracelets); facial recognition technology and smartphone apps (e.g. Excalibur, Sea Beyond). They allow guests to embark and disembark seamlessly; follow the progress of their luggage; automatically access their cabin; adjust lighting and temperature in cabins; sign up for shore excursions; organise dinner reservations; pay for purchases on board; geo-locate their children and even order drinks and have them delivered wherever they may be. The Princess Cruises' "Ocean Medallion", represented a "first-of-its-kind" wearable device, which could be worn in a variety of ways (as a wristband, pendant, clip, or even be tossed in a pocket or purse), augmenting the entire cruise customer journey. Before the cruise, the company posts the device to passengers' home. To add personalisation, guests can customise their ocean-themed "Tagalong avatar" with accessories and stickers.

Franke and Schreier (2010) find that customers are willing to pay more for self-designed products, which add more value than standardised products. Beyond its WOW Band functionality, the system utilises "nowness" and context-based recommendations. The Ocean Medallion ecosystem utilises artificial intelligence for tracking guests' service interactions and offering real-time suggestions for cruisers based on their location, time of day, and activities occurring at that time. The newest MSC cruise ships provide tailor-made services through the "MSC for Me" suite, an app with 130 different technological functions (Table 2) (Deloitte, 2018). Norwegian Cruise Line also offers an app, which allows passengers to check-in before their embarkation and make purchases. "Smart Cruising" aims to facilitate essential processes; increase personalisation; facilitate C2C co-creation; reduce time wasted and improve efficiencies in dealing with the environment both for the individually and collectively with their party.

Smart entertainment on-board. Cruise lines are competitive in providing e-technology-based entertaining experiences at sea. Royal Caribbean focus on innovative experiences and imaginative ways to surprise cruisers. This trend continues with water parks, surfing and skydiving simulators, the North Star, roboscreens-video entertainment, digitally transformable public venues, and IMAX cinema, with six robotic moving screens, while projecting images onto ultra-HD screens (like the "Wayfinder" interactive LCD touch-screen). Entertaining elements include the X-ray vision apps, which give the ability to cruisers to 'see' through certain walls interesting places, like the galley. They also introduced Bionic Bars with robots instead of bartenders and Virtual dining. Norwegian Cruise Line introduced their "Freestyle Cruising" for personalised dining experiences whilst Carnival and Norwegian follow RCCL's example, offering Virtual Reality (VR) and AR experiences that transform ship spaces into virtual environments and enable active games

SYSTEMS	FUNCTION AND PROCESS
MSc for Me App	Comprehensive app to facilitate context-based experience co-creation
MSC for Me Wristband	Wearable waterproof device for purchases, bookings and cabin key
MSC for Me Chat	Chat messaging through the app without an internet package
AI Virtual Assistant Bot	ZOE in cabin virtual personal cruise assistant
VALUE	FUNCTION AND PROCESS
Efficient check in and check out	Mobile check-in saves time during arrival and departure
Personalisation	Helps cruisers personalise experience through profile and preferences
Co-creation	Uses digital technology that interconnects the guests, the crew and the ship
Integrated technology	Interactive touchscreens around the ship, interactive cabin TV and the app
Languages	ZOE speaks seven languages
Billing and charging	Credit card registration and centralising billing functionality
Navigation	Interactive map helps guests get oriented once on board
Nowness	Real time cruising identifying daily events, activities, and highlights
Bookings	Information and help in booking shows, spas and excursions
Contextualisation	Relevant promotions, offers and events
Family and Friends Locator	Enables cruisers to be independent, while connected with family and friends

Table 2. Smart applications on smart cruise ships – the case of "MSC for me" app

or interactive HD screens in public areas. Tech partners, such as Xevo, create shows with live performers that take on-board entertainment to new heights.

Smart guest-services and experience augmentation on-board. Examining the various on-board digital innovations of the main cruise corporations (Table 3) illustrates that the larger cruise companies compete to introduce smart technology to empower cruisers experience. High-tech cruise apps enhance passenger experience, by supporting experiential travel. This also grows ancillary revenues on board, as cruisers spend more on shore excursions, high-speed internet access, and join preceding tech-entertaining experiences. Lusch and Nambisan (2015) emphasise the dual role of technology as an operand resource (facilitator or enabler) in the customer experience and as an operant resource (initiator or actor) in service innovation.

According to Padgett, chief experience and innovation officer at Carnival Cruise Line, the company mission is to deliver entirely new levels of differentiation and personalisation by using distributed intelligence in combination with smart sensors worn by passengers. Carnival's interactive customer experience, named "ICX" (I for the interaction, C for the consumer and X for any band or pass technology) begins for each guest the moment a trip is booked and ends upon guest's disembarkation. By incorporating the crew interface component – the Crew Compass app – with the guest-experience design, the crew is empowered to even anticipate and respond guests' preferences, delivering a high-level quality experience. The same technology enables officers to track people during muster drills or, even, during an emergency.

The scope of smart technology diffusion in cruising extends beyond the exploitation of business potential at the micro-level. Despite the growth of passenger numbers during the last decade, the first maturity signs in the cruise offer's life cycle were beginning to emerge, signified by increased competition, decreasing ticket prices and evident cost-pressures (CLIA, 2020b). COVID19 has rendered new source markets and/or new itinerary

Table 3. Cruise operator guests on-board digital innovation

ROYAL CARIBBEAN CRUISE LINES (RCCL)		
	Royal Caribbean International (Quantum class ships)	• *VOOM* , Wi-Fi connection at sea
		• GPS mapping and Bluetooth for navigation on-board
		• Facial recognition technology
		• *Excalibur app*
		• *Sea Beyond app* to help customers prioritize their activites
		• *WOW* electronic bracelets using RFID technology
		• *Star Trek* -looking digital boards for monitoring the engine
		• VR Dining
		• AR for steering the ship in low visibility
		• Virtual balconies using HD LED screens
		• *RipCord* , virtual skydiving simulators
		• *Sky Pad,* VR bungee trampoline
		• *Laser tag battle for planet Z*
		• Bionic Bar with two robotic bartenders
		• *iQ app* which integrates customers' on board experience with the *Cruise Planner app* , a tool that helps you pre-plan your vacation
		• The *Wayfinder* interactive LCD touch-screen using RealMotion technology
		• VR mini-golf
		• *X-ray vision app*
		• *GoBe interactive platform* offering Virtual shore excursions, tours and activities
		• *Two70°*, digitally transformable public venues using roboscreens
		• *ARKit and ARCore* games to make better use of ship space.
	Regent Seven Seas Cruises	• CRM system to track and record guest preferences
		• *Magic Carpet,* a floating platform which changes mood, function, and its location
	Celebrity Cruises	• *Eden space,* a multi-purpose space whose design is based on a mathematics equation
		• Interactive Menus on iPads (*Qsine restaurant*)
		• *Edge Access Tour app,* a behind-the-scenes 3-D tour using AR
		• Luxury *"Smart Glass"* Shower, using electro chromatic tech
		• Digital backdrops in lieu of elaborate sets
CARNIVAL CRUISE LINE GROUP (CCL)		
	Carnival Cruise Line	• EA Sports Bar using iPads
		• Crew Compass
	Princess Cruises	• MedallionNet, Wi-Fi connection at sea
		• *Ocean Medallion*
		• *Ocean Compass* : a schedule of on board activities
		• *Ocean Ready* to submit travel documents and go paper free
		• *Play Ocean* : mobile video games that can be played on or off the ship
		• *Ocean Concierge* : for purchasing shore excursions, viewing stateroom account and all activities offered on board
		• *Ocean View* : app offering more than 100 acclaimed "Ocean Original" episodes with compelling experiential travel content
		• *Ocean Now* : for personalized guest service on demand
		• *Ocean Casino app*
	Holland America	• Microsoft business intelligence (BI) software / Oracle BI software
	AIDA / COSTA	• *"Pepper"* : the first robot which recognizes human emotions and interact with the surrounding environment
	Cunard Seabourn	• Cunard ConneXions, educational and entertainment daily programme of activities
GENTING GROUP		
	Crystal Cruises	• In-room tablets
		• Mobile app
NORWEGIAN CRUISE LINES (NCL)		
	Norwegian Cruise Line	• App allowing passengers to check in before their embarkation or to make purchases
		• Virtual game with virtual ocean views (in widow-sized for interior rooms)
		• Virtual mini-golf
		• Epic app, an iConcierge for connecting guests and crew
		• Facial recognition for matching guests to photos captured on board
		• Interactive touchscreens for navigating and booking activities
		• Interactive digital signage on board
THE WALT DISNEY COMPANY		
	Disney Cruise Line	• Magical Porthole, virtual window, showing Disney animated characters together with live ocean view
		• The Animation Magic Show (Animator's Palate restaurant)
		• MyMagic+ technology project
		• MagicBand No. 2 for additional interactivity
		• MyDisneyExperience app
		• Magic PlayFloor, an interactive floor which blends the latest in gaming technology with Disney-style storytelling
		• MagicBand bracelets to connect cabin keys, payments and PhotoPass information using RFID, Bluetooth Low Energy (BLE), and Near-Field Communication (NFC) technologies
		• Skyline Bar, with virtual windows on the bar's walls recreate realistic skyline views of the world's capitals
		• Two phones for free in each stateroom for internal communication
MEDITERRANIAN SHIPPING COMPANY (MSC)		
	MSC Cruises	• MSC for Me app with 130 different technological functions
		• 114 interactive screens (MSC Meraviglia) for booking several activities on-board
		• MSC for Me bracelets / RFID bracelets / Waterproof wristband as ID
		• MSC for Me touchpoints
		• Interactive maps to guide guests around the ship
		• For children: interactive game shows, touch screens and 3D printers

development (i.e. geographical diversification) ineffective as growth strategies. Technological innovation practically remaining the only transformational option (Papathanassis, 2020). As the cruise industry has accelerated towards a transformational crossroad, smart technologies represent solutions to a number of long-lingering problems ranging from energy efficiency to safety and security on board. While such a technological transformation comes with its own risks and costs, their deployment has become more pressing than ever. The ability and willingness of different cruise operators to engage in a challenging technological transformation of their business models may vary, but there is clear evidence for it potential (Papathanassis, 2019b)

Several strategies continue to be explored, such as: "door-to-door" concept (starting from the time of booking till the return of passengers to their homes), expanded cleaning and sanitation practices for ships, as well as comprehensive shipboard incident prevention, surveillance and response measures (CLIA, 2020b). Adopting a holistic approach the cruise industry will engage in smart technologies to monitor flows of products and passengers. Agility in tracking and tracing; real time information on ports; collaboration with authorities and ashore will all require smart technologies and securing the entire value chain and cruise ecosystem.

Synthesis: towards a smart cruise ecosystem

From a strategic perspective, the cruise industry increasingly relies on digital infrastructure for its smooth function. The various actors operate independently and competitively except for certain cases (embarkation/disembarkation process), when they need to jointly coordinate their actions (Watson and Boudreau, 2011). A range of smart technology applications synthesise the Smart Cruise Ecosystem landscape, to support this economic activity and facilitate the experience on-board and ashore.

Before travelling, cruise companies maximise revenues and optimise routes. Machine learning algorithms and programmatic advertising drive traffic to websites and increase customer conversion rates by serving dynamic content based on web-user behaviour. Improvements in data modelling and mining identify new segments with a high propensity for conversion and optimisation of email-marketing performance. Geo-location and behaviour-based digital advertising generate sales leads. Using machine learning, cruise companies optimise the content of marketing emails to support conversion and maximise Revenue Per Available Cabin (RevPaC). Virtual Reality (VR) and increasingly Metaverse are used extensively to showcase ship hardware at trade shows and to provide "walk through" for prospective customers. A large amount of fragmented online data from numerous cruise forums, social network groups, cruise-portals and blogs are accumulated (Papathanassis *et al.*, 2012).

During the cruising experience, there is a large spectrum of smart hospitality applications to support on-board experiences. Smart innovations are used by marketing departments on board, supported by robust Customer Relationship Management systems (CRM) to track and record guest preferences and; anticipate their needs. Robots, Artificial Intelligence and Service Automation (RAISA) technologies are increasingly evident in tourism (Ivanov and Webster, 2019). Customer service Bots, such as ZOE of MSC Cruises (Buhalis and Moldavska, 2021) and robots like "Pepper" of Costa Cruises, provide concierge services about on-board facilities and shore trips whilst collecting evaluations about the experience. They are available 24/7 to address passenger needs, give information and can customise experiences based on individual preferences, using streaming analytics, contextual awareness and machine learning. Technology innovations also include VR that enables engagement with working spaces such as the bridge, kitchens or the engines, which are normally not accessible and visible for cruisers. VR can also enrich physical spaces on board, with virtual aquariums and other virtual features taking advantage of technology to create attractions in confined places. By turning walls into digital installations, cruise companies can install interactive virtual balconies, with high-definition LED screens which show real-time video of the outside the ship; upgrading the look and feel of inside cabins. The effect is completed by piping in the rhythmic sounds of calming waves or gentle rain showers, and having a faux sunrise serve as an alarm clock and the night sky revealed on the concept cabin's ceiling (Locker, 2017). They can create a space where people can see views of the ocean and skies from inside their cabins, without having to necessarily go to the promenade of the ship.

The smart technology constitutes a holistic smart ecosystem to manage all actors, controls, devises and systems to optimise ship operations and management, whilst co-creating value for with guests and crew in an effective way. The multiplex Smart Cruise Ecosystem (SCE), illustrated in Figure 1, is enabled by digital technologies implemented by several actors with different functions, supporting several services. Smart technologies including (amongst others): object detection, IoT, satellite communications, Big Data, automation, robotics, AI, Cloud Computing, AR, VR, collect, access and process big data dynamically. These are utilised on-board for enriching cruisers' experiences and at shore for enabling cruise operations and asset management. Central to this smart business system is the cruiser as a dynamic smart actor, interacting with crewmembers and other guests, both on-board and ashore (check-in/out process, visits in different destinations, etc.), enabling co-creation and value exchange for all actors. This resides on a seamless coordination between ship- (Deck and Engine), hotel- and shore-operations, involving the alignment of diverse

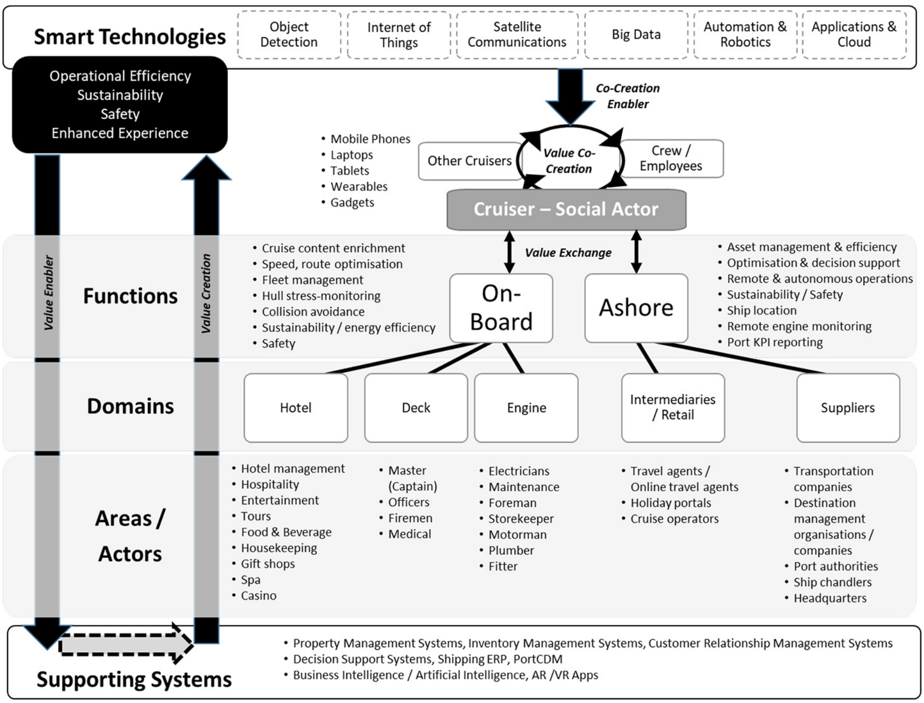

Figure 1.
Smart Cruise Ecosystem Framework

land-based partners and suppliers and the mobilisation of intermediaries and retailers. In turn, a range of interoperable and interconnected supporting systems form the basis of the smart ecosystem.

Hence, the Smart Cruise Ecosystem can be defined as:

> A cruiser-centric multiprocessing environment, where on-board and port communities, supported by interconnected digital systems, co-create and exchange value in the form of enhancing cruisers' experiences; facilitating operational efficiency, safety, sustainability, value and wealth creation for all stakeholders.

Smart cruising and digital technologies enrich, customise and personalise cruiser experiences. Augmented reality apps, integrated with wearable technologies enable seamless navigation and information on-demand. With AR aggregators, phone apps optimise the experience and address any unexpected occurrences or personal preferences. From a company's perspective, real-time data collection and business intelligence (BI) can be used to analyse preferences, to enhance loyalty and drive revenue-generating performance at the various venues, based on reliable constructs of guests' behaviours and attitudes. As ships sail between ports, cruise companies segment their guests, analyse behavioural patterns and dynamically adjust offerings and programs as to better fit cruisers' preferences (Accenture, 2017). This solution leads to real time data-driven decision-making, resulting to increased revenues and improved guests' experiences.

Smart cruising is not limited to minimising personnel and variable costs on-board, but also extend to optimising resource utilisation throughout the entire business system. An example of efficiency includes sea traffic management of "connected ports" using Data-Distribution Services (DDSs). Unfortunately, in many ports, the necessary data is not shared, preventing a common Decision Support System (DSS) between the different actors, so coordination is often poor (Wartsila, 2017). Cruise companies use an Automatic Identification System (AIS) for designing new digital services, providing raw data to investigate the potential value and estimate the cumulative benefit of process innovations, such as green routing (the shortest safe distance) and green steaming (the lowest operational speed to arrive on schedule). The Port Collaborative Decision-Making (PortCDM) system facilitates the process of collaborative dynamics for port call coordination (internal collaboration) and port call synchronisation (external collaboration). This optimises port visits by flexibly balancing capacity utilisation and turn-around time, port visit disruptions to a minimum (Lind *et al.*, 2015).

