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An evaluation model of cruise ports using fuzzy analytic hierarchy process

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Abstract

Purpose – Cruise tourism is the fastest-growing segment of the shipping and port industry. This study aims to develop an analytic model to assess the key criteria and sub-criteria influencing four cruise port's development in Taiwan.

Design/methodology/approach – Based on the literature review, four criteria and 13 sub-criteria are developed and analysed by fuzzy analytic hierarchy process (FAHP). Four cruise ports include Kaohsiung, Keelung, Taichung and Hualien ports. The 26 relevant field experts (including cruise operators, governmental officials and academics) were invited to provide information for assessing the sub-criteria in the model.

Findings – The results indicate that port infrastructure and facilities are the most important criterion, followed by port-city development plans, port geography and climate and port regulations and services. In addition, the three most important sub-criteria overall are the onshore tourism programme, the city's historical and cultural features and the green port hinterland transport system. Also, Keelung port is ranked as the best port, followed by Kaohsiung, Taichung and Hualien.

Originality/value – As Asia is an important cruise market in the world (ranked as third) and passenger number in Taiwan has achieved the top two in Asia, denoting Taiwan is a good market to develop an evaluation model of cruise ports. The findings present a holistic picture of the relative importance of the various criteria associated with cruise port development and raise issues related to cruise port marketing and the economic and environmental sustainability of ports and their hinterlands.

Keywords Tourism policy, Fuzzy analytic hierarchy process, Cruise competition, Cruise port development, Expert knowledge

Paper type Research paper

1. Introduction

Cruise tourism is the fastest-growing segment of the tourism industry (Jones, 2011; Brida *et al.*, 2012; Blas and Carvajal–Trujillo, 2014; Lee and Yoo, 2015; Karlis and Polemis, 2018; Ren *et al.*, 2018) and is greatly driven by and connected with the pace and direction of global economic development (Liu *et al.*, 2016). In cruise tourism, the "home port" denotes the port where a cruise ship takes on the majority of its passengers and a "port of call" denotes a port

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where a cruise ship stops during a cruise. Those cruises that begin and end at the same port are known as "closed-loop" cruises, with the port in such cases generally being the home port and are characterized by generating significant economic benefits in the area surrounding the port. According to Cruise Lines International Association (2020), the number of global cruise ships in 2020 will be 278. Globally, the two largest cruise markets are located in North America and Europe. Nevertheless, the Asia area is ranked as the third largest and is considered an emerging cruise market. The number of global cruise passengers in 2018 and 2019 was 28.5 and 30.0 million. It is expected to reach 32.0 million in 2020 (Cruise Lines International Association, 2020). Data for 2018 also show that 4.240 million passengers participated in the Asian cruise market, with the number of Taiwanese passengers (9.3%) being the second-largest source market in Asia.

In terms of past research related to the cruise industry, various aspects of cruise operations and of the wider cruise industry have been investigated in previous studies. For example, Wang *et al.* (2014) evaluated cruise port locations in East Asia and found that "tourism attractions" around a port are the most important consideration for a cruise ship to call into the port. Wang *et al.* (2016a) reviewed the cruise shipping industry and identified various cruise operation problems, including cruise ship itinerary design and cruise service planning. Regarding safety issues, Vassalos (2016) surveyed the damage survivability of cruise ships and subsequently, Vairo *et al.* (2017) conducted a case study of three recent cruise ship accidents to evaluate cruise ship risk and to provide guidance in the planning of ship routes when balancing economic and environmental issues. From a customer service perspective, Ozturk and Gogtas (2016) investigated cruise passengers' intentions to revisit and recommend cruise services based on cruise destination attributes and levels of satisfaction. Aregall *et al.* (2018) adopted a global perspective to review port authorities and their green hinterland strategies and concluded that the measures taken in the green hinterland are often motivated by port congestion. DiPietro and Peterson (2017) used Aruba as a case study to explore passengers' cruise experience, satisfaction and loyalty. Santos *et al.* (2019) explored the cruise terminal port's role in the economic and socio-cultural sustainability. Ruiz–Guerra *et al.* (2019) predicted the impact on air quality of the cities receiving cruise tourism in the port of Barcelona. Chen *et al.* (2019) used a meta-regression to analyse the direct economic impact of cruise tourism on port communities. Jeon *et al.* (2019) investigated cruise port centrality and spatial patterns of cruise shipping in the Asia market. Finally, in Taiwan, Chen (2016) explored how Taiwan can best build a niche in the Asian cruise tourism industry. Tseng and Pilcher (2019) indicated that environmental regulation and economic leverage are two important factors for green port development. Cruise tourism is still an emerging segment in coastal and ocean management but has an immense potential to contribute to the port's socio-economy. While the policy of cruise ports will be done in a sustainable manner, it is strategic to understand how a cruise port is chosen is an important component of decision-making for cruise operators. This is because the decision-making processes involve cruise companies' strategic management and planning (e.g. cruise scheduling, marketing strategy development and operational cost-revenue forecasting). However, this decision-making issue has not been much investigated in the literature (Wang *et al.*, 2016a, 2016b). Therefore, based on a comprehensive literature review and an analysis of expert opinions through fuzzy analytic hierarchy process (FAHP), this study investigates the various criteria (which are "port infrastructure and facilities", "port regulations and services", "port-city development plans" and "port geography and climate") related to the evaluation of n a cruise port. The number of cruise passenger arrivals in Taiwan ports has achieved the status of the top two in Asia (Cruise Lines International Association, 2019). In recent years, cruise services in Taiwan have become increasingly popular. Major cruises

that regularly visit Taiwan include the Princess Cruise (Majestic Princess and Sapphire Princess), the Costa Asia Cruise (Costa Fortuna and Costa Neoromantica) and the Star Cruise (Superstar Virgo and Superstar Aquarius). Therefore, using Taiwan as an example can be a representative model to assess the criteria of the cruise ports. Based on these criteria, the study then assesses and compares four ports (Keelung, Taichung, Kaohsiung and Hualien), which are the main cruise ports in Taiwan and can be representative alternatives in our study. The model can be further extended to other cruise markets in the world. Besides, the research findings should provide important decision-making guidelines for cruise or tourism operators when evaluating the criteria and choosing cruise ports. In addition, the ranking of the various criteria will help cruise stakeholders (e.g. cruise operators, port operators and tourism service managers and operators) to understand the most important and relevant aspects of cruise ports and, in turn, to optimize their resources through informed strategic planning. These aspects are of critical importance when developing cruise port policies.

2. Hierarchical structure of cruise port selection

Cruise tourism has brought economic benefits to the ports but meanwhile generates impacts on the environment of port regions. Cruise tourism is characterized by bringing large numbers of visitors to concentrated areas of ports for a short period, inevitably multiplying and concentrating both positive and negative impacts to cruise ports. The impacts and their implications are one of the challenges in coastal and ocean management.

2.1 Cruise ports in Taiwan

Taiwan is among the world's most popular destinations for experiencing the growth of cruise tourism. A study of Taiwanese cruise ports has an advantage that all cruise ports in Taiwan exclude gambling activities and the shore excursion experiences will not be biased or dominated by gambling.

Currently, there are four main cruise ports (Keelung, Taichung, Kaohsiung and Hualien) in Taiwan (Figure 1 and Table 1), all of which can serve a cruise liner with 160,000 gross tonnages. Data provided by the Cruise Lines International Association (CLIA) (2018) show that the number of Taiwan's cruise passengers increased from 106,487 to 374,835 between 2012 and 2017, representing a 22% compound annual growth rate, which, in turn, has stimulated growth in the associated cruise service market.

Table 2 shows the number of cruise passengers in four ports in Taiwan. When accumulating the cruise passenger numbers in 2015 ~ 2018, Keelung port was ranked as the first, followed by Kaohsiung, Taichung and Hualien. It is clear that the number of