The future of the maritime complex is also driven by sustainability (TravelPulse, 2016). Sustainability entails the reduction of marine litter, waste and pollution, the reuse of energy sources and international regulations, and the recycling of materials and production residues. The future maritime ecosystem is expected to minimise carbon emissions and reduce environmental impacts (Accenture, 2017; Wartsila, 2017; Xevo, 2018). The common target is a 40% reduction of carbon emissions rates by 2030, compared to 2008 (CLIA, 2020a).

Safety on-board will require the latest GPS technology available for both employees and cruisers (wearables, gadgets). Operational safety will include preventive maintenance, risk management, accident prevention and anti-piracy technology systems. On-board safety technologies include electronic stability control (ESC), forward collision control and braking, inside cab facing cameras, over-speed alert systems and electronic logging devices. They provide direct digital feedback to fleet safety management and enable management practices dependent on safety technology (Woodrooffe, 2017; Meriteollisuus Finnish Marine Industries, 2016; Van Dijk *et al.*, 2018).

Autonomous shipping will be a reality as with all transportation. AI introduces automation in all functionalities, aiming at the development of autonomous devices, vehicles and vessels. The latest Rolls-Royce's project in partnership with Google Cloud makes remotely-operated vessels a reality propelling fully autonomous unmanned ocean-going ships by 2035 (Rolls-Royce, 2017). Japan's NYK has completed a trial on the world's first autonomous cargo ship, sailing from China to Japan (NYK Line, 2020). Yara to start operating the world's first fully emission-free container ship will be in commercial operation from 2022. The vessel's 'virtual captain' operates in an ecosystem, where decision-making relies on data, smart algorithms, artificial intelligence, drones, and ongoing process optimisation. Over the next years, remote-controlled and autonomous ships, using Intelligent Awareness (IA) systems will reduce the risk of injury or death for ship's crews and guests, as well as the potential loss or damage of valuable assets (Rolls-Royce, 2017). The benefits of autonomous shipping to support timely, safe, environment-friendly and cost-efficient sailing are well-recognised in the shipping industry (Van Dijk *et al.*, 2018). The absence of human intervention and/or involvement raises concerns regarding the ability of such technologies to deal with exceptional, complex crisis-scenarios at sea. The extent to which autonomous or semi-autonomous vessels are capable of effectively reacting to non-standardised scenarios is questionable and still a long way from public, political and legal acceptance. Apart from technological challenges, incidents such as: engine problems fire, and emergencies at sea, render these developments hypothetical; at least for the cruise sector. Although it is unlikely that cruise ships will become completely autonomous, smart operations will eliminate a number of work positions on board; with the remaining crew primarily focusing on customer services rather than shipping.

Smart cruise technology limitations and risks

Technological development comes at a cost, with an own set of risks and challenges for all stakeholders. To address the following threats, advanced crew training, cruisers' awareness education and back-up systems ought to become an industry-wide standard.

Connectivity at sea is challenging as Internet access at sea still depends on very expensive and less reliable satellite internet connections. Connectivity bandwidth is limited on board against an ever-increasing customer expectation for free, unlimited and fast connectivity. To respond to this challenge, companies use the fastest internet connection via Wi-Fi (like VOOM in RCCL), offering different pricing packages for passengers and the possibility to even enjoy movies on Netflix, video chatting on Skype and playlists on Spotify on-board (RoyalCaribbean, 2022). Edge computing could assist by deploying sensors and mobile data collection devices on-board closer to where the data originates, reducing latency and server-side network traffic (Horowitz, 2019).

*Cyber-security r*isks related to cyber threat, data breach, malicious attacks and ransomware safety and content reliability, will be more frequent with an 80% of offshore security breaches as the result of human error. Thus, companies are increasingly looking into cyber-security, secure cloud and blockchain technologies, as well as standards such as the IMO guidelines on Maritime Cyber Risk Management and the "Cyber Security On-board Ships" by the International Maritime Council, to develop recovery plans. Blockchain, as a digital ledger where virtually everything of value can be recorded (Tapscott and Tapscott, 2017), will find wide application in the cruise sector, for tackling issues related to vessel maintenance, overbookings, fraud in refunds and chargebacks and real-time alerts for data breaches.

Data privacy concerns, security and integrity of data across the ecosystem raises questions of accountability. Incorrect content, beyond the control of cruise operator and outside the confines of the cruise vessel, may negatively affect the expectations, satisfaction and even compromise the safety of the passengers, leading to complaints and refund requests at best and lawsuits for corporate negligence at worst. The highly fragmented legal framework of international maritime law, flags of convenience, diverse conventions and standards poses a compliance and enforcement challenge in this respect. To overcome this risk, companies are required to adopt to the standards set by the General Data Protection Regulation (GDPR) rules and proactively act to ensure compliance.

Conclusion and further research

This paper contributes an analytical Smart Cruise Ecosystem framework, unifying all technology-empowering aspects of cruising and paving further research. The paper conceptualises the application scope and potential of smart technologies in cruise tourism towards enhancing the value co-created for all stakeholders. Technology diffusion and digital consumption have transformed the entire cruise experience to a dynamic ecosystem. Technological innovation and digitally enabled interactions between cruisers, organisations and stakeholders drive value co-creation, efficiency, effectiveness and profitability. Cruisers act as active co-creators of service experiences, generating value for themselves, other cruisers, cruise operators and the communities involved in their trip. This analysis suggests that cruise companies have the common goal of offering innovative personalised experiences.

Theoretical Implications reveal a gap for context- and case-specific human-computer-interaction research and refined technology acceptance modelling. The Smart Cruise Ecosystem Framework serves as a roadmap for scoping the corresponding studies, contextualising their relevance, and comparing findings between the various featured user-groups (actors/areas) on-board and ashore (domains). A holistic consideration and the corresponding depiction of the functional-domain interdependencies between the multitude of actors and entities characterising the cruise tourism system, highlights an untapped smart technology research potential for tourism in general and for cruising in particular. It is tempting to reduce the theoretical and research scope of the cruise phenomenon to its various facets (e.g. Accommodation and transport – cruise as a “floating hotel”), failing to acknowledge it as a comprehensive experience production system. The evident scarcity of smart-technology research and literature on cruises supports this contention. Providing a comprehensive analytical framework frames and uncovers opportunities for smart technology research in the cruise context.

Managerial Implications engage the integration of the technological innovations to provide opportunities for the restarting of cruising. The Smart Cruise Ecosystem framework provides the “info-structure” for optimising cruise tourism. The integration of seemingly isolated smart-technology innovations within an ecosystem strategically interlinks them with organisational actors and support systems. Without interoperability and interconnectivity (“smartness”), the detached prospect of developments related to internet access at sea, mobile devices, wearables (e.g. RFID Bracelets), AR/VR technologies and robotics, is one where they serve as guest “satisfiers” or nice-to have “exciters” (Kano *et al.*, 1984). “Smartness” cumulatively augments them to strategic enablers; of process-, resource- and capacity-related efficiency; of service-delivery effectiveness; and of revenue maximisation, and of sustainability, safety and security. Yet, transferring this knowledge to practice lingers between an abstract notion of “smartness” and the specificity of fragmented technological use-cases. The proposed framework provides contextual specificity to the term “smartness” while uniting distinct technologies and aligning them to wider organisational objectives. The analysis and the framework serve as a benchmark for assessing individual cruise operators' degree of technology assimilation (Nolan, 1973) compared to the rest of the sector, aiding the identification of development-project needs and incorporating them into their IT strategies. With the cruise sector facing disruptive decline in the post-COVID-19 era, the imperative of organisational transformation and challenge of economic continuity rest upon the evolution of technological smartness to business intelligence.

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Article

Structural and Logical Model of Transport Maritime Functioning Based on Modeling Information Technology

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Abstract: The article presents the sectoral structure of cruise (maritime) tourism and identifies the factors influencing the level of demand and supply of cruise tourism products. The sources of the influence of the cruise industry on the economic growth of the state and the welfare of its citizens are also considered. On the basis of specific features of cruise tourism functioning and the peculiarities of creating a cruise tourism product, a model of the functioning of a cruise (maritime) tourism complex has been built. Representation of the relationship of tourist needs according to the hierarchy of needs and a species classification of cruise tourism and the industries involved in its development is also given. The model of indicators and the structural components described are built in an environment of geoinformation modeling.

Keywords: modeling; cruise industry; COVID-19; cruise tourism; transformation; model; maritime

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1. Introduction

Tourism has proven to be one of the sectors hardest hit by the COVID-19 pandemic, which is seriously affecting economies, people's livelihoods, public services and limiting opportunities on all continents. Preserving the livelihoods that depend on this sector should be a priority, and the recovery of tourism offers opportunities for transformation, with an emphasis on managing the impact of the pandemic on tourist destinations and creating greater potential among the population and companies operating in this area by countering through innovation, digitalization, sustainability and partnerships.

Cruise tourism, as one of the most dynamically developing, unique and popular types of business, has certain advantages and features that allow it to remain more stable for a long time amid other economic sectors (Brida and Aguirre 2008; CLIA 2008; Navarro-Ruiz et al. 2019). Thus, over the past 10 years, cruise passenger traffic has increased by more than 1.6 times, and the growth rate of total revenues from the development of cruise tourism amounted to about 150%. According to the Cruise Lines International Association, "globally, the cruise industry generates over $150 billion in economic activity every year, supporting 1.17 million jobs paying more than $50 billion in salaries and wages" (CLIA 2008). The intensity of the industry's development involves the identification of key components that form the potential of this sector and create the basis for its effective development, both for an individual cruise destination and for entire countries, regions and complexes.

Note that the development of cruise tourism is based on the process of creating a cruise tourism product. Its promotion and implementation is provided by many enterprises and organizations (MacNeill and Wozniak 2018; Papathanassis 2019). A significant number of participants in the cruise business predetermine the system-forming nature of its functioning. It also indicates the need to identify all its constituent elements in order to understand the cause-and-effect relationships between the main, auxiliary and supporting processes of creating a cruise tourism product (Logunova et al. 2020).

The objective of the study is to build structural and logical model of the cruise tourism functioning based on the identification of its structural components and representation of the link between tourist needs, the species classification of cruise tourism and the industries involved in its development (Papathanassis 2017).

The tourism sector is still suffering huge losses due to the COVID-19 pandemic: in the first five months of 2021, international tourist flows in some parts of the world decreased by as much as 95%, and 100–120 million jobs were at risk. At the same time, according to forecasts, by the end of 2021 the volume of world GDP will decrease by more than 4 trillion dollars. "For developed countries this is a serious shock, but for developing countries it is an emergency situation," said UN Secretary General Antonio Guterres (International Tourizm 2021).

In his message on the occasion of World Tourism Day, he noted that the tourism sector is connected with almost all spheres of the economy and sectors of society, but not everyone can take advantage of its benefits. On the other hand, a tourism crisis such as the current one is hitting the poorest and most vulnerable groups in the first place. That is why this year the theme of the World Day was the call for the inclusive development of the tourism sector.

As of 2019, tourism accounted for 7% of world trade, and the sector, which employs 1 in 10 people on the planet, through a complex value chain (UNWTO 2020b, 2020c). Interconnected industries provide livelihoods for millions of people in developed and developing countries. As borders closed, hotels shut down and air traffic dropped sharply, international tourist arrivals fell 56%, and the tourism sector lost $320 billion in the first five months of 2020, more than three times the period of the 2009 global economic crisis. Governments are trying to compensate for the loss of revenue that is needed to fund public services, including social and environmental protection, and meet debt maturities (UNWTO 2020b).

2. The Main Ingredients of Influence in the Industry

The activities of transport and logistics companies in the world were also significantly affected by quarantine measures due to the ban on the movement of passengers on all types of transport and the restriction of freight traffic by some countries. Rail freight transport, as well as combined transport, appear to have been less affected by the pandemic, especially at the initial stage, and in some cases their condition even improved by freeing up more rail routes for freight traffic due to the cancellation of passenger flights. For the marine and cruise industries, the measures also had a strong impact.

Considering the impact of the cruise industry on the economy of a country in a region or a separate area, it should be noted that this business involves all economic sectors, reflected in the System of National Accounts and characterizing the set of institutional units (Nyberg et al. 2021):

1. Non-financial corporations, founded by legal entities or individuals, organize the processes of tangible and intangible production associated with the supply and production of goods necessary for the organization of cruise tourism, construction and maintenance of cruise ships, the provision of port, transport and other non-financial services.
2. Financial corporations, specializing in financial intermediation, provide banking and insurance services to both entrepreneurs and tourists. They also invest in the development of priority investment projects in the cruise business.
3. General public administration, represented by government bodies at the central, regional and local levels, exercises legislative, judicial and executive power, implements tax, environmental, customs and social policies, creates state and regional

development programs, coordinates the activities of cruise industry enterprises, and contributes to the creation of favorable investment climate in the tourism sector.

4. Households that unite individuals as consumers, taking care of their financial well-being, increasing human capital and improving the health of family members, provide consumer services, partially provide education and health services and contribute to expanding the range and improving the quality of tangible and intangible benefits thereby stimulating the activity of other economic sectors.
5. Non-profit organizations serving households bring people together according to professional, cultural and other interests; provide non-market services of a socio-cultural, medical, housing and recreational nature for employees of cruise tourism enterprises.
6. The "Rest of the World" sector expands economic cooperation and interaction of the state with other countries of the world through the joint attraction of international tourist flows and contributes to obtaining a favorable image in the world tourist market.

Moreover, depending on the connection with the market, the market sector should be distinguished. It determines the ratio of supply and demand and covers the production of goods and services to create an integrated cruise tourism product (Figure 1). It is also necessary to highlight the non-market sector, which is based on the production of goods and services for direct use in the production process of the cruise industry enterprises, as well as the provision of services by tourist associations and organizations for free (Nyberg et al. 2021).

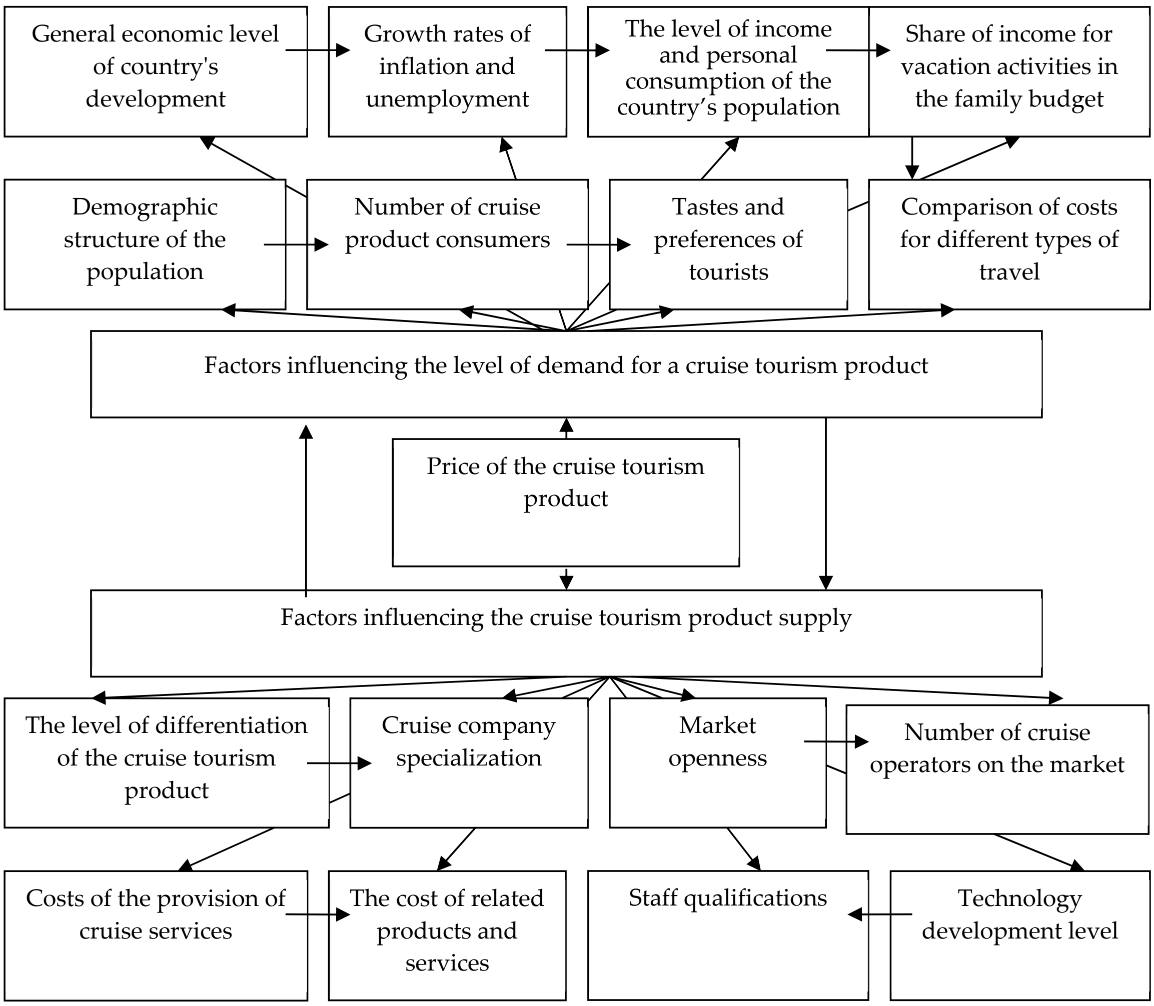


Figure 1. Factors influencing the level of demand and supply of cruise tourism product.