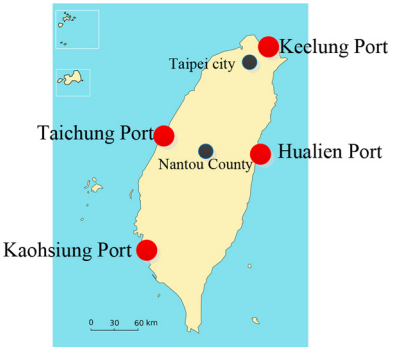

Figure 1.
Four main cruise port locations in Taiwan

passengers for Keelung port has been gradually increasing because of the fact that the location of this port is near the Taipei metropolitan area and plays a cruise home-port role for other cruise ports in Japan and South Korea (e.g. Ishigaki Island, Fukuoka, Kagoshima, Okinawa, Miyazaki, Nagasaki, Naha, Miyako, Tokyo, Shizuoka, Kobe, Pusan, Lishui, Jeju Island, etc.). Therefore, Keelung port can enjoy various types of travel resources and attractions, and therefore, has attracted many cruise passengers in the past years. The number of passengers for the Taichung port has quickly decreased due to the fact that many cruise trips in East-South coastal cities in China had quickly reduced and affected the arriving number of passengers. For the Kaohsiung port, the number of passengers dropped during 2015-2016 and 2017-2018. The number of passengers for the Hualien port has been gradually decreasing. The reasons for the fluctuations in passenger numbers in Kaohsiung and Hualien ports might be affected by the trip planning of cruise companies.

Each of the four ports has its local attractions for tourists. In Keelung (near Taipei city)[1], the Taipei 101 building, the National Palace Museum and the Miaokow Night Market are all accessible attractions. In Taichung (close to Nantou County) [2], travelers can visit Sun Moon Lake, National Taiwan Museum of Fine Arts and the National Taichung Theatre. In Kaohsiung, Love River and Cijin Island are well-known attractions. Finally, in Hualien, Taroko National Park and various hot springs are popular destinations for sightseeing visitors.

Regarding security inspection, generally, customs clearance processes include passenger quarantine, document inspection (passenger and document conformance), luggage inspection (including contraband, tax imposing on items exceeding the limit, animals and plants). These inspection authorities include the centre for disease control (ministry of health and welfare), national immigration agency (ministry of the interior), customs administration (ministry of finance) and coast guard administration (ocean affairs council).

Data	Keelung		Taichung		Kaohsiung		Hualien	
Berth No.	E2-4	W2-4	18	19	30-31	2-3	8-10	23-24
Berth length (m)	558	555	360	283	640	287	442	543
Depth (m)	−10	−11	−11	−9	−14	−9	−10.5	−14
Rate of customs passenger clearance*	2,000		2,000		2,000		2,000	

Note: *Unit: people/hour

Table 1. Cruise terminal data for the four studied Taiwanese ports

Port	Keelung		Taichung		Kaohsiung		Hualien	
Year	Cruise arrivals	Passengers	Cruise arrivals	Passengers	Cruise arrivals	Passengers	Cruise arrivals	Passengers
2015	190	563,345	34	94,004	46	128,608	16	37,461
2016	222	663,458	5	16,007	12	42,998	10	28,334
2017	269	831,162	2	8,202	41	117,559	9	23,698
2018	282	94,0404	2	1,383	27	56,553	6	10,337
Total	963	2,998,369	43	119,596	126	345,718	41	99,830

Sources: Taiwan international ports corporation; www.twport.com.tw/en/

Table 2. Number of cruise arrivals and passengers in Taiwanese ports

2.2 Key criteria

It cannot be denied that many criteria (sub-criteria) might affect the evaluation of cruise ports. After reviewing the related literature (Sections 2.2.1 ∼ 2.2.4 below), we categorized into four main criteria together contain 13 sub-criteria (Table 3) and discussed, in turn, below.

2.2.1 Port infrastructure and facilities. It is argued that port infrastructure and restrictions on such infrastructure may affect the service function of cruise ports (Baird, 1997; Ozturk and Gogtas, 2016; Ma *et al.*, 2018). In recent years, to serve the needs of the increasing sizes of passenger liners, many ports have adapted their infrastructure and facilities (including berth capacity and depth). A modern cruise terminal must have sufficient capacity to serve two (or more) cruise ships simultaneously (Jordan, 2013; Lau *et al.*, 2014; Esteve–Perez and Garcia–Sanchez, 2015). In addition, a comfortable and clean passenger terminal building instils a favourable impression on cruise passengers (Ahola and Mugge, 2017).

In recent years, in efforts to reduce pollution generated by ships (e.g. air emissions, ballast water and waste), various green terminal facilities (e.g. shore power system, the use of LNG and vessel speed monitoring via automatic identification systems) have gradually been introduced into passenger terminals and have become important green port indicators (Chang and Wang, 2012; Caric and Mackelworth, 2014; Pavlic *et al.*, 2014; Tseng and Pilcher, 2015; Tseng and Pilcher, 2019; Chang and Jhang, 2016; Innes and Monios, 2018; Wan *et al.*, 2018). Wan *et al.* (2018) showed that port infrastructure and facilities are important in improving port sustainability. For example, installing "cold ironing" (the provision of shore-side electrical power to a berthed ship while its main and auxiliary engines are turned off) can reduce air pollution while ships are berthed in port (Innes and Monios, 2018). Based on the aforementioned studies, four sub-criteria were considered here, namely, berth facilities, navigation facilities, cruise terminal building features and green terminal facilities.

2.2.2 Port services and regulations. Port services include ship-shore communication, pilot services, arranging the arrival/departure/mooring of a ship, navigation services, conducting port state control (PSC) policy, port operation efficiency and pollution regulations (Ding *et al.*, 2014; Dragovic *et al.*, 2018; Eleftheria *et al.*, 2016; Tseng *et al.*, 2017; Tsai *et al.*, 2018; Wang and Han, 2018; Zhen *et al.*, 2018). From the passengers' perspective, cruise operators and agents must help and guide passengers to pass through customs, immigration, quarantine and security while boarding or disembarking from the cruise liner. Basically, apart from safety and security checking service, the port service function includes fuelling, water and food supplies, maintenance and related supply-chain services. More efficient port service and quicker/convenient customs clearance service are beneficial to cruise operators and passengers (Ding *et al.*, 2014). Also, some cruise-related services are provided in cruise terminals such as cruise agents, insurers and souvenir stores. In addition, cruise charges are levied by port authorities all around the world (Castillo–Manzano *et al.*, 2014; Esteve–Perez and Garcia–Sanchez, 2015). Therefore, cruise operators (or cruise ship-owners) always conduct port charge assessments during their scheduled service planning to compare passenger charges and related operational costs. Based on the aforementioned studies, three sub-criteria were included, namely, PSC, cruise service functions and port charges.

2.2.3 Port-city development plans. To increase onshore revenue from cruise passengers and to arrange various tourism activities, many port and city authorities have introduced sustainable port-city development plans (including tourism marketing strategies) to attract cruises to visit their ports (Klein, 2009; Ding *et al.*, 2014; Esteve–Perez and Garcia–Sanchez, 2015; Lee and Yoo, 2015; Toudert and Bringas–Rabago, 2016; Wang *et al.*, 2016a, 2016b; Schipper *et al.*, 2017). For example, Pallis *et al.* (2018) indicated cruise companies' innovative

Criteria	Sub-criteria	Description	Sources
Port infrastructure and facilities	Berth facilities	Qualified berth capacity, depth and channels for servicing all kinds of cruises	Baird (1997); (Ding *et al.*, 2014; Caric and Mackelworth (2014), Lau *et al.* (2014); Pavlic *et al.* (2014), Wang *et al.* (2014); Ozturk and Gogtas (2016), Wang and Han (2018)
	Navigation facilities	Vessel traffic services, pilot services and tugboat services	Pavlic *et al.* (2014); Dragovic *et al.* (2018)
	Cruise terminal building	Physical and environmental design characteristics, green space and clear guidelines for cruise users	Jordan (2013); Pavlic *et al.* (2014), Sagun *et al.* (2014); Esteve–Perez and Garcia–Sanchez (2015), Ahola and Mugge (2017); Wan *et al.* (2018)
	Green terminal facilities	Facilities and processes for reducing potential environmental pollution (e.g. air pollution, water pollution and garbage) from cruises and port operations	Chang and Wang (2012); Ding *et al.* (2014); Tseng and Pilcher (2015), Chang and Jhang (2016); Tseng *et al.* (2017); Wan *et al.* (2018) and Innes and Monios (2018)
Port regulations and services	PSC	Cruise's safety regulation check (e.g. ship certificates), passenger and crew check, operational processes and documents, safety and rescue facilities	Wang *et al.* (2014); Ding *et al.* (2014); Vidmar and Perkovic (2015); Eleftheria *et al.* (2016), Tsai *et al.* (2018); Zhen *et al.* (2018)
	Cruise service functions	Fuelling, water and food supplies, maintenance and related supply-chain services	Wang *et al.* (2014); Esteve–Perez and Garcia–Sanchez (2017); Chen *et al.* (2017)
	Port charges	Cruise port fees	Castillo–Manzano, Fageda and Gonzalez–Laxe (2014), Wang *et al.* (2014); Esteve–Perez and Garcia–Sanchez (2015) and Chen *et al.* (2017)
Port-city development plans	City's history and culture	Interesting historical and cultural attractions[a]	Diedrich (2010); Ettema and Schwanen (2012), Pranic *et al.* (2013); Esteve-Perez and Garcia-Sanchez (2015), Toudert and Bringas-Rabago (2016); Schipper, Vreugdenhil and Jong (2017)
	Green port hinterland transport system	Convenient and green public transportation services (e.g. metro, train, bus and bicycle) and green hinterland space	Petit-Charles and Marques (2012); Ding *et al.* (2014); Wang *et al.* (2014), Schipper *et al.* (2017) and Aregall *et al.* (2018)
	Onshore tourism programme	Arrangement of a variety of interesting tourism activities	Jones (2011); Ettema and Schwanen (2012), Esteve-Perez and Garcia-Sanchez (2015); Lee and Yoo (2015), Ozturk and Gogtas (2016); Chen *et al.* (2017); Pallis *et al.* (2018) and Sun *et al.* (2019)
Port geography and climate	Port location	Port location within the sailing region	Marti (1990); Pallis *et al.* (2018); Soriani *et al.* (2009)
	Port-city climate	Pleasant climate and favourable temperatures	Soriani *et al.* (2009); Wang *et al.* (2014)
	Natural resources	Natural attractions such as mountains, scenic countryside[b]	Soriani *et al.* (2009) and Wang *et al.* (2014)