Thus, the main factors affecting the level of demand for a cruise tourism product include both external economic factors and individual preferences of tourists. External economic factors include the general economic level of the country's development, which determines the rate of inflation and unemployment, the level of personal income and consumption and their share of vacation time in the family budget. Individual preferences of tourists are predetermined by their demographic, socio-economic, psychological and other characteristics, according to which they organize the infrastructure of the cruise ship and the program of tourists' stay on board and shore (Selivanov 2010).

Cruise operators, agents and companies, which are mostly represented by the non-financial corporations sector, meet the needs of various target audiences in a quality tourism product and organize interaction between economic sectors (Figure 2).

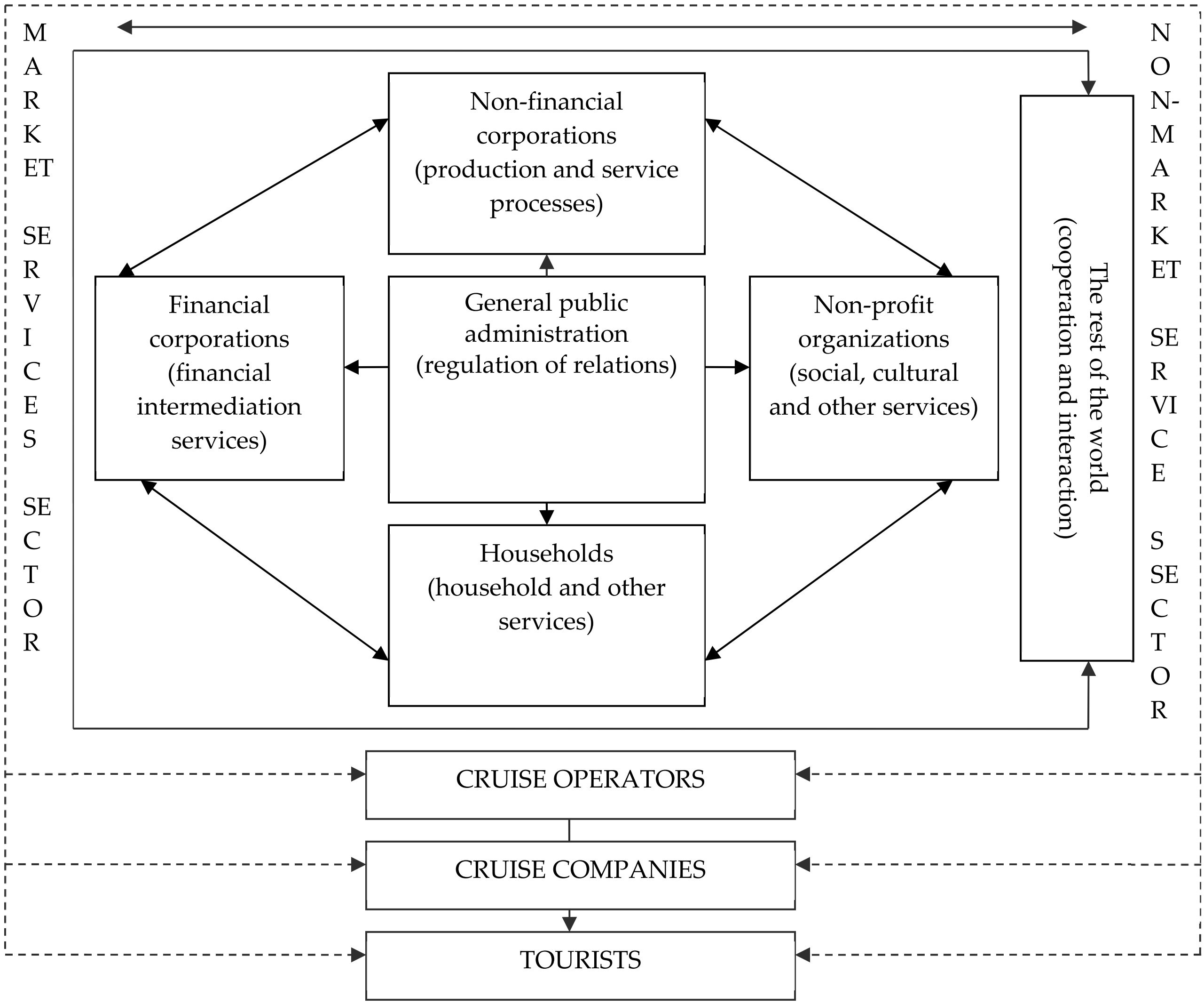


Figure 2. Sectoral structure of cruise tourism.

Thus, if we consider tourism as a complex branch of the economy, then cruise tourism is its mutually transformable independent sub-industry based on structural and functional differentiation. It, in turn, includes a wide range of industries (sub-industries) involved in the creation of the cruise product indirectly (mechanical engineering, transport and communication, food, light and printing industries, etc.) (CLIA 2008).

Each sub-industry (industry), taking into account its functional specialization, differentiates into third-level industries (mechanical engineering—into shipbuilding, automotive, etc., transport and communication—into ports, aviation and passenger transport, etc., food industry—into the dairy, confectionery, bakery industries, etc.).

No country has escaped serious losses in its tourism sector, from Italy, where tourism accounts for 6% of national GDP, to Palau, where tourism accounts for nearly 90% of all exports. This crisis was a serious shock for the developed countries and caused the most vulnerable segments of the population and developing countries to actually find themselves in emergency situations. The impact of the crisis on small island developing States (SIDS), least developed countries (LDCs) and many African countries is a matter of concern. In Africa, this sector accounted for 10% of all exports in 2019 (UNWTO 2020a, 2020b).

3. Aggregation and Structuring in the Industry

This distribution is based on the combination of a set of enterprises that have their own specific characteristics, predetermined by their business environment, which is significantly influenced by such external factors as:

1. Natural and climatic factors, including meteorological and climatic factors (winds, air and water temperatures, precipitation and fog), hydrological factors (fluctuations in water levels, waves, currents), geomorphological factors (geological structure of the area, variability of the coast and bottom, movement sediment and soil properties), natural monuments and exotic natural objects, the richness of flora and fauna. All these have a primary impact on the possibility of organizing cruise tourism and the manifestation of tourist interest.
2. Political and legal factors that determine international relations in the field of the cruise business, contributing to the country's positive image formation in the world tourism market and determine also the safety of navigation in the internal waters of the state. Moreover, these factors form the regulatory and legislative framework in the tourism sector. The role of political factors increases with the growth of turmoil, terrorist attacks, hostage-taking in a number of Arab countries, change of political regimes and testifies to the growing importance of international cooperation in order to resolve differences and ensure the safety of tourists at all stages of travel.
3. Economic factors, which are based on tax, investment, foreign economic activity of the state, distribution and employment of labor resources by economic sectors, as well as the growth rate of inflation, interest rates and energy prices, which determine the level of income and quality of life of the population. Economic factors directly affect the formation of the cost of the tour, determine the demand for cruise tourism products and create the preconditions for cruise tourism development.

A separate aspect in the analysis of economic factors in cruise tourism is the level of port dues set for cruise ships, and border and customs conditions for tourists who prefer a sea voyage.

4. Socio-demographic factors affecting the volume of consumed cruise services due to an increase (decrease) in the number and changes in the demographic structure of the population, birth rate, mortality, life expectancy, indicators of demographic load and the nation ageing, work capacity and labor mobility, intensity level labor and its complexity, the length of free time, the length of the vacation period, etc.
5. Scientific and technical factors that improve the quality of the cruise product and expand the range of related tourist services. These factors affect technological progress in the cruise business and contribute to reducing unit costs through the use of energy-saving technologies and improving the material and technical base of enterprises in this industry.

One of the modern approaches of building a structure of complex processes is using machine learning approach to understand interactions between different factors in a system.

The most appropriate way to understand this structure is by using Bayesian networks or Markov chains. Bayesian networks represents an acyclic graph, where its nodes are some factors (in our case different sectors of economy) and edges are relations between them.

Generally, a Bayesian network defines relations between different factors, that builds more complex system. In the case of the functioning of cruise tourism, it will describe dependency between natural, political, economic, social and science factors, which will lead to a deeper understanding of this complex system and also help to build a more sustainable business system.

The main feature of Bayesian networks are based on the conditional independence of variables or, in our case, different factors of the complex cruise tourism system. This means, that two different factors A and B are conditionally independent from factor C, if with defined factor C, the value of B does not increase information about factor A, or:

$$p(A|B,C) = p(A|C)$$

The complex scheme of using Bayesian network in modelling of cruise tourism functioning is provided in Figure 3. This scheme represents relations between environmental (green), economic (blue), political (red), populational (yellow) and industrial (purple). Understanding the relationship between different variables that form a cruise tourism system is important for predicting optimal strategy from economic growth and tourist happiness. Due to the complex basis of every system, the success of cruise tourism for both companies and tourists depends mainly from large group of variables that can obviously vary it space-time continuum. This groups generally represents different groups of predictors of different origins. To visualize this structure, we used EU spatial data for Mediterranean Sea and R-package "bnlearn". Spatial data were stored in group of "NetCDF" files containing corresponding data for different periods of time. To process this dataset with R and learn the structure of the Bayesian network we transform these geospatial layers to "dataframes". A learning structure using "bnlearn" package was based on receiving probabilities of changing variables X_i as a response of any change of variable Y_i. Thus, we visualized the cruise tourism structure in the Mediterranean Sea as a directed acyclic graph. The group of predictors were colored using "Adobe Photoshop" to detach one group of predictors from another. From Figure 3 we can see that a cruise tourism system is mainly based on environmental variables. This group of predictors generally does not depend on any external influence, except fundamental processes. Other groups of predictors are a derivative of human activity and economic and political systems and can be changed depending on the political or economic situation.

In general, the sources of influence of the cruise industry on the economic growth of the state and the welfare of its citizens can be grouped as follows (Figure 4).

1. Supply management (consumables and lubricants, food, clothing, spare parts, etc.);
2. Taxes and fees;
3. Cruise ships building and maintenance;
4. Services provided by ports (mooring, fresh water replenishment, lighting, garbage disposal, etc.);
5. Expenses of passengers and crew on land (excursions, hotel accommodation, transfer to the airport, taxis, etc.).

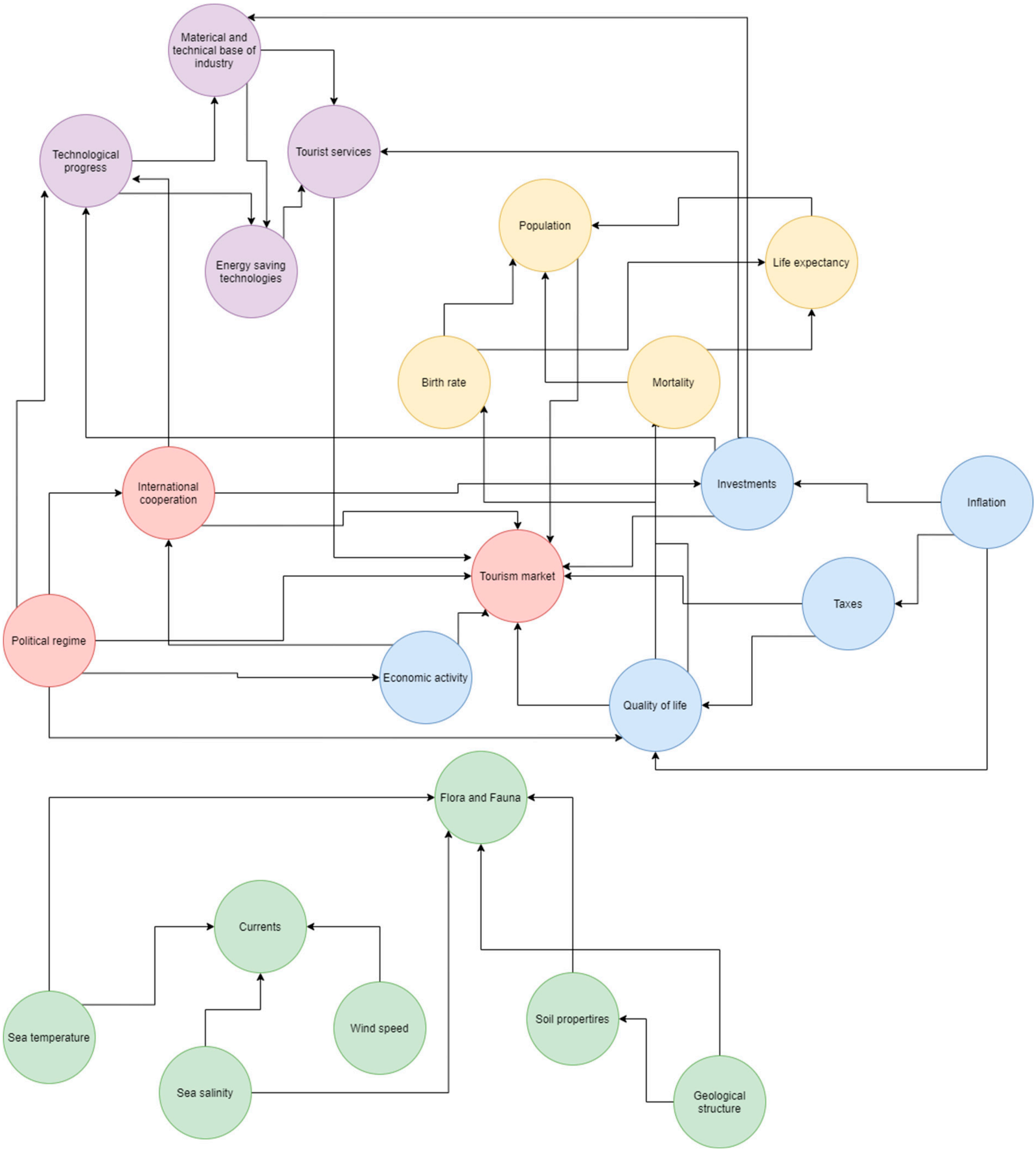


Figure 3. Complex scheme of using Bayesian networks to understand the structure of the cruise tourism system.

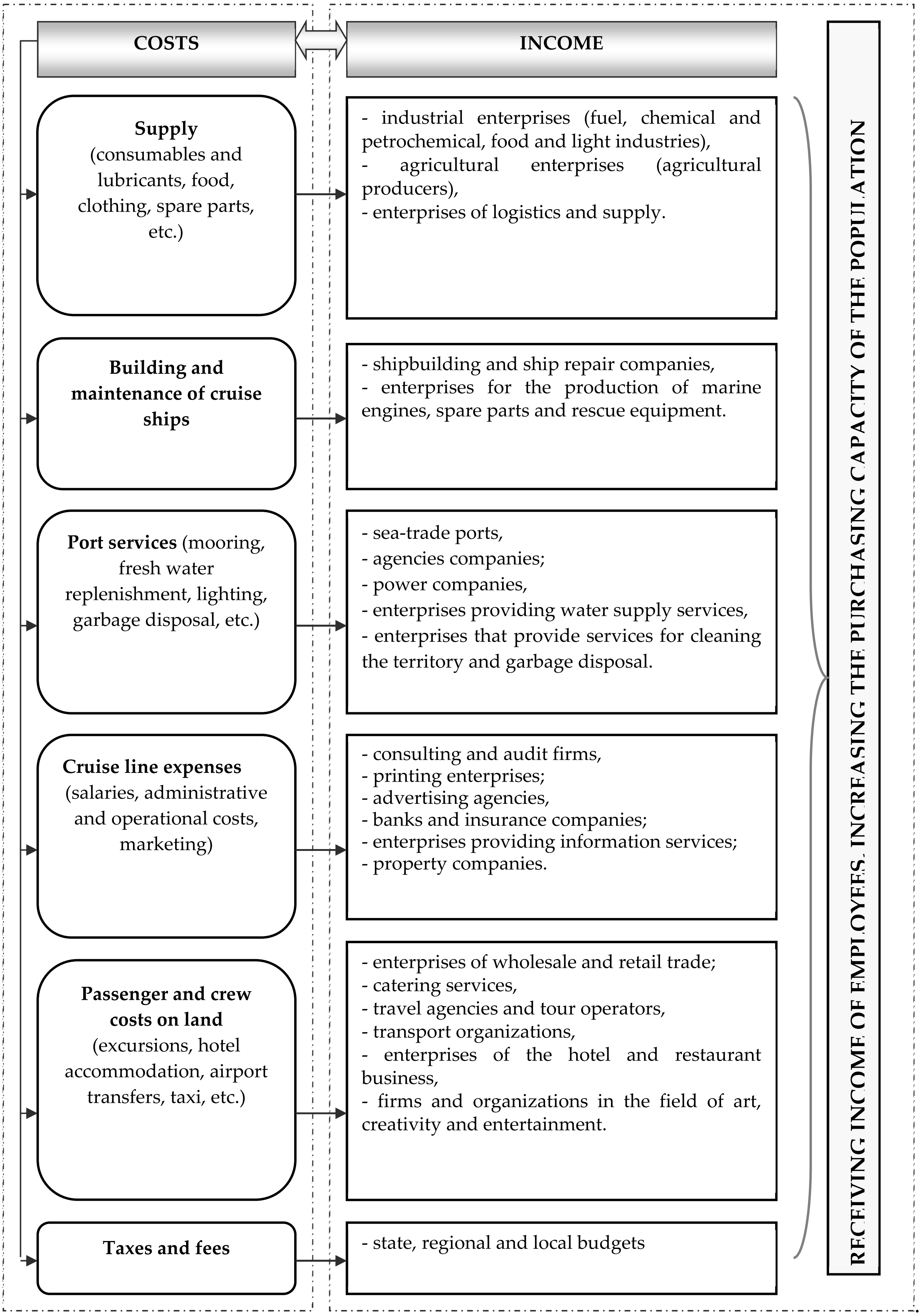


Figure 4. Sources of influence of the cruise industry on the economy.