Notes: [a]It means the city's development history, architecture characteristics and city culture such as Taipei 101 building and National Palace Museum in Taipei city; [b]Natural and beautiful scenery, which is not artificial architecture or building such as Taroko National Park in Hualien

Table 3.
Criteria and sub-criteria influencing the selection of a cruise port for ship calls

commercial and onshore activities should match the preferences of the tourists. Pallis *et al.* (2019) considered that the port cruise should respond to the changing need of tourists, provide strong incentives (e.g. nearly touristic destination) and conduct societal integration of ports with the surrounding urban communities. Social, economic and environmental aspects should be integrated when considering port-city-related development plans. From the perspective of cruise services, onshore tourism resources (e.g. sufficient qualified tour guides, the provision of transportation feeder services, sightseeing tour, city safety, shopping, restaurants and hotels, natural and historical attractions, etc.) and hinterland service contents are important factors that affect cruise calls (Diedrich, 2010; Pranic *et al.*, 2013; Ozturk and Gogtas, 2016; Wang *et al.*, 2016a, 2016b). For example, the Mediterranean is an attractive region for cruise services because it offers aspects of past civilizations such as the art and architecture of the Italian Renaissance (Ettema and Schwanen, 2012). These tourism activities need to be supported by various stakeholders such as local government, transport operators and tourism operators (Petit–Charles and Marques, 2012; Wang *et al.*, 2014).

Generally, cruise passengers have about 6 to 8 h to experience the attractions of the city/town during the ship's berthing period. Cruise onshore time must be effectively controlled because it involves itinerary schedule design and cruise service planning. Therefore, cruise destination managers and local governments and policymakers in ports must regularly discuss and formulate marketing strategies to provide onshore travel services, including the arrangement of visiting attractions and good time control (scheduling) while passengers are onshore (Brida *et al.*, 2012). Sun *et al.* (2019) found that sufficient time for sightseeing, variety shops and attractiveness of sightseeing attractions in the cruise onshore programs could attract customers' satisfaction in the cruise service. Based on previous studies, the three sub-criteria adopted in the present study were the city's history and culture, the green port hinterland transport system and the onshore tourism programme.

2.2.4 Port geography and climate. Distances between the ports of call affect cruise schedule planning (Marti, 1990; Castillo–Manzano *et al.*, 2014). Also, seasonality is an important concern for cruise services because of the uneven demand overtime for such activities as sightseeing, shopping and transport services. Climate change is a longer-term phenomenon that will affect the traffic volume of cruise ports (Ozturk and Gogtas, 2016; Esteve–Perez and Garcia–Sanchez, 2017). Cruise services are constrained by tight itineraries and routes and a port's function and location are important determinants that affect sailing service planning in both the home port and the various ports of call (Jones, 2011; Rodrigue and Notteboom, 2012). Also, a beautiful beach view is an important attribute of cruise visits (Ozturk and Gogtas, 2016).