As the result, the goal of cruise tourism modelling is determining the most suitable touristic areas and visualizing them on a cruise tourism suitability map. Suitability analysis described in this paper represents a search for an optimal location, area or route that is characterized by a combination of certain properties, appropriate for using or traveling. In our case it should be an area or route that will lead not only to the economic growth of cruise companies, but also to the satisfaction of tourists and to increasing their numbers. Also, an important result of cruise suitability analysis and planning is a decreasing harmful impact on the natural environment. The result of the suitability analysis often represents a suitability map. It shows which locations, areas or routes are suitable for tourism use in a form of a thematic map. The opposite variation of the suitability map is a risk map which segregates specific areas that are dangerous or not appropriate for tourism or that will not help to increase income or economic growth. The conduct of the suitability analysis and creation of the suitability map is based of analysis of variables with different genesis which are represented at Figure 3. Evaluation of suitability is often based on different methodologies and can be used not only for a good experience of other successful cases, but also in clustering a combination of variables and finding more suitable places. The most appropriate way to evaluate suitable areas for cruise tourism is to use the weights of evidence approach. Suitability analysis is this case based on fact that when we analyzing the factors for a given number of grid cells $\{D\}$, containing the event D and the total number of grid cells $\{T\}$, the prior probability is expressed by (1):

$$P\{D\} = \frac{N\{D\}}{N\{T\}} \quad (1)$$

Assuming that a binary predictor of influencing factor B occupies $N\{B\}$ grid cells, and if a certain number of known successful tourism area are within the cells of this factor, then the probability of suitability, given the possibility of the presence of a predictor factor and the absence of an influencing factor, can be expressed by (2) and (3).

$$p\{D|B\} = P\{D\}\frac{P\{D|B\}}{P\{B\}} \quad (2)$$

$$p\{D|\overline{B}\} = P\{D\}\frac{P\{D|\overline{B}\}}{P\{\overline{B}\}} \quad (3)$$

The posterior probability determines the presence or absence of a factor and is denoted by $\{D \mid B\}$ and $\{D \mid B-\}$, respectively. $\{D \mid B\}$ and $\{D \mid B-\}$ denote the posterior probabilities of finding the grid cells of factor B in the grid cells of event D.

Weights for binary factors are determined by (4) and (5):

$$W^{+} = \log_e \frac{P\{B|D\}}{P\{B|\overline{D}\}} \quad (4)$$

$$W^{-} = \log_e \frac{P\{\overline{B}|D\}}{P\{\overline{B}|\overline{D}\}} \quad (5)$$

where W^{+} and W^{-} are the weights of the absence or presence of factors affecting cruise tourism suitability, respectively.

The final result of the analysis using the weights of evidence method is the calculation of the cruise tourism suitability index (*CTSI*) by (6).

$$CTSI = \exp(\sum W^{+} + \ln(O_f)) \quad (6)$$

where O_f—weight coefficients of cruise tourism successfulness in the study area.

Thus, the creation of a cruise tourism product is a process of interaction of both production and non-production sectors of various economic sectors.

Therefore, cruise tourism is an intersectoral complex, which includes: cruise companies and cruise operators; transport organizations; collective and individual accommodation facilities; restaurant business enterprises, etc. Thus, cruise tourism is inextricably linked to the enterprises of related and supporting industries such as port and agriculture, shipbuilding and ship repair, mining and extractive industries, light and food industries and many other industries and enterprises (from manufacturers of electronic computers to organizations providing consulting and information services). All these industries help to ensure cruise tourism sector efficiency (Navarro-Ruiz et al. 2019).

According to the concept of effective development, the level of competitiveness of cruise tourism as an important economic sector depends on the degree of customer satisfaction. Meanwhile, a cruise tourism product is not just a set of interrelated tourist services. It helps to satisfy spiritual and emotional needs of a consumer and gain experience of staying in unusual conditions by contemplating an environment unusual for a tourist (Logunova et al. 2020; International Tourizm 2021; Papathanassis 2020; Navarro-Ruiz et al. 2020).

Consequently, discomfort even at one stage of the voyage will have a negative impression on the entire vacation and form a negative attitude towards both the cruise product itself and the companies that provide it, and towards the region in particular.

Thus, during a voyage, a cruise passenger consumes a variety of services: passenger transportation, accommodation, catering, trade, recreational and cultural, health, excursions, etc. However, first of all, a passenger needs life-support services, including housing, food, transport, leisure. This results in the creation of appropriate transport and tourist infrastructures, the necessary conditions for the development of which are: a favorable investment climate, initiative and interest from business structures and authorities, and the possibility of integration with international cruise organizations (Figure 5).

In addition to the COVID-19 pandemic, climate change is a major obstacle to tourism development. Small island states are particularly affected, where tourism accounts for nearly 40% of economic activity. However, with the right approach to rebuilding and developing the tourism sector, it can provide decent jobs and develop a viable inclusive economy that all members of society can benefit from. Analysis of the situation of tourism development is very relevant and important.

Information flow between sectors is key to understanding the impact of the pandemic and designing effective responses. Specific data on the socio-economic impacts of the COVID-19 pandemic on culture and tourism, as well as on solutions being implemented to rescue tourism will make it possible to develop mitigation plans to meet different needs and replicate best practices. The recovery and health improvement of citizens during a pandemic is another urgent task. Forecasting and analysis of monitoring the situation in the tourism sector is a strategic planning for the world.

Figure 6 shows the structural and logical model of cruise tourism functioning, based on the relationship of tourist needs according to the hierarchy of needs, the species classification of cruise tourism, and the industries involved in its development.

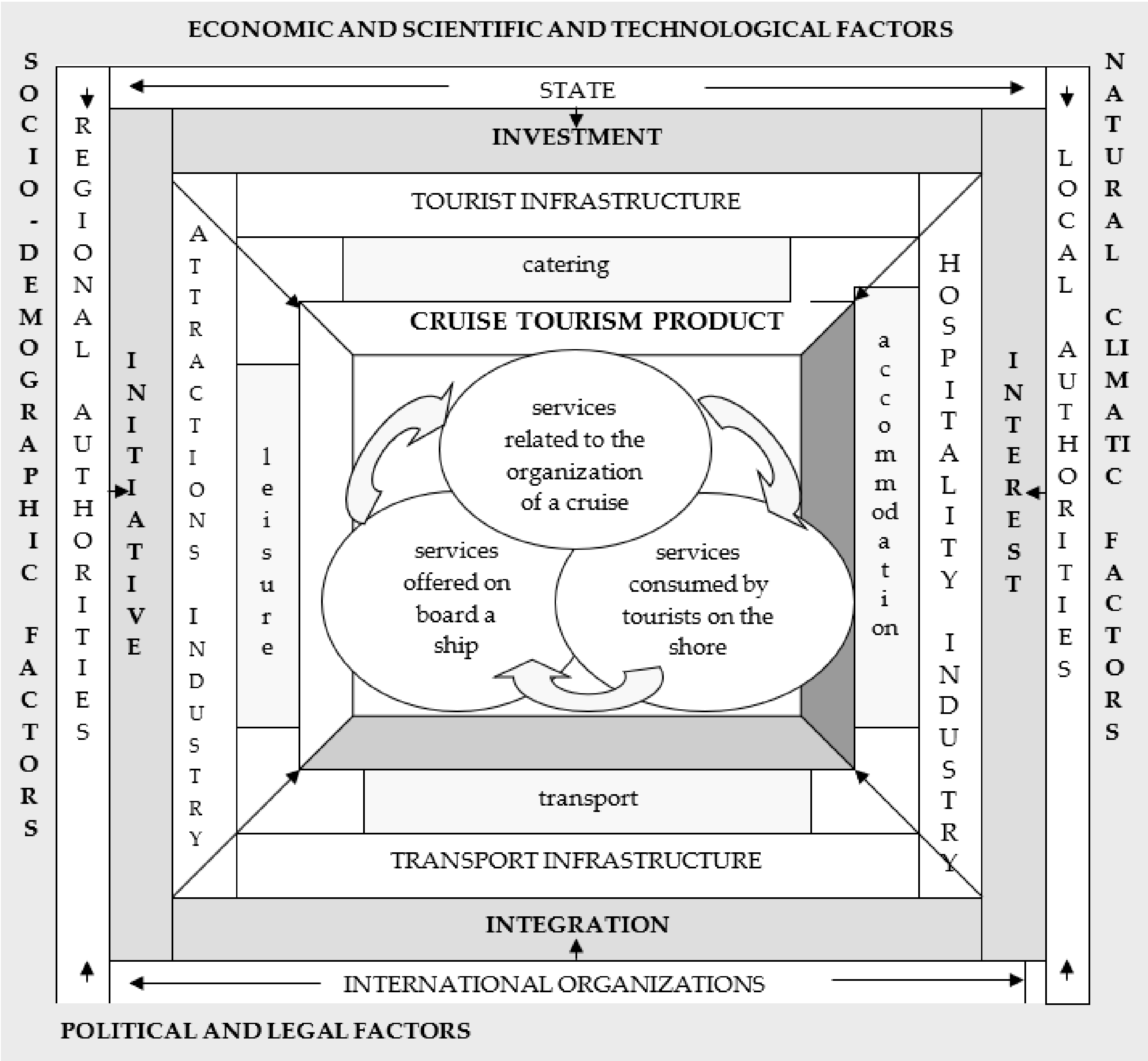
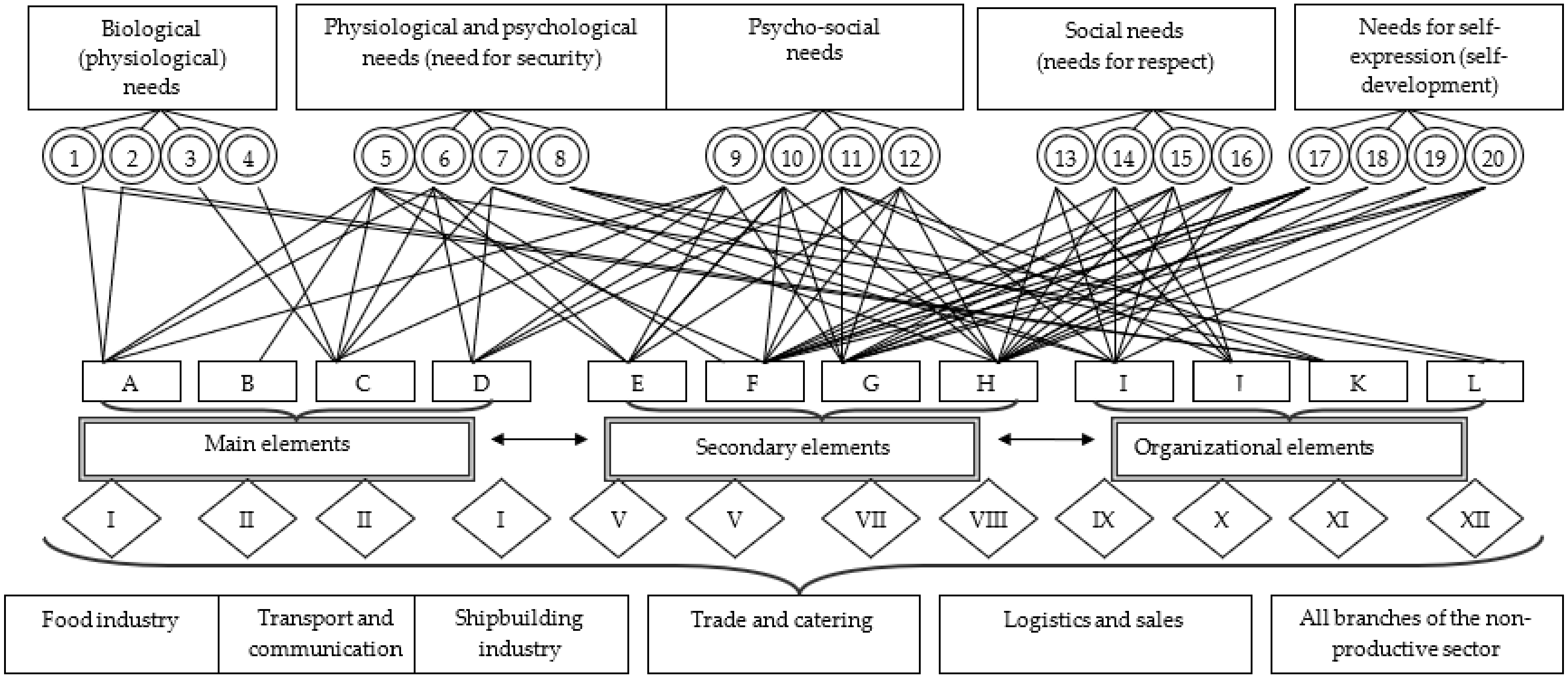


Figure 5. Model of functioning of a cruise tourism complex.



Notation keys: Needs: 1 - food, 2 - water, 3 - shelter, 4 - sleep, 5 - personal safety, 6 - health, 7 - family, 8 - stability, 9 - love, 10 - friendship, 11 - communication, 12 - support from others, 13 - recognition, 14 - respect, 15 - approval, 16 - self-esteem, 17 - personal improvement, 18 - personal development, 19 - creativity and creation, 20 - the realization of goals and abilities.

Elements of cruise tourism: A - food system, B - transport service system, C - hospitality system, D - entertainment system, E - health resort complex, F - sports complex, G - cultural and educational complex, H - educational complex , I - financial and information service system, J - excursion service system, K - trade service system, L - consumer service system.

Types of cruise tourism: I - historical and cultural tourism, II - congress tourism, III - expedition tourism, IV - educational tourism, V - retro tourism, VI - scientific tourism, VII - gastronomic tourism, VIII - religious tourism, IX - rural tourism, X - yachting tourism, XI - sports tourism, XII - wedding tourism

Figure 6. Structural and logical model of the cruise tourism functioning.

4. Data Visualization and Forecasting in a Geographic Information System (GIS)

A practical part of cruise tourism mostly depends on the environmental state. Different environmental variables can impact on its success. Routing of the cruise vessel must be based on the suitability of the environmental drivers. For example, sea temperature and salinity can impact on a good climate and sea state for tourist relaxation, while a high level of chlorophyll-a or water pollution can decrease attractiveness. Great importance is also attached to fisheries, the impact of which can be reflected in overloading of the marine environment with water and noise pollution, decreasing tourist happiness. This variable reflects not only the environmental state of the cruise area, but also the political and economic situation there (Ruan and Zhang 2021; Mahon et al. 2021; Stojčić et al. 2021).

Based on this we suggest complex system from visualization to forecasting using spatial data and GIS technologies.

Environmental and economic data were provided by the EMODnet Central Portal and Copernicus Marine Environment Monitoring Service. Data were processed using QGIS 3.12. Complex analysis of indicators allows monitoring based on fundamental models and with the possibility of real-time mode. Timely dynamics allow the building of both economic and socio-economic trends.

This model based on the machine learning approach with combining Bayesian networks and k-means clustering (Yemelyanov et al. 2021). This will helps to distinguish different zones that are suitable and unsuitable for cruise tourism.

Bayesian networks are partly based on determining the structure and interactions of environmental variables between each other. Generally, Bayesian network can be represented as an acyclic graph where nodes describe different variables, while edges are relations between them. In the case of cruise tourism these variables have environmental, economic or political origins. For example, as Bayesian network nodes X_n can be water temperature, water pollution, fisheries areas, etc. Every node X_i in a network can be connected with the node X_j by an edge, that represents manifestations' probability of node X_j from node X_i:

$$P(X_1, \cdots, X_n) = \prod_{i=1}^{n} p(X_i|Pa(X_i))$$

where probability X_i depends from probability of corresponding connected node and is represented by a random value.

Calculations of the cruise tourism structure were undertaken using R-package «bnlearn» inside QGIS with RQGIS connector.

Spatial zoning of the marine area was undertaken using a k-means clustering approach. Clustering means a task of dividing of a dataset into several dissimilar groups based on different variables. Zoning using k-means clustering consists of several steps:

1. Selection of appropriate variables in dataset;
2. Data normalization;
3. Verification of clustering tendency;
4. Optimal number of clusters selection;
5. Clustering and validation.

To predict cruise tourism suitability in the Mediterranean Sea as variables we choose sea surface temperature, fish species diversity, primary net production, sea surface salinity, water pollution, chlorophyll-a and dissolved oxygen concentration, PO_4 and popular fishing areas (Figure 7).

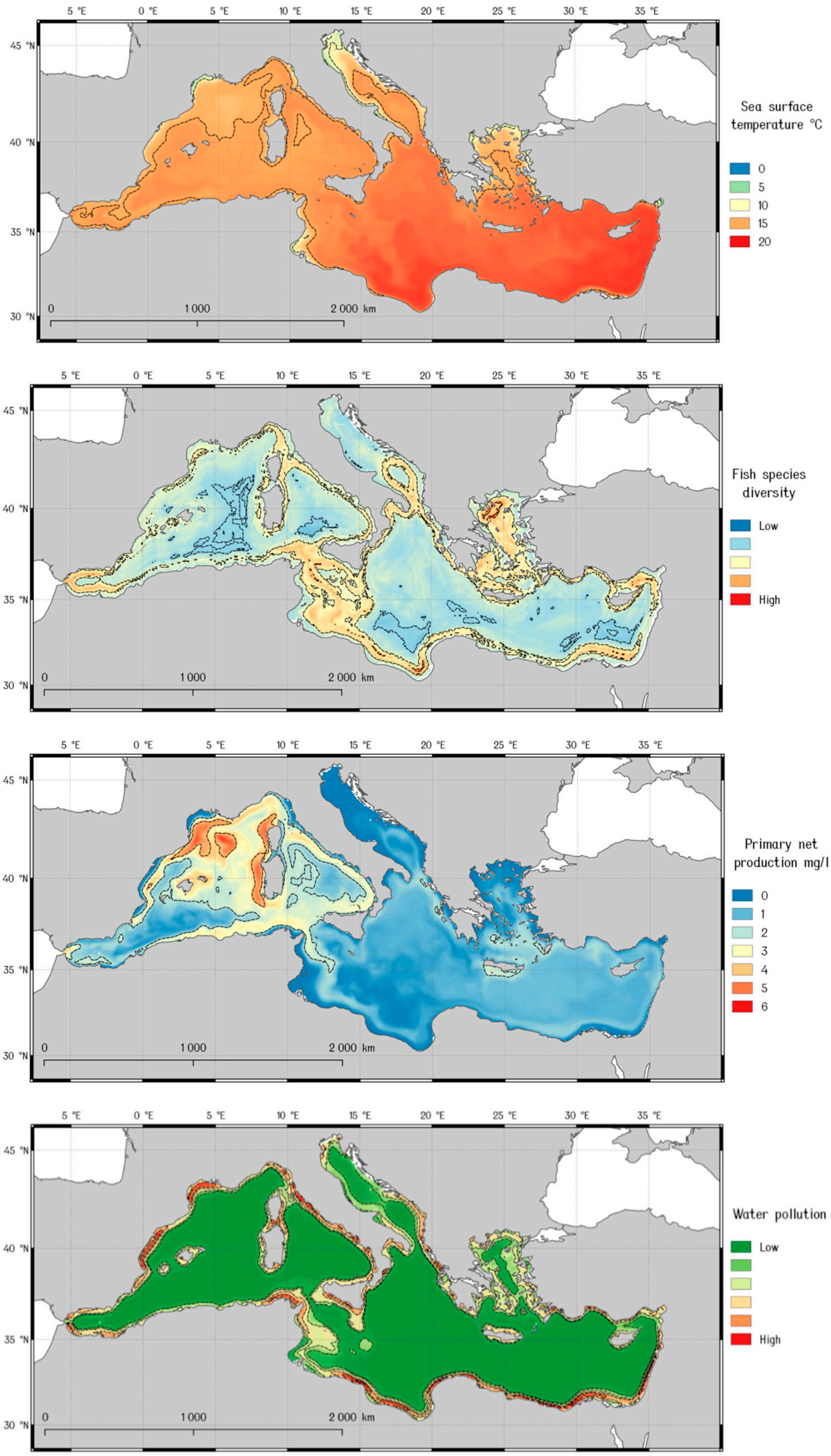
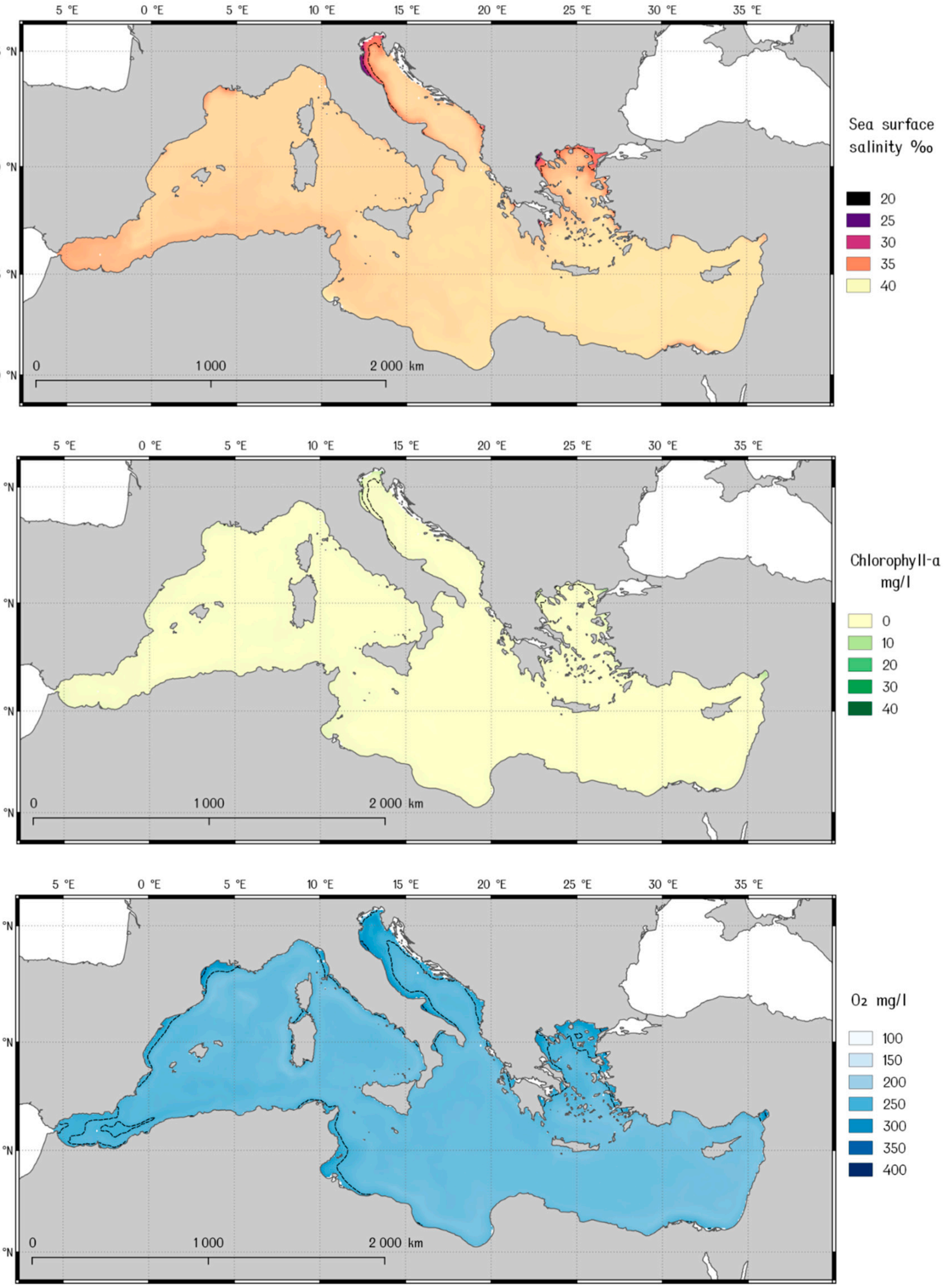


Figure 7. *Cont.*



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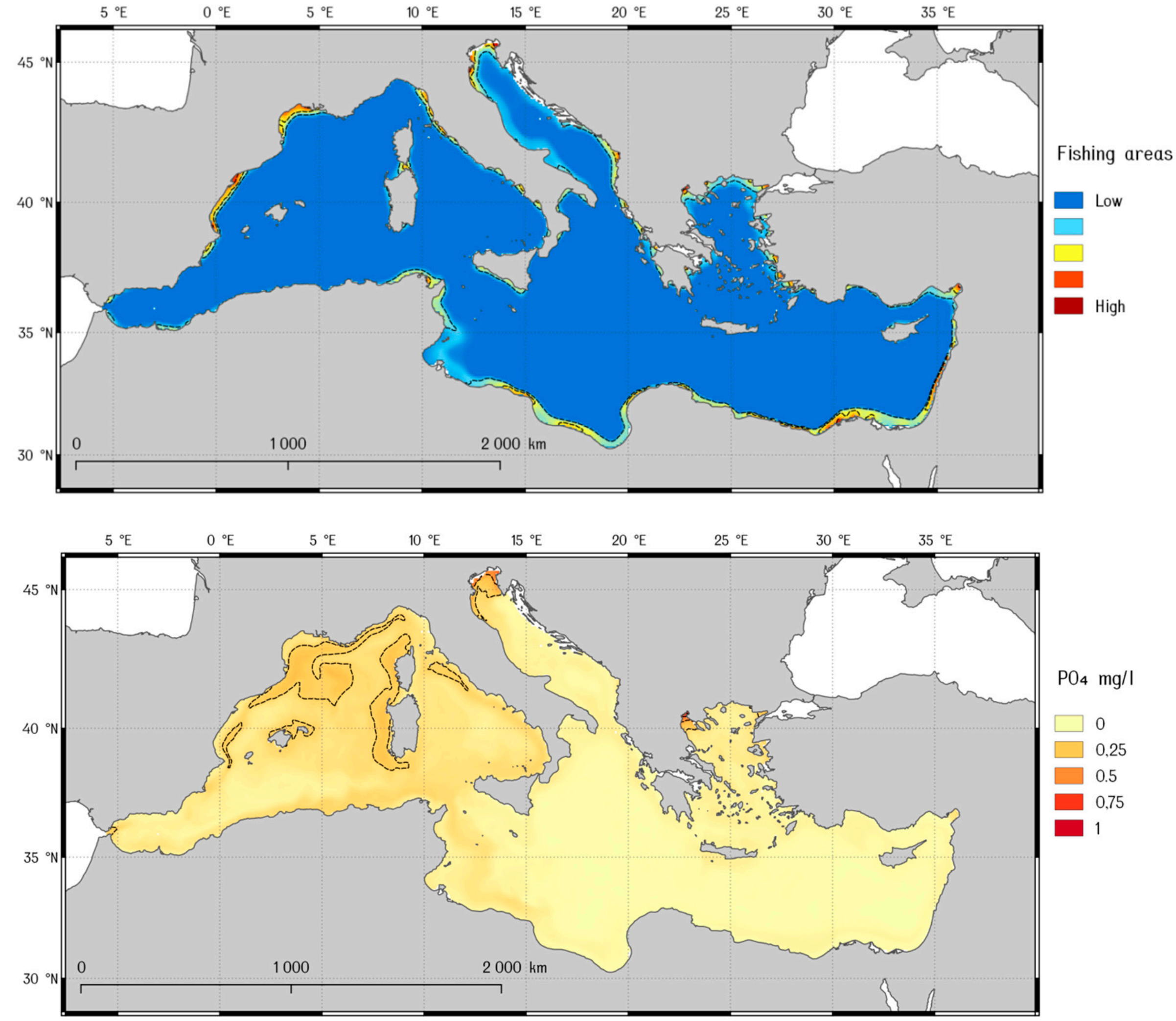

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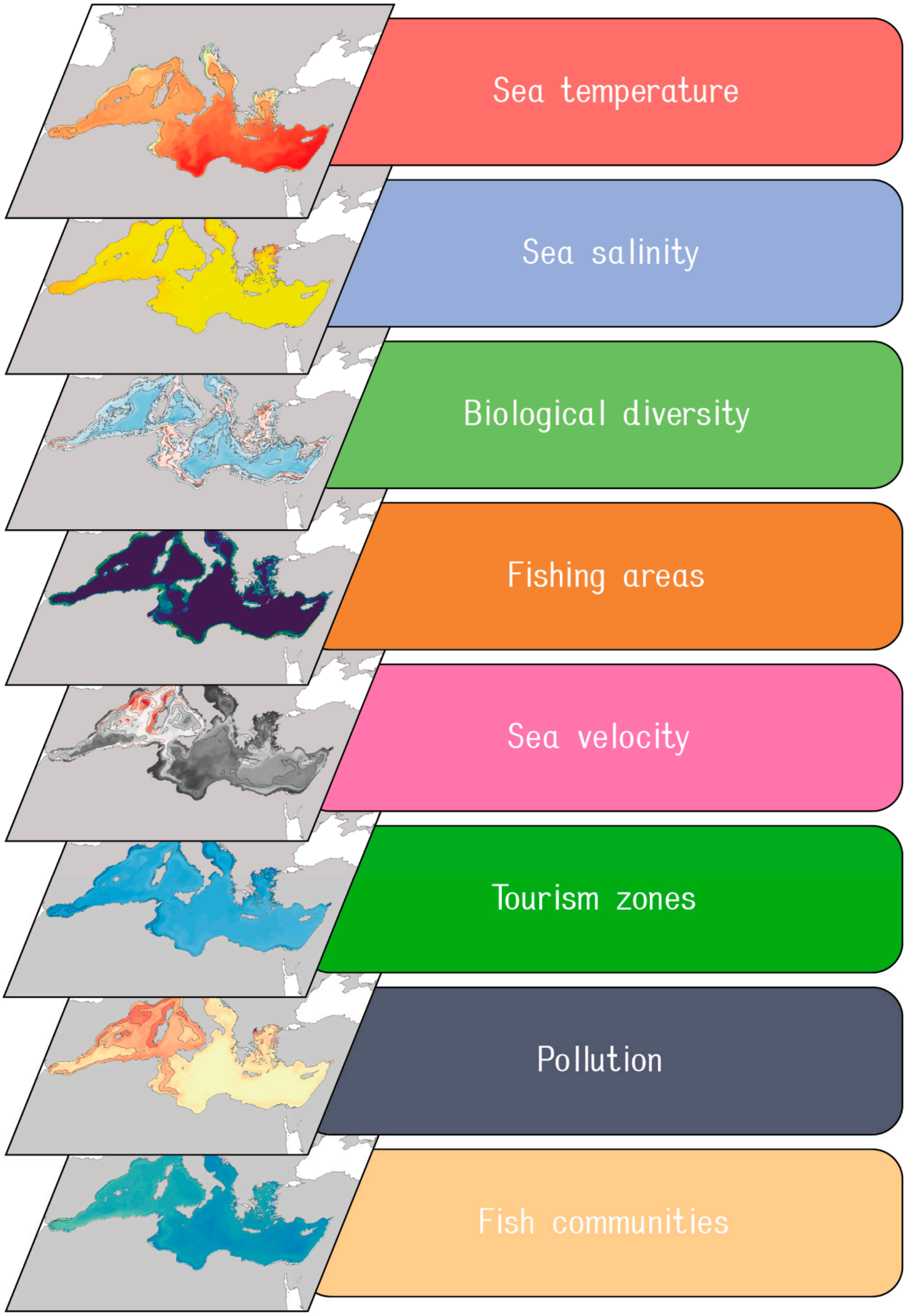


Figure 7. Information modeling of tourism resource.

To perform k-means clustering in QGIS we used the SAGA module k-means clustering for grids.

Let us simulate our indicators and the structures described above in a geoinformation modeling environment (Figure 7).

As a result, we receive a final map with clustered areas (Figure 8). The most suitable for cruise tourism are areas with high and very high suitability (blue and green). Most of these areas are located near the shoreline and in the central part of the Mediterranean Sea. The main reason for such zonation, in our opinion, is based on the domination of suitable parameters for the environmental variables, that provide good and attractive conditions for tourists. Areas with low and very low suitability for tourism are located in the most polluted areas with high industrial pressure. Models and characteristics of critical quality indicators can be either assessed by experts in a simple manner or implemented using information technologies and neural networks.

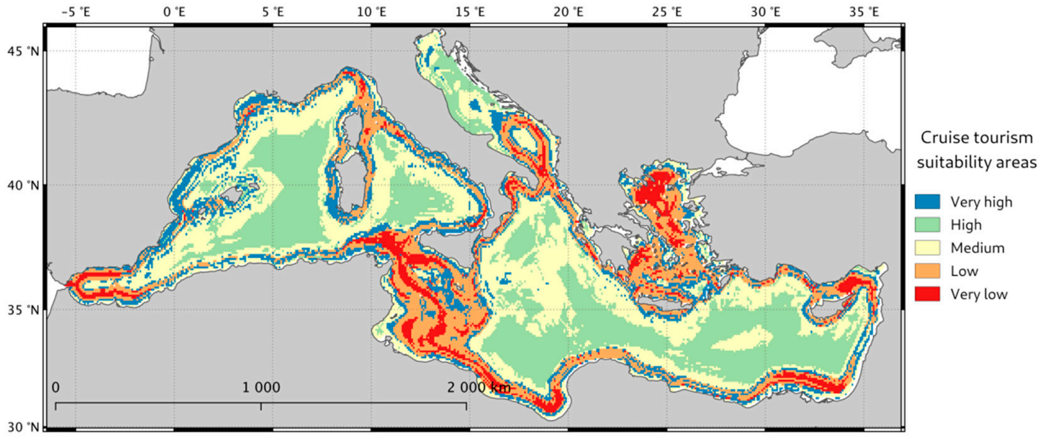


Figure 8. Cruise tourism suitability map.

Thus, the cruise tourism development depends on all economic sectors, which are closely interconnected and together create a high-quality cruise product.

Covering all spheres of economic activity, the cruise industry provides an opportunity for the simultaneous development of many unrelated types of industries. Thereby, it contributes to an increase in the competitiveness and performance of both the enterprises involved in the process of creating a cruise product and the economic growth of the region and the country as a whole.

In order to ensure high growth rates of the national cruise market and find quantitative parameters, we carried out economic and mathematical modeling based on the construction of an empirical regression equation, which makes it possible to assess the degree of influence of individual variables on the level of effectiveness of the development of cruise tourism of the most successful tourist destinations.

It should be noted that, mathematically, the problem of correlation-regression analysis is reduced to the search for an analytical expression that would reflect as best as possible the relationship of factor attributes with a productive attribute, i.e., to finding the function $\overline{y}_x = f(x_1, x_2, x_3, \ldots, x_n)$:

Taking into account that any function of several variables can be brought to a linear form by a logarithm or change of variables, the multiple regression equation was expressed in linear form, and the parameters of the equation were found by the least squares method:

$$\overline{y}_x = a_0 + a_1x_1 + a_2x_2 + a_3x_3 + \ldots + a_nx_n.$$

where $\overline{y}_x$—the calculated values of the effective feature-function;

$x_1, x_2, \ldots, x_n$—factorial signs;

$a_0, a_1, a_2, \ldots, a_n$—parameters of the equation.

The selection of variables in the multiple regression equation was carried out using a step-by-step approach, according to which the factors are included in the equation sequentially, then their significance is checked and it is determined how much the sum of squares of the residuals decreases and the multiple correlation coefficient increases. In this case, the addition of new explanatory variables to the model was carried out as long as the adjusted coefficient of determination and the value of the Fisher criterion grew.