The Mediterranean region has a favorable climate with very rich natural resources and provides cruise services for six-eight months of the year (Soriani *et al.*, 2009; Blas and Carvajal–Trujillo, 2014). The maximum cruise demand occurs in a cruise season of about 40 weeks duration. Therefore, cruise operators always carefully evaluate a port's geography and climatic characteristics to safeguard the return on deployed capital (Jones, 2011; Esteve–Perez and Garcia–Sanchez, 2017). Based on previous studies, the three sub-criteria adopted in this study were port location, port-city climate and natural resources.

We have developed a FAHP model to select the best cruise port through four criteria (port infrastructure and facilities, port regulations and services, port-city development plans and port geography and climate) and 13 sub-criteria (Figure 2). The four studied cruise ports are Keelung, Taichung, Kaohsiung and Hualien port. During the period of 2-16 February 2018, six experts in cruise-related knowledge fields reviewed and finalized the measures of the questionnaire prior to the survey being conducted. The content (including wording) of

criteria (sub-criteria) was repeatedly surveyed of these six experts until their opinions achieved the consistent. Such a Delphi method process can provide the validity of our criteria (sub-criteria) (Chen, 2016).

3. Methodology

Saaty (1980) initially developed the analytic hierarchy process (AHP) for solving multiple criteria decision-making problems. The process provided a systematic hierarchy structure, with its ratio scales being used to make reciprocal comparisons for each element and layer. However, classical AHP may not fully represent decision-makers' ideas. In essence, in classic logic, it is certain that an element either belongs to a set or not. However, in fuzzy logic, an element might be partially inside the set or partially outside the set. Related research can be further referred to Chen (1997), Cheng and Lin (2002), Raj and Kumar (1999) and Zimmermann (2001). In this paper, the fuzzy logic concept is adopted to help solve uncertain and vague decision analysis problems in this project (Zadeh, 1965). Fuzzy logic is a theory that allows decision-makers to use middle values such as "middle", "high" and "low" rather than classical variables such as "yes", "no", "true" and "wrong". Such an analysis model can improve traditional AHP method and normalize the weight of criteria (sub-criteria) and calculates the geometric distance to the ideal and the negative-ideal solution. Following Zadeh (1965) and Buckley (1985), fuzzy linguistic variables and corresponding fuzzy triangular numbers can be used for comparisons among the included elements, thereby helping to solve vague and uncertain problems in decision-making. Therefore, the FAHP method is a mature decision analysis method and has been widely used in various fields (van Laarhoven and Pedrycz, 1983; Chang, 1996; Duru *et al.*, 2012; Zhu, 2014) (For example, Ahmed *et al.* (2017) explored the theoretical comparison between AHP and FAHP. Sahin and Yip (2017) used the Gaussian FAHP model to conduct shipping technology selection (22 samples) Dozic *et al.* (2018) adopted FAHP to select passenger aircraft types. Tseng and Cullinane (2018) adopted FAHP to evaluate key criteria influencing the choice of Arctic Shipping (25 samples). Analysis results of our paper can provide scientific contributions to cruise industries (e.g. cruise lines and cruise ports, etc.), passengers, academic groups and other stakeholders. Although some researchers (Zhu, 2014; Shapiro and Koissi, 2017) have criticized that FAHP has existed some problems (e.g. unreasonable priorities and information loss), we have collected three groups of field experts' opinions and used 26 effectively questionnaires in our study. The research findings can synthesize various field experts' opinions (including cruise operators, governmental officials and academic scholars) and reduce potential preference bias. Also, it can reduce these potential problems due to methodology limitations, which will be elaborated in Section 4.