As an effective indicator, it was decided to use direct income from cruise tourism (Y), and factor indicators gradually introduced into the model were indicators characterizing the economic, social and resource efficiency of the cruise industry:

- number of tourists who preferred cruises, thousand people (x_1);
- index of competitiveness of travel and tourism of a particular country (x_2);
- length of the coastline of the state, km (x_3);
- index of the cost of living (x_4), which determines the level of prices in a particular country;
- the number of workers in the cruise industry, thousand people (x_5);
- capital investments in the development of the tourism sector, million euros (x_6);
- average monthly salary of one worker in the cruise industry, EUR/person (x_7);
- number of ports with the necessary infrastructure to receive cruise ships (x_8),
- labor productivity of workers in the cruise industry, thousand euros/person (x_9).

At the same time, the selected variables reflected the average values of the development of the European cruise market for 2005–2011 (Tables 1 and 2).

To establish the correspondence of the mathematical model to the experimental data and to assess the adequacy of the inclusion of explanatory variables in the equation in order to describe the dependent variable, the adequacy of the model was checked by calculating the average approximation error. As a result of the values obtained, three countries (Denmark, Finland and the Netherlands) were excluded from the sample of 15 European countries, the approximation error of which exceeded 40%. This took into account the fact that, starting with the six-factor model, the coefficients of determination had rather high values; in addition, the actual Fisher criterion significantly exceeded the tabular indicators, in order to avoid penetration into the regression equation of the random term for choosing the most adequate model, and we calculated the parameters at which the average approximation error reaches the smallest value using the Excel program and the Search for solution function.

It should be noted that, despite the preservation of the general proportions, the parameters of the regression equations using two different methods are somewhat different. In addition, given that the values of the regression coefficients do not allow one to judge which of the factor indicators included in the model has a greater effect on the level of direct income from cruise tourism, since the coefficients are incomparable with each other and in fact the phenomena reflected by them are not only incomparable but also expressed in different units of measurement, we calculated the partial coefficients of elasticity and β-coefficients.

Partial coefficients of elasticity (ε_i) were determined by the formula:

$$\varepsilon_i = a_i \frac{\overline{x}_i}{\overline{y}}$$

where a_i is the regression coefficient for the i-th factor;

$\overline{x}_i$—the average value of the i-th factor;

$\overline{y}$—the average value of the effective factor;

Table 1. Calculation table for constructing a nine-factor model of the dependence of the income level of the European cruise industry on explanatory variables.

Country	National Tourists, Thousand People	Travel and Tourism Competitiveness Index	Length Coastline, km	Cost Index Life	The Number of Employees in the Cruise Industry, Thousand People	Capital Investments in the Tourism Sector, Million Euroso	Average Monthly Wage per Employee, EUR/Person	Number of Ports, Units	Labor Productivity, Thousand Euros/Person	Direct Income the Cruise Sector, Million Euros	Theoretical Income, Million Euros	Absolute Deviation, Million Euroso	Error Approximations
	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	y			
Greece	17,500	4.75	13,676	89.81	3570	5443	1,614,510	103	112,745	438,429	455,111	16,682	0.038
Norway	22,500	4.95	25,148	139.53	4332	2636	2,615,120	79	89,576	411,714	404,841	6873	0.017
Denmark	26,000	4.98	7314	119.67	0.790	1892	2,946,770	159	177,848	140,500	140,473	0.027	0.000
Portugal	29,286	5.01	1793	73.09	2712	2971	1,171,390	29	51,622	166,000	113,489	52,511	0.316
Malta	9000	4.92	197	78.23	0.971	0.144	940,980	2	88,614	76,952	64,691	12,261	0.159
Cyprus	23,000	4.84	648	90.96	0.520	0.324	1,501,500	4	98,171	49,571	52,351	2779	0.056
Austria	71,857	5.39	0	95.23	0.357	2757	3,712,880	4	109,397	34,714	34,711	0.004	0.000
France	320,000	5.31	4853	101.17	5420	17,214	3,779,120	159	162,377	1,032,571	1,030,242	2330	0.002
Italy	709,143	4.90	7375	95.85	34,081	14,600	2,533,580	311	101,979	3,833,857	3,841,321	7464	0.002
Spain	531,429	5.38	4964	76.08	8291	17,314	2,533,080	105	119,467	1,004,857	1,364,540	359,683	0.358
Germany	949,714	5.39	2389	87.19	12,489	15,314	3,043,390	98	144,012	1,998,714	1,998,178	0.536	0.000
United Kingdom	1,420,286	5.38	12,429	93.80	21,340	8643	3,044,350	389	105,811	2,225,000	2,225,195	0.195	0.000
Average across countries	344,143	5.10	6732	95.05	7906	7438	2,453,056	120	113,468	951,073	977,095	38,445	0.079
Elasticity Coeffi-cients	0.096	−0.474	0.024	0.024	0.949	0.217	−0.094	−0.254	0.540	-	-	-	-
β-coefficient	0.104	−0.019	0.021	0.004	0.995	0.161	−0.029	−0.208	0.132	-	-	-	-

Table 2. Variation of parameters of multiple regression equations.

Characteristic	Factor Parameters									Multiple Correlation Coefficient, R	Multiple Determination Coefficient, R^2	Adjusted Coefficient of Determination	Fisher's Criterion Actual	Fisher's Criterion is Tabular	Significance Fisher's Criterion
	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9						
Pairwise linear regression	1.9817	-	-	-	-	-	-	-	-	0.7842	0.6150	0.5765	15,977	4.96	0.0025
Two-factor model	2.546	−1,813,968	-	-	-	-	-	-	-	0.8431	0.7108	0.6465	11,058	4.26	0.0037
Three-factor model	2.580	−1,897,966	−0.007	-	-	-	-	-	-	0.8439	0.7123	0.6045	6603	4.07	0.0148
Four-factor model	2.754	−2,108,604	−0.031	12,172	-	-	-	-	-	0.8529	0.7274	0.5717	4672	4.12	0.0374
Five-factor model	0.125	193,841	−0.014	4379	109,807	-	-	-	-	0.9862	0.9725	0.9497	42,513	4.39	0.0001
Six factor model	0.386	−581,902	−0.023	8383	89,800	38,872	-	-	-	0.9960	0.9921	0.9826	104,538	4.95	0.0001
Seven-factor model	0.390	−613,355	−0.022	7931	89,577	38,504	0.012	-	-	0.9960	0.9921	0.9783	95,527	6.09	0.0004
Eight factor model	0.709	−1142,212	−0.015	4822	94,176	34,865	0.154	−1684	-	0.9982	0.9964	0.9868	103,427	8.85	0.0014
Nine Factor Model	0.267	−85,828	0.004	0.231	113,763	27,816	−0.040	−2017	4514	0.9983	0.9966	0.9814	65,513	19.38	0.0151
Average parameter value	1.343	−1,111,065	−0.017	6833	96,868	35,287	0.095	−1783	1514	-	-	-	-	-	-
Average standard deviation, σ	1.034	739,485	0.008	3016	7677	4003	0.060	0.099	-	-	-	-	-	-	-
Coefficient of variation, CV, %	76,955	−66,556	−44,323	44,137	7925	11,345	63,583	−5526	-	-	-	-	-	-	-

$$У = 0.448 + 0.267x_1 - 85{,}828x_2 + 0.004x_3 + 0.231x_4 + 113{,}763x_5 + 27{,}816x_6 - 0.040x_7 - 2017x_8 + 4514x_9.$$

Beta coefficients (β_i) were calculated using the formula:

$$\beta_i = a_i \frac{\sigma_{x_i}}{\sigma_y}$$

where σ_{x_i}—standard deviation of the *i*-th factor;

σ_y—standard deviation of the effective trait.

To characterize the tightness of communication in multiple linear correlation, the multiple correlation coefficient ($R_{yx_1x_2}$) was used, calculated by the formula:

$$R_{yx_1x_2} = \sqrt{\frac{r^2_{yx_1} + r^2_{yx_2} - 2 \cdot r_{yx_1} \cdot r_{yx_2} \cdot r_{x_1x_2}}{1 - r^2_{x_1x_2}}}$$

$r_{yx_1}; r_{yx_2}; r_{x_1x_2}$—paired linear correlation coefficients, allowing to evaluate the influence of each factor separately on the effective indicator, and determined by the formulas:

$$r_{yx_1} = \frac{\overline{yx}_1 - \overline{y} \cdot \overline{x}_1}{\sigma_y \cdot \sigma_{x_1}}; \quad r_{yx_2} = \frac{\overline{yx}_2 - \overline{y} \cdot \overline{x}_2}{\sigma_y \cdot \sigma_{x_2}}; \quad r_{x_1x_2} = \frac{\overline{x_1x_2} - \overline{x}_1 \cdot \overline{x}_2}{\sigma_{x_1} \cdot \sigma_{x_2}}.$$

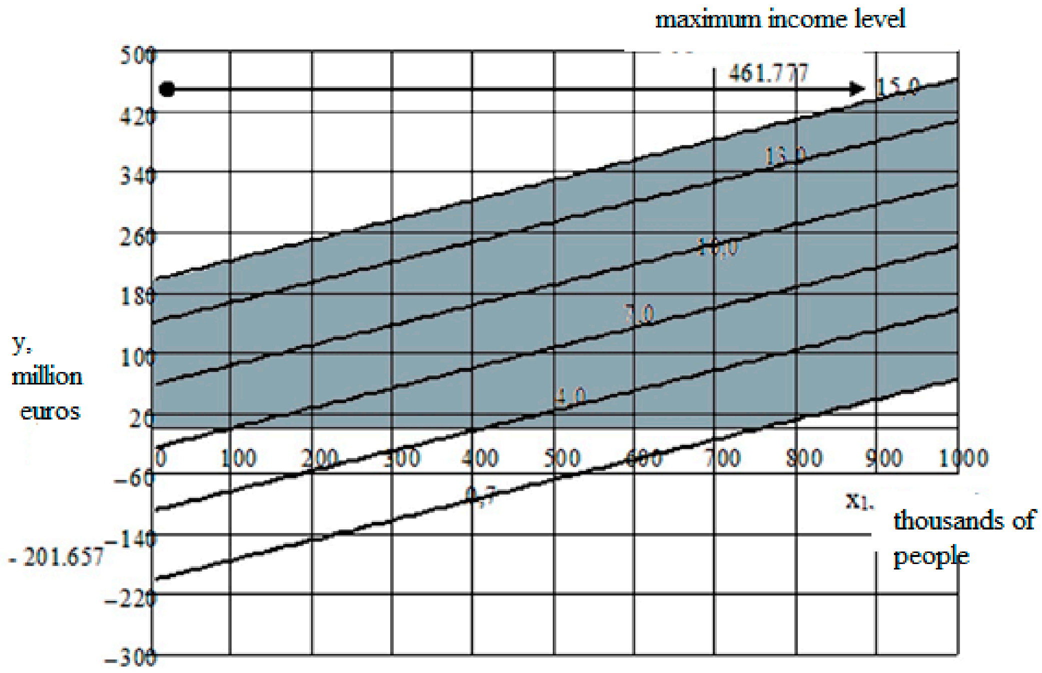
On the basis of paired correlation coefficients, partial first-order correlation coefficients were found, showing the relationship of each factor with the investigated indicator under conditions of complex interaction of factors, calculated by the formulas:

$$r_{yx_1(x_2)} = \frac{r_{yx_1} - r_{yx_2} \cdot r_{x_1x_2}}{\sqrt{\left(1 - r^2_{yx_2}\right) \cdot \left(1 - r^2_{x_1x_2}\right)}}; \quad r_{yx_2(x_1)} = \frac{r_{yx_2} - r_{yx_1} \cdot r_{x_1x_2}}{\sqrt{\left(1 - r^2_{yx_1}\right) \cdot \left(1 - r^2_{x_1x_2}\right)}}.$$

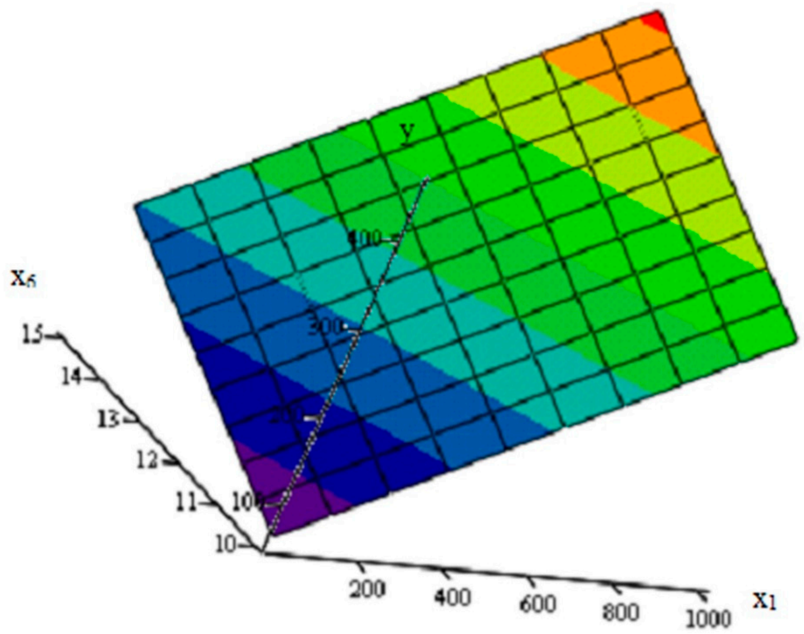
The scale of the negative consequences depends on the type of transport and the state's integration into the global transport and logistics structure. During the first wave of the pandemic, up to 90% of flights were canceled in EU countries, and there was a decrease in the volume of passenger traffic by cars in the aisles of 60–90%, and by public transport by about 50% (McCarthy 2003). According to the generalized data for 2020, the global volume of freight traffic will decrease by approximately 36%, and the losses of Russian transport companies will amount to 230 billion rubles. Today, the countries are in a transitional stage: in the transport sector, there is an adaptation to the updated conditions of activity and adaptation to new conditions. However, there are a number of risks involved (Shpilko and Androsova 2012; Yemelyanov et al. 2021; UNWTO 2020a, 2020b, 2020c).

According to the calculations, the most complete relationship between the level of income obtained as a result of entrepreneurial activity in the cruise business is described by the nine-factor model, the average approximation error of which has the smallest value (7.91%) (Figures 9–11) (Ruan and Zhang 2021; Mahon et al. 2021; Stojčić et al. 2021; Lloret et al. 2021; Ren et al. 2021; Yuen et al. 2021; Yang et al. 2021; Logunova et al. 2020):

Of particular importance for the development of cruise tourism are investments, which, according to J. Christopher Holloway, are a key criterion for determining the degree of success of the tourism industry in a particular destination, and on the technical condition of infrastructure facilities, production (transport, communications, construction, water-heat and energy supply) and social (trade, public catering, consumer services, cultural, children's, medical institutions) components, which is confirmed by the parameters of the regression equation (coefficient at ×6): an increase in capital investment by 1 million euros generates an inflow of direct revenues from the cruise sector of more than 27 million euros.



(a)



(b)

Figure 9. Impact of cruise passenger traffic and capital investment growth on the tourism sector to the level of direct income from cruise tourism: (**a**) change in direct income of cruise tourism, subject to an increase in capital investments from 0.7 to 15 million euros and cruise passenger traffic from 5 to 1000 people; (**b**) change in direct income from cruise tourism, subject to an increase in capital investments from 10 to 15 million euros and cruise passenger traffic up to 1000 people.

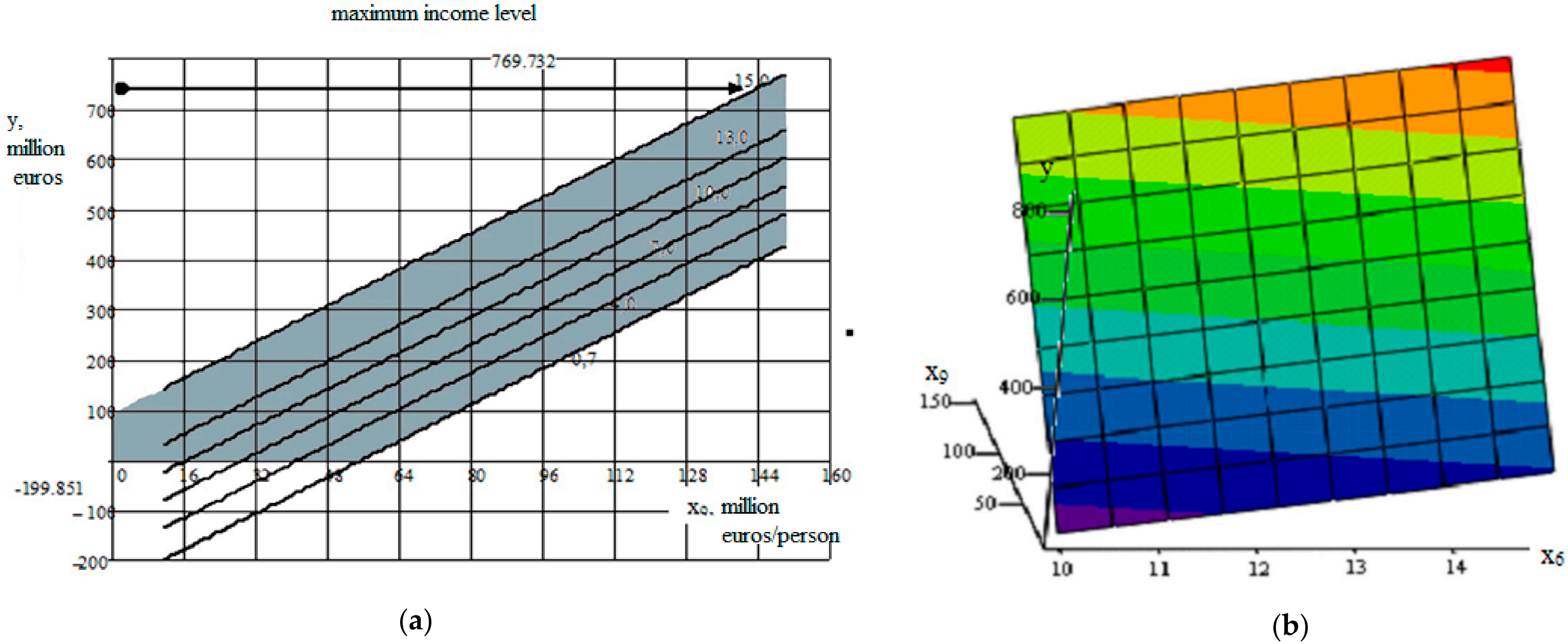


Figure 10. Impact of worker productivity growth and capital investment in the tourism sector to the level of direct income from cruise tourism: (**a**) change in direct income from cruise tourism, subject to an increase in capital investments from 0.7 to 15 million euros and labor productivity from 10 to 150,000 euros/person; (**b**) change in direct income from cruise tourism, subject to an increase in capital investments from 10 to 15 million euros and labor productivity up to 150,000 euros/person.