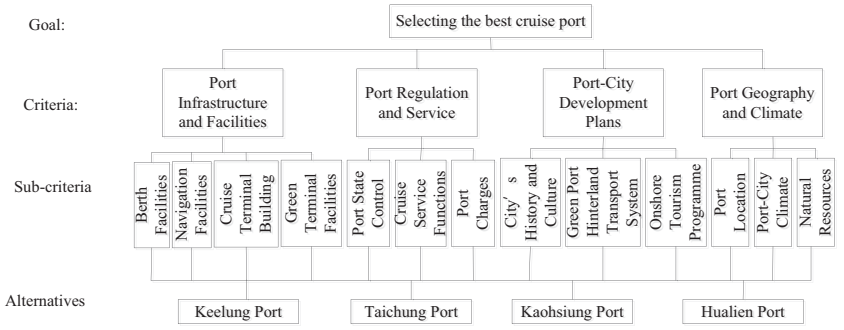

Figure 2.
Hierarchical analysis structure of cruise port selection

In the present study, fuzzy logic with fuzzy pairwise comparison matrices (Chang, 1996) was used to reduce the uncertainty in the AHP method, as, thus, a robust mathematical tool can be used for comparing various the elements and reduce vague and uncertain problems in decision analysis (Li *et al.*, 2020; Duru *et al.*, 2012; Bulut and Duru, 2018). Triangular membership functions, with fuzzy pairwise comparison matrices, are used to conduct interval judgments. Therefore, an integration of the fuzzy set theory and AHP is used to identify the key criteria and sub-criteria influencing the selection of the best cruise port. A column geometric mean method combined with the extent analysis method to calculate the weights (Buckley, 1985; Chang, 1996). The triangular fuzzy number used as the member function is expressed in Figure 3. Its membership function is defined by the triplet (l, m, u) as in equation (1) (Zadeh, 1975):

$$\mathrm{U(x)} = \begin{cases} \dfrac{(x-l)}{(m-l)}, & l \le x \le m \\ \dfrac{(u-x)}{(u-m)}, & m \le x \le u \\ 0, & others \end{cases} \tag{1}$$

Where m is the most possible value of the fuzzy number U(x), l and u are the lower and upper bounds, respectively.

The analytical procedures of the FAHP constitute seven steps as follows:

(1) Constructing the hierarchical model;
(2) constructing the pairwise comparison matrices;
(3) calculating fuzzy numbers;
(4) building the fuzzy positive reciprocal matrix;
(5) calculating the fuzzy weights;
(6) performing defuzzification; and
(7) conducting normalization and synthetic analysis.

A questionnaire survey conducted as part of the study asked individual experts to respond to a series of pairwise comparisons to establish the relative importance of the different criteria and sub-criteria. The anchored rating scales method was adopted to measure the respondents' perceptions of what was relatively "important" and "unimportant", with a nine-point rating scale (anchored by "important" and "unimportant") being used. Saaty (1980) used the consistency index (CI) to capture any inconsistency within judgements in each aggregate pairwise comparison matrix and in the overall decision structures. The

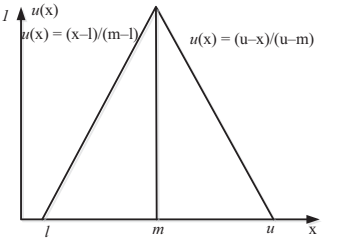

Figure 3.
A triangular fuzzy number

consistency ratio (CR) is used to measure how a given matrix compares to a purely random matrix in terms of the CI. The CI and CR are computed as follows:

$$\mathrm{CI} = \frac{\theta_{\max} - n}{n - 1} \tag{2}$$

$$\mathrm{CR} = \frac{CI}{RI} \tag{3}$$

where: $\theta_{\max}$ is the maximum eigenvalue; n is the number of elements in the judgement matrix; and RI is the consistency index of a randomly generated reciprocal matrix derived from the nine-point scale, with forced reciprocals. The CR is obtained by comparing the CI with the random inconsistency (RI) values (Table 4). The judgments in the comparison matrix are said to be consistent. For matrices larger than 3×3, a value of CR of ≤ 0.1 is considered acceptable whereas larger values of the CR require the decision-maker to revise their judgements (Saaty, 1980) [3].