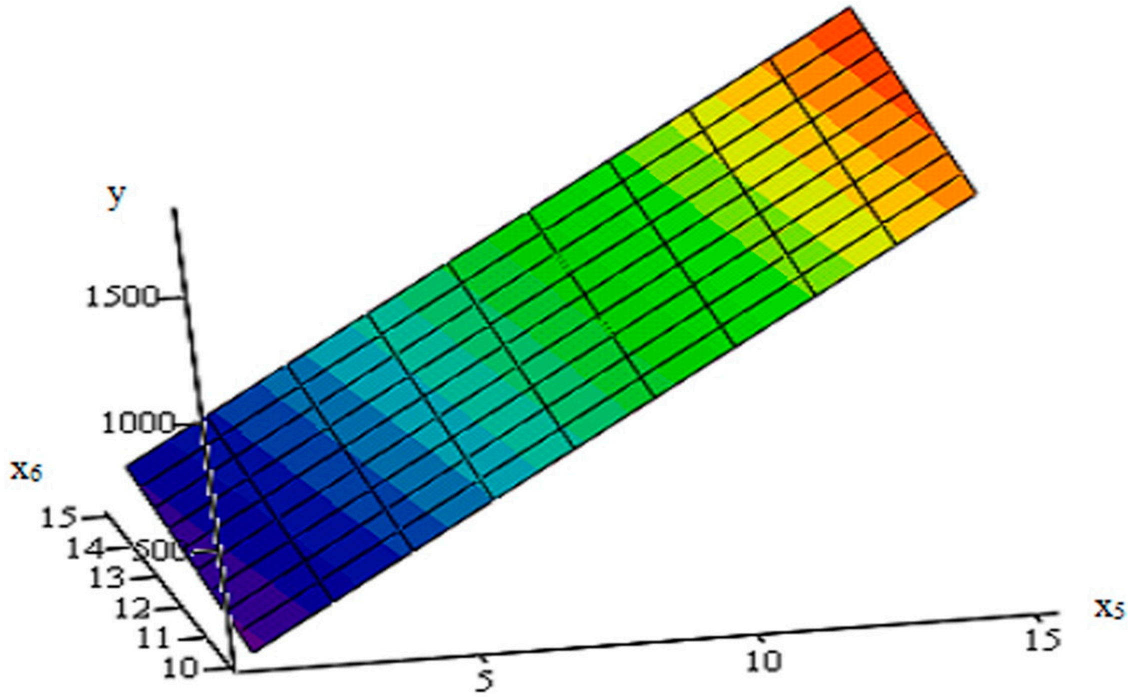


Figure 11. Impact of the growth in the number of workers employed in the cruise industry and capital investment in the tourism sector on the level of direct income from cruise tourism.

The impact of COVID-19 on passenger maritime transport has also been colossal, especially as some countries advised against sailing and major cruise lines suspended operations. Cruise shipping is one of the key tourism industries and makes a significant contribution to the economies of the countries to which tourists travel, especially SIDS. Cruise tourism, serving 28.5 million passengers, generated approximately $150 billion in global goods and services production in 2018 and generated over 1 million jobs, according to the International Association of Cruise Lines (ICL). Along with the impact on jobs, as of early August, some 5000 seafarers were still on board cruise ships awaiting repatriation, which was delayed by the closure of ports and lack of coordination and support between countries (UNWTO 2020b).

It was found that the number of workers employed in this area and the level of their labor productivity have the greatest impact on the development of cruise tourism, which is fully consistent with the generally accepted statement about the importance of the most important resource of any state—a person, as well as investment in infrastructure development and objects of tourist interest.

5. Conclusions

The global transport and logistics system turned out to be one of the areas most affected by the pandemic (COVID-19). The negative consequences are based on various factors: the closure of state borders, the imposition of restrictions on the movement of people and goods, the rupture of supply chains, and a decrease in demand and purchasing power. The combination of these factors affected all types of transport—from the use of personal and public transport in cities to the implementation of passenger and freight transport both within countries and between them.

The impact of COVID-19 on tourism is fraught with increased poverty (SDG 1) and inequality (SDG 10), and risks undermining conservation efforts. The pandemic also risks slowing progress towards the Sustainable Development Goals (SDGs) (http://tourism4sdgs.org) (accessed on 1 May 2021). The variety of approaches to the process of creating a cruise tourism product predetermines the representation of the cruise industry as a special socially relevant independent industry that ensures the implementation of tourist needs and is carried out at all stages of a cruise, from the provision of accommodation and catering services (physiological needs) to cognitive and creative processes (self-development).

The paper provides a methodological analysis of the sea tourism industry. Algorithmic and conceptual bases of situation analysis are proposed. An overview of the state of the industry during the COVID-19 pandemic was undertaken. We developed an interactive GIS monitoring map for industry tracking analysis and decision support.

Connectivity provided by air, land and sea transport forms the backbone of tourism. Before the crisis, roughly 58% of the 1.5 billion tourists who crossed borders annually traveled by air, and 39% of travelers used ground transportation (UNWTO Tourism Data Dashboard, Global and Regional Tourism Performance, available at https://www.unwto.org/global-and-regional-tourism-performance) (accessed on 1 September 2021).

In connection with the pandemic, large banks and other financial institutions have lowered their forecasts regarding the growth of the global economy. Due to the pandemic, the incomes of the population have decreased, and some citizens have completely lost their jobs. This negatively affected the retail, aviation and restaurant business. The pandemic has had this impact on the service sector in most countries, including Russia and the United States. The risks and fears associated with coronavirus have negatively impacted investor sentiment, resulting in a sharp decline in share prices in major markets.

The analysis has looked at the state of the transport maritime industry in the period before and during COVID-19. On the basis of predictive and factorial models, functional diagrams and factorial analyzes of indicators were built (Figures 9–11). A model for monitoring the situation in the industry is proposed. An illustrative example of modeling in a geoinformation system environment of components (Figures 7 and 8) is presented. This allows us to build active and timely cloud models during the digitalization period.

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ORIGINAL PAPER

Systems engineering and digital twin: a vision for the future of cruise ships design, production and operations

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Abstract
Cruise ships are among the most complex and demanding products of the shipbuilding industry. The very special "payload" and exclusive operational profile, i.e. passengers looking for leisure and entertainment, imply outstanding performances in terms of safety standards and customer satisfaction. Attention to environment is relevant as well, since these ships are used to operate in spectacular marine ecosystems. The need of European shipyards to continuously progress to preserve the market leadership requires a virtuous evolution of the ship design process projected on a life cycle perspective. In this regard Systems Engineering appears to be a robust and reliable paradigm, able to provide the necessary comprehensive view of the cruise ship system as a whole together with a systematic methodological framework that, among the other advantages, enables the active and constructive participation of all the involved stakeholders in the decision-making process. In particular, Systems Engineering strongly relies on the so-called model-based engineering to share, integrate, combine and improve the level of details relevant to the system under development. In this paper the digital twin model will be discussed as a natural evolution of above-mentioned model-based engineering and its utilization in the shipbuilding field will be described as a very promising application especially in the field of cruise ships.

Keywords Digital twin · Systems engineering · Cruise vessels

1 Introduction

Shipyards specialized in delivering ships characterized by outstanding economical value and intensive technology application need to continuously evolve to better fulfill the growing expectations of the market in a scenario of evolving competitiveness.

The successful exploitation of digitalization, as an enabling technology, is one of the several strategies to this aim, permitting continuous improvement of design solutions in alliance with innovative technology implementation. At present, the use of digitalization in the whole shipping field, well beside the only shipyards' domain, is definitely a hot topic.

One of the most complex products of the shipbuilding industry is the cruise vessel, characterized by passengers as a very special "payload", which implies demanding performances in terms of customer satisfaction together with the highest safety standards. At the same time, this ship typology is used to operate in the most wonderful marine areas all over the world, entailing therefore a noteworthy attention to the environmental issues.

Beside the unquestionable priority of safety and environmental friendliness, the huge number of persons onboard, several thousands, amplifies the challenges also in terms of comfort and entertainment issues targeted for example by the inspired spaces and areas solutions onboard, proper energy production and delivery for lighting, conditioning systems, fresh water, restaurant and bar services.

In addition to the challenges during the design process, it is not difficult to imagine then implications for the ship production/building activity, in relation with the typical significant size of cruise ships and with the noteworthy number of different systems to be installed and integrated onboard.

Finally, cruise companies engaged in the management of such ships must deal with the complexity of running what is very often called "floating cities" along their operational life. At the same time a great attention to the cruise market

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and its evolution is necessary in order to improve in terms of competitiveness.

From what above, it is evident the need to boost the continuous evolution of a robust and "value focused" ship design process able to project the decision making activity in a ship life cycle perspective.

As better detailed in the following, in this regard Systems Engineering appears to be a suitable paradigm, able to provide the necessary comprehensive view of the cruise ship system as a whole together with a systematic methodological framework that, among the other advantages, enables the active and constructive participation of all the involved stakeholder in the decision-making process.

The so-called model-based engineering, hinged into Systems Engineering, is able to guarantee an efficient approach to share, integrate, combine and improve the level of details relevant to the system under development. In the run to digitalization, the digital twin model might be proposed as a natural evolution in line with model-based engineering, with huge margin of improvement for deployment of very complex asset like large cruise ships.

1.1 Systems engineering and model based engineering

Systems Engineering, in the form of the organized interdisciplinary approach as it is known today, appeared in the early fifties of the twentieth century, spurred by the launch of unprecedented, large-scale and high complexity projects, combining challenging goals with time pressure. The abundance of new technologies becoming available at the time was indeed creating the opportunity for the development of a wide range of new devices, but, at the same time, the need to integrate a plurality of novel and heterogeneous technologies introduced a level of complexity that engineering had never experienced before. To address that complexity a new approach to engineering was developed, combining both systematic and systemic aspects; it was systematic for taking a structured, orderly approach to solve the problem and to implement the system, and systemic for making a holistic appreciation of the problem/system of interest, by considering its context, stakeholders, and the ensuing interrelationships and interconnections.

The systemic aspect had its root in the fertile humus of new elements of the cultural context, mainly: General Systems Theory (open system, emergent property), Cybernetics (feedback, system behaviour) and Operations Research (multidisciplinary team approach) [3]. The systematic aspect, in the following years, has been codified and progressively refined into handbooks and standard (just to cite a few: the "Handbook of Systems Engineering" from the International Council On Systems Engineering (INCOSE), and the ISO/IEC/IEEE standard "15288:2015 Systems and software engineering—System life cycle processes").

A recent evolution of the way to implement Systems Engineering is Model-Based Systems Engineering (MBSE); INCOSE that, back in 2007 launched an initiative to promote it, defines MBSE as "the formalized application of modeling to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases" [13]. MBSE is actually part of a more general trend of engineering toward a model based approach: Model Based Engineering (MBE); MBE is defined as "an approach to engineering that uses models as an integral part of the technical baseline that includes the requirements, analysis, design, implementation, and verification of a capability, system, and/or product throughout the acquisition life cycle" [15].

The main intent driving the INCOSE MBSE initiative was to overcome the limitations of the historical document-based approach (risk of ambiguity and lack of consistency, poor traceability, difficulty in assessing the effects of changes, etc.) by providing a new way to elicit and capture knowledge about both the problem and the solution space, and to improve communications among the system development team, and between it and the entire stakeholder community of the project.

A model ["a physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process" [6]] is a powerful means of communication. This last is a primary necessity for engineers; indeed the early modern engineers of the late Middle Ages and Renaissance introduced the use of drawings (a kind of models) mainly to present their devices to patrons and investors (to enable evaluation and getting approval), and to provide instruction to the artisans carrying out the work [17].

Descriptive models (which describe the functional and physical architecture, and the requirements of a system) are a very effective way of communication, a characteristic MBSE has largely capitalized on.

A second type of models, the analytical ones, are applied to evaluate in advance the characteristics and performances of design solutions. Analytical models are typically generated by the discipline engineers both in the concept and the design phase, but all too often they fail to be integrated with the descriptive ones and to be kept 'aligned' and updated all the way through the life-cycle of the system; as a result, a large part of the product design know-how soon becomes obsolete, if not completely lost [4].

To address this problem, and close the gap between descriptive and analytic models, the U.S. Air Force defined, in a year 2013 report, the "Digital Thread" concept: "the creation and use of a digital surrogate of a material system that allows dynamic, real-time assessment of the system's current and future capabilities to inform decisions in (all the life cycle phases)"; here the "digital surrogate" is defined as "a physics-based technical description of the weapon system resulting from the generation, management, and application of data, models, and information from authoritative sources across the system's life cycle" [22].

Actually, the original idea of a digital replica of a physical system was introduced, back in 2002, by Michael Grieves who, in 2011, also introduced the term "digital twin" to define "a set of virtual information constructs that fully describes a potential or actual physical manufactured product from the micro atomic level to the macro geometrical level" [11]. The core aspect of the digital twin concept is that the digital replica, in addition to the design data and engineering models which thoroughly describe the structure, components, geometry, materials, behaviour and performances of the system, includes also all the "as-built" and operational data which fully characterise a specific "twinned" physical system (Fig. 1). Thus, if the "twins" are kept aligned throughout the life cycle (recording engineering changes, maintenance history, and data from on-board sensors), then "any information that could be obtained from inspecting a physical manufactured product can be obtained from its digital twin" [11].

In the Concept and Development phases of the life-cycle, the digital twin anticipates the physical one, and the models can be used to predict the future behaviour and performances of this last one; but beyond that, in a Model Based Design environment, the cross-domain perspective provided by the models can support the evaluation of tradeoff decisions by a multidisciplinary team of designers, thus improving the flexibility to address changes in operational needs and requirements. In these phases, the digital twin and Thread collect all the information and knowledge about the system under development; as a result, they provide a single and authoritative "source of truth", greatly improving coherence and consistency. This, in turn, helps to improve efficiency, in terms of time and costs, by reducing engineering changes and reworks and improving first-time part fit.

During the Utilisation and Support phases, the integration of the high fidelity models of the digital twin with data (measured by health and usage sensors) can allow to assess and forecast the health of a specific physical asset, and thus support decisions on the usage profile to help in preventing damage and to increase the life span. More, the identification of failure modes (obtained via the analysis of data gathered from a set of assets) may be combined with the results of the simulations of the digital twin models of a specific asset, thus opening the way to predictive maintenance; that is just-in-time corrective and preventive maintenance tailored to the specific asset, that can replace scheduled maintenance (with reduction of unnecessary downtime and related costs).

The digital twin approach has been spearheaded by the military and the defence industry, but has quickly expanded into other fields. A paradigmatic example is General Electric; in the effort to transform itself in a "global digital industrial company", GE has strongly invested in the development of digital capabilities, primarily for the development of the PREDIX platform. Applications of GE digital twins span sectors as diverse as energy, aviation and oil & gas; the company has more than 1.2 million of them in operation today [12].

Another area being explored for the application of the digital twin is the modelling of production processes; the purpose is to reproduce their behaviour and dynamics with virtual simulations to be analysed to support their optimisation and reorganisation [8].

The opportunities offered by the digital twin and Thread (and the underlying Model Based Engineering approach) look very promising, but the other side of the coin is that their implementation may pose a few serious challenges [19, 23]. Some of these, like Design Tool Compatibility, Adequate Computer Processing Power, Software that Leverages that Computer Horsepower are of a technical nature, and it looks reasonable to assume that they will be addressed and solved in the next future. Others, like Protection of Intellectual Property, Model Verification, Validation, and Accreditation, Model Maintenance, will require setting up appropriate

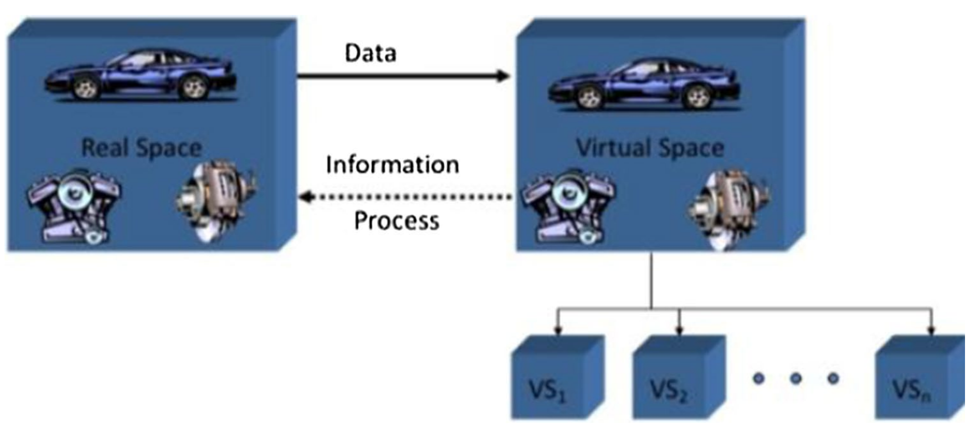

Fig. 1 The original concept of the "twinned" digital system [11]

processes and rules. A last group, including Bureaucracy, Cultural Inertia and Knowledge Assessment ("the assignment of validity to any particular piece of information or expertise") refers to social aspects. These last will likely take a longer time to be solved as they require a change in mindset; just consider the need to generate "buy-in" ("trust and willingness in a tool, as well as the ability to use it") both in the technical staff and in the decision-makers. Last, but non less important, is the cybersecurity aspect; here the main cause of concern is the huge breadth and deep of information gathered by the the digital twin (and Thread), which would provide potential attackers with a single target to go after [19].

1.2 The digital twin: a model for the entire cruise ships life cycle

In the shipbuilding industry as well, in the recent years, a discussion is open about digitalization and the possible advantages deriving from key enabling technologies based on digitalization and industrial internet of things (IIoT).

The attention toward the digital twin model is constantly increasing both for merchant and naval ships and some applications are already proposed by researcher teams and companies active in the shipping industry. The potential for business improvement in terms of efficiency, competitiveness and added value is in principle very significant, especially if empowered within the Systems Engineering paradigm.

Nevertheless from a literature overview it appears how the prospective but also the definitions are still "work in progress", due to the present situation of transition and great evolution.

The potentials of digital twin for holistic ship design, from the cradle to the ship in operation, are evidenced by Stachowski and Kjeilen [21]: in the concept phase, a digital master model representing the 3D general arrangement would enable the evidence of aesthetic view, functional space layout, providing moreover a baseline for computer aided analysis (CAE) analysis. In the following basic and detailed design phases, an evolution to the digital Twin could be obtained for example by integrating all the information useful for classification society and flag state approval regarding structures, pipings and outfittings. In the complex process of ship design, the collaboration among the different interested parties is vital and the digital twin is an excellent facilitator to this aim permitting an improvement in terms of process transparency and better product.

The transition from digital ship models to digital twins can be in support also of ship operations and maintenance. The digital master from which digital twin could be derived, is considered a driver for further digital transformation. Not only it supports the improvement of the existing business processes, but also enables the development of new value-added services and service oriented business models in combination with the information collected during operations [10].

Accessibility of information and the possibility to efficiently manage it through an enhanced user interface is one of the possible use of digital twin. During the operational life of the ship, the tailored delivery of the proper amount of information, i.e. an improved management of information, is at the base of a robust safety and of an efficient maintenance policy [1, 5]. An outstanding value of the digital twin is also the possibility to support learning and training activities as a booster for safety performance and operational efficiency.

A methodological framework to better develop the concept of digital twin is outlined by Erikstad [7]. Since digital twins are going to serve a wide spectrum of different needs it is important to reason about design patterns: assuming the classical patterns [9] as grouped in creational, structural and behavioral, the author suggests to split the behavioral pattern group into further two i.e. insight patterns and computational patterns. The first ones provide engineering insight based on digital twin output (functional value) while the second focus on how the solution can operate efficiently with respect to computation, storage and communication (form aspects).

Different types of digital twins can be defined in relation for example with the building phase selected as a boundary: Ash [2] proposes two of them, one is used before the asset is built (digital prototype) and the other after (digital twin).

To this regards it is also possible to speculate that in the very first part of ship life, i.e. the during the concept development, the digital twin could in principle be a virtual duplication of several ships of the same typology, characterized more or less by the same characteristics. It is only during the production phase and the operational period that the creation and storage of data, more and more unique for the specific ship, make the digital twin exactly the alter ego of a real well definite ship.

The possibility to "fuel" the digital twin with sensors creates a strong link with the real world operation in order to permit the model to become more predictive which in turn enables grater proactivity to avoid risks and maximize profitability. As far as risk is regarded, a possible further development is the probabilistic digital twin: it is a forecasting tool to support effective risk management in operations coupling the digital twin to risk models which are continuously updated on actual conditions and new knowledge [20].

Ship design process requires wide knowledge and competence in several engineering fields together with the capability of mediation among various constraints and expectations. A considerable amount of creative approach is necessary and a thorough theoretical knowledge of the problems must be accompanied by a sound practical attitude to solve them.

To understand the relevance of digital twin, it is worth pointing out that the knowledge and competence needed in ship design are often well beyond the merely engineering fields and that moreover they are usually found in different persons as well as data and information are stored in different repositories [18]. This might create waste of time and inefficiencies that can be overcome by the integration structure and philosophy at the base of the digital twin asset.

As already mentioned, passengers as a payload is what specifically characterizes cruise ships. Passengers motivation is not secondary: people sail on board cruise ships to undertake a voyage specifically meant as an occasion of pleasure and amusement. In general such ships are expensive assets, firstly because aspects of safety of life at sea are particularly demanding and secondly because of their glamour, that is what makes the ship attractive to passengers, usually well happy to pay for it.

The digital twin represents the ideal context in order to implement the so called "user centered design" where a common and comprehensive "domain for discussion" is necessary in order to elicit the users requirements and propose and discuss adequate design solutions in that perspective. In fact, as already mentioned, the digital twin concept enables the merge and integration of the so called descriptive models and the suitable analytical models: several data and information about the ship are stored together and the tools to analyze the ship performances can rely on an harmonized set of input and produce consistent set of output. Therefore the digital twin can be defined also as an integrated and interactive model. In the specific field of cruise ships, the interaction at the base of the so called "user centered design" is very challenging: it involves several players and even the definition of "user" is not so straightforward. The passengers, the crew members the owner, all of them can be defined as the user of the final product i.e. the ship, in relation with their own perspective. All of them can take advantage of the digital twin to interact with the design process. Moreover, they will take advantage of the digital twin asset also during the ship operational life, exploiting it possibly as a very comprehensive and interactive dashboard. The "multi-user" centered design enabled by digital twin is represented in Fig. 2, in relation with the perception of the ship as respectively: a place where to find fun and entertainment, a transportation vehicle, a commercial asset for business advantage; the projection on the whole lifecycle is put in evidence.

Cruise ship typologies can be differentiated mainly in relation with dimensions, number of passengers, cabins and public spaces, etc. Such features have an impact on the different market segments (Mass Market, Premium and Luxury) where cruise vessels are meant to operate and defined in relation with the space ratio (GRT/number of passengers), the ratio between crew members and number of passengers, the kind and level of services for guests onboard.

Among the most important safety issues to be tackled with during the design process are for example the intact

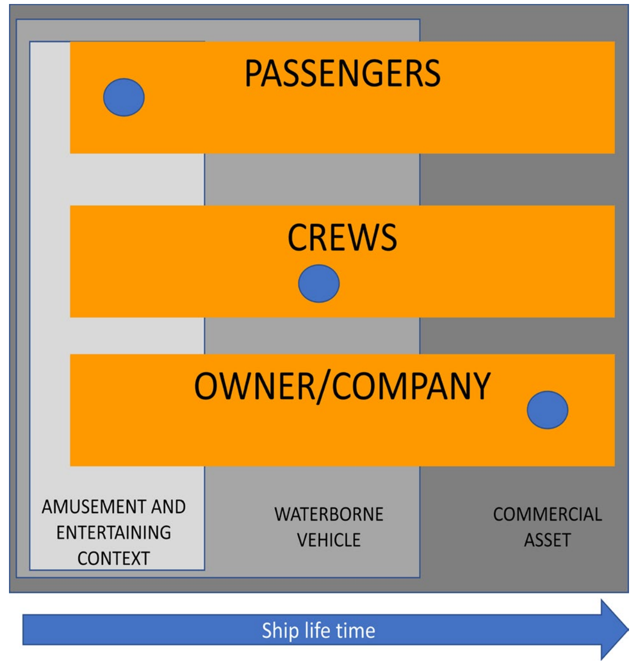

Fig. 2 "Multi users" definition for the application case of cruise ship design in the context of "user centered design" enabled by the digital twin model

and damaged stability, the passive and active fire fighting, the evacuation routes and the life saving appliances.

The level of comfort that the ship can offer to guests is in relation with a very wide spectrum of complex and interrelated technical issues like: vibrations, noise, accelerations and ergonomics. Human beings identify their comfort in the suitable and personal balance among vital features like: air, water, light, feeding, resting and relax, sanitation.

In the development of the design process of cruise ships, among the main involved parties are: the owner team who defines the "mission requirements" in relation with the operational profile i.e. defines the ship size, speed, autonomy, the geographical area, the targeted customer market; the designer team who has the responsibility to impress the ship "character" in line with the owner indications, designing accommodations and public spaces, their decoration, layout and mutual integration; the naval architect team who is devoted to the definition and the development of the ship as the suitable and reliable platform able to integrate what above; the shipyard in charge to build the ship as far as possible in adherence with the design specification by use of modern and sophisticated technology and innovative materials. The role of classification societies is of outstanding importance as a support during the design, building phase as well as during the ship life.

A successful design will deliver an asset which completely fulfill the customer expectations, whoever identified as the customer (the cruise company or the very final user i.e. the passenger). The aforementioned characters are called to discuss about problems (requirements) identification and trade off solutions and to this aim the digital twin would be a comprehensive dynamic dashboard able to put in relation the different phases of the ship life time and therefore to better set up the decision making.

In Fig. 3 a graphical representation of the potential use of digital twin in the cruise ship sector is evidenced. Numbers (from 1 to 4) represent the main possible uses of digital twin as derived from Madni et al. [14] and reported in the following. The digital twin can be used to:

1. Validate system model with real world data
2. Provide decision support and alerts to users
3. Predict changes in physical system over time
4. Discover new application opportunities and revenue streams

Hull, structure, machinery, passengers leisure and entertainment, safety are evidenced in the representation to characterize the cruise ship i.e. the asset modeled by the digital twin; few notes are given below in order to describe cruise ship design challenges and subsequently suggest ideas about tailoring of opportunities of digital twin uses for the specific case of cruise ships.

1.2.1 Structures

The so called midship section is a fundamental structural drawing to be conceived when designing a cruise ship and attention to several issues are then considered in relation with it, e.g. the interaction of the cabins "modulus" with the primary and secondary structural elements, the deck high in relation with the beam girder high and with the piping and systems lines passing over the ceiling, the pillars alignment, the positioning of the lifesaving appliances, the vertical relation of passenger spaces in the general arrangement plan. For passenger ships structural design, finite element calculations are widely applied, both for local and global strength.

1.2.2 Machinery

Cruise ships power generation and distribution systems are meant to support both of propulsion at different service speed and the delivery of electrical power for the so called hotel services. High standards in terms of reliability and maintainability (for safety and economic reasons) are to be guaranteed for the generation and for the distribution grid.

One of the main voices of the electrical balance is the air conditioning system, also in relation with the operational area, the season and especially when large spaces with glass walls are provided. Other hotel services which require significant electric power generation are: production of fresh water, food refrigeration, laundries activities etc. Not negligible is the power required from bow and stern thruster in harbor maneuvering.

1.2.3 Passengers leisure and entertainment—volume/deck areas organization

Passenger ships are considered "volume type" ships; in fact the definition of necessary volume/deck areas are among the main parameters to start with during the design phase. Cabins, which occupy the larger part of the ship, are assumed as the basis "modulus" influencing several other aspects.

Main public spaces to be considered for space need definition and distribution are: Atrium, passages corridors, foyers, entrances, stairs, lift; Restaurants and dining room; Lounge, bars, casino; Shops, bureau, promenades; Swimming pools, Gymnasium, Sauna; Cinema, theatres, disco.

The full appreciation of the experience on board from the passengers side relies also on the creation of the suitable

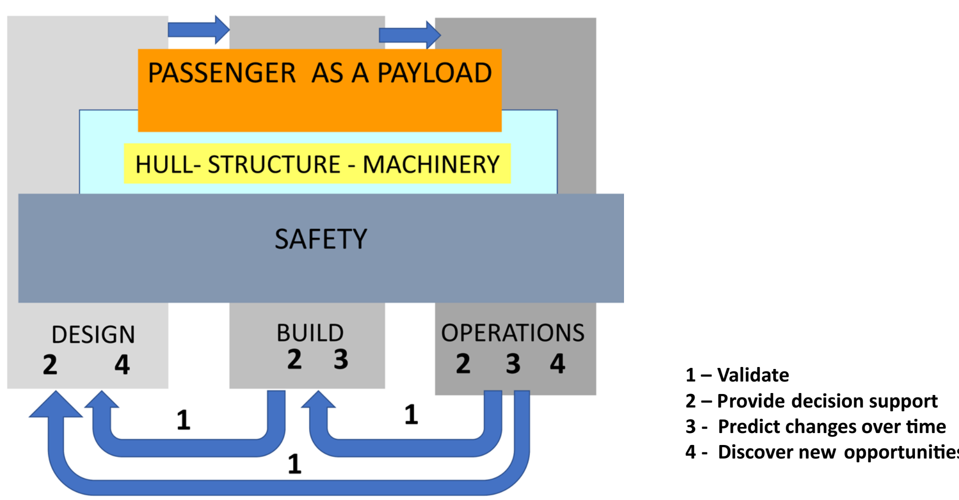

Fig. 3 The possible use (numbers legend from the text) of digital twin in the design, build and operation phase of a cruise ship

flows of people all around the ship zones, from cabins to public spaces and vice versa, at any hour. The separation and, at the same time, the easy communication between the private and public spaces are the result of trade off efforts which have to pay attention also to the source of vibration and noise which can't be completely eliminated on board.

The proper flow must be guaranteed also for all the provision supply (food, beverages etc.) to be loaded on board safely and rapidly, stores and eventually delivered to customers at the right moment, in the apposite places onboard, along the all day.

1.2.4 Safety aspects

The watertight subdivision for the residual buoyancy and stability after damage and the vertical separations made by main fire bulkheads for passive fire fighting purposes should be considered by the design team as far as possible with a global approach, aiming to align the main transversal subdivision as much as possible.

Of outstanding importance are also the means of escapes, the evacuation routes and the number and locations of the stairs towers. Moreover especially in case of several thousands of passengers onboard, the allocation of sufficient spaces and suitable accessibility for the huge number of necessary lifeboats is a challenging task.

In the design phase the evacuation procedures are investigated thanks to simulations and assessment on the 3D ship model; but the availability of the digital twin provided with the suitable sensors might contribute to the awareness process necessary when dealing with an emergency procedure. To this aim, as already mentioned earlier, the digital twin could also support the training of seafarers, to give them the suitable level of confidence with operations to be carried out when thousands of people are preparing to abandon the ship.

1.2.5 Final considerations

At present, in order to face all the issues exemplified above, the design and production process of cruise vessels strongly relies on Computer Aided Design (CAD), Computer Aided Engineering (CAE) and Computer Aided Manufacturing (CAM) technology.

The basis to evolve toward a digital twin model are therefore already available, since what has been defined in the previous paragraph as descriptive models and the analytical models, are already in the best practice of European shipyards.

The sound motivations to evolve are there as well. From one side a more integrated ship data source, with a consistent and harmonized management of numerical tools, visualizations, documents and information would allow more comprehensive simulations and analysis during the design phase; in turn this would further empower the so called "left shift" [3] for better outcomes in terms of customer satisfaction and the cost efficiency.

On the other side the shipping companies are asking more and more for a life-time projections of evaluations carried out during the design phase in order to better perform the decision making process aiming to define the better ship configuration in a life cycle perspective. At present this is of significant importance as far as power generation solutions are concerned, due to the demanding environmental rules requirements posed on exhaust gases. The kind of power generation system will have an impact also on the maintenance costs and a cost effective policy for ship maintenance would definitely take advantage from a digital twin model that would gain a role beside the design process also in the operational life of the ship.

The real boost will take place in the following phase i.e. the building/manufacturing of such a complex ship typology, because of the decisive passage from having a digital model of a generic ship of that typology to the digital twin of that specific physical ship.

The turning point would be nevertheless to provide the ship with the proper set of sensors and measuring devices that adequately processed will definitely provide a disruptive change in the operational life of the cruise ship. It is very convincing that the existence of a digital twin ship corresponding to the real one in terms of identity, representation, state, behavior and context [7] would permit to develop a ship maintenance policy totally innovative not only for the machinery plants and all the other technical systems on board but also for ship structures and outfitting. To this aim IIoT, connected visualization and virtual reality are claimed to play a significant role.

But the advantage of digital twins exploitation in the cruise ship market will be outstanding when impacting on the real mission of the ship i.e. the customer satisfaction, comfort, entertainment and safety: all the processes dealing for example with the food and beverages, their presence and flow on board; the passengers luggage withdraw and delivery; the level of people crowding in real time in the several parts of the ship; all the information that the passenger could be interested in for their leisure and entertainment would be mirrored at his disposal on the digital twin.

Therefore not only the technical engineering department of the cruise company would benefit of the digital twin but also the marketing department, customer oriented by definition. The digital twin of that specific ship during that specific voyage could represent an exciting dashboard for passengers on board.

2 Conclusions

Starting from a historical overview, Systems Engineering and the digital twin together have been discussed as a very powerful combined approach for the design of complex asset.

As an example, a focus has been proposed for the decision making path "from design to operations" of a cruise ship.

The systems engineering approach is based on the "value thinking" [16], i.e. the identification of the fundamental values to be targeted by the asset under development before the identification of alternative design solutions. In most of the cases, fundamental values appear to be emergent properties that can be properly assessed during the design process only thanks to the existence of a complete and integrated model of the real complex system, like a digital twin.

At the same time, systems engineering encourages the "left shift" attitude, aimed to anticipate as much as possible all the critical issues in order to fix possibly all of them in a design phase where it is still reasonably less expensive. To do that it is necessary a high level of knowledge about details that is possible in a procedure toward a digital twin model.

The potential advantages deriving from digital twin are even larger in a whole life time perspective (design, build, operations phases) and some of them are presented for a cruise ship operational life, putting in evidence that such positive outcomes are well beyond the maintenance issues, at present the most discussed application within the literature, about digital twin uses in the shipping field.

The implementation of digital twin may pose nevertheless serious challenges that need time, resources and effort like Design Tool Compatibility, Adequate Computer Processing Power, Protection of Intellectual Property, Model Verification, Validation, and Accreditation, Model Maintenance and continuous update.

Among the duties of universities and research institutions is the role to favor the right environment for overcoming the cultural inertia and for developing the necessary knowledge.

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