4. Results

4.1 Data collection

The questionnaire included three parts. The first part was aimed at obtaining respondents' characteristics (profiles). The second part addressed the evaluation of the relative importance of the various criteria and sub-criteria. The final part involved an evaluation of the best cruise port based on the relative importance of the four criteria and 13 sub-criteria (Appendix). The findings of questionnaire surveys will be used to set the values of four criteria and 13 sub-criteria. On 1 March 2018, 27 potential respondents in three groups of experts (nine cruise operators, nine governmental officials and nine academics) were identified and reviewed to ensure that they were appropriately qualified to participate in the study. When reviewing these experts' backgrounds, we expect their seniority (or teaching, research experience) should be at least 10 years [4]. Also, the questionnaire participants did not include cruise passengers in this study [5]. Then, these potential respondents were contacted by phone to make sure that they were willing to complete the questionnaires. On 10 March 2018, these 27 questionnaires were sent to potential respondents and by 20 March 2018, all 27 questionnaires had been completed and returned. The CI of each questionnaire was tested to confirm the consistency of its pairwise comparison matrix. The results identified one questionnaire as being highly inconsistent ($\mathrm{CI} > 0.1$) and it was consequently discarded (Saaty, 1980). Therefore, the overall response rate was 96.3% (=26/27). The CI and CR values of the 26 questionnaires were, therefore, all less than 0.1, and thus, satisfied the consistency test (Saaty, 1980). Respondent profiles are contained in Table 5.

Table 4. RI Values for different sizes n of the comparison matrices

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Source: Saaty (1980)

4.2 Results of the fuzzy analytic hierarchy process

As described in Section 3.1, the collected quantitative and qualitative data and information were combined and analysed in the FAHP (Figure 3). The data and information were converted into fuzzy numbers, following, which the difference minimization method was used to calculate the local weights of the criteria and sub-criteria. The global weight of each sub-criterion was calculated by multiplying the local weight of the sub-criterion by that of the corresponding higher-level criterion. The higher of weight score, the more important of criteria (or sub-criteria alternative) based on analysis results.

4.2.1 Weights comparisons between various questionnaire participants. To understand each group of experts' opinions, Tables 6-8 show weight analysis results of three groups of questionnaire participants (including cruise operators, governmental officials and academics). The rank comparisons are based on scores of global weights. Results found that the government officials and the academics are similar weights in criteria. The cruise operators thought "Port-city development plans" is the most important criterion and "port geography and climate" is the least.

Regarding all sub-criteria ranking, the cruise operators thought "onshore tourism programme" is ranked as the first. It can be explained that cruise operators think a good

Respondents	Range	Cruise operators[b] Frequency	(%)	Governmental officials[c] Frequency	(%)	Academics[d] Frequency	(%)
Job title/rank	President/Director	1	11.1	2	25.0	–	–
	Senior deputy director	5	55.6	4	50.0	–	–
	Division director	3	33.3	2	25.0	–	–
	Supervisor	0	0	0	0.0	–	–
	Professor	–	–	–	–	4	44.4
	Associate professor	–	–	–	–	5	55.6
	Assistant professor	–	–	–	–	0	0
	Sub-total	9	100.0	8	100.0	9	100.0
Age (years)	≤40	0	0	0	0	0	0
	41-50	2	22.2	1	12.5	1	11.1
	51-60	6	66.7	6	75.0	5	55.6
	≥61	1	11.1	1	12.5	3	33.3
	Sub-total	9	100.0	8	100.0	9	100.0
Educational level	PhD	0	0.0	2	25.0	9	100.0
	Master	4	44.4	6	75.0	0	0.0
	Bachelor	5	55.6	0	0.0	0	0.0
	Sub-total	9	100.0	8	100.0	9	100.0
Seniority (years working in field)	10-15	0	0.0	0	0.0	0	0.0
	16-20	2	22.2	1	12.5	2	22.2
	21-25	5	55.6	4	50.0	6	66.7
	≥26	2	22.2	3	37.5	1	11.1
	Sub-total	9	100.0	8	100.0	9	100.0

Notes: [a]Basically, the number of field experts are not too many in one country. Referring to other FAHP studies [e.g. Wang *et al.* (2008) (samples), Sahin and Yip (2017) (22 samples) and Tseng and Cullinane (2018) (25 samples)], the number of our samples (26) is reasonable in this study; [b]These cruise operators are full-time staff who work in the cruise companies and are responsible for cruise operations and management affairs; [c]These governmental officials work in the Taiwan International Ports Corporation or Maritime Port Bureau in Taiwan and take charge of cruise port supervision and management works; [d]These academics must understand issue of cruise port planning and development strategies and they work in the shipping management-related departments in the universities in Taiwan

Table 5.
Profiles of the questionnaire respondents[a]

Criteria	Local weights	Sub-criteria	Local weights	Global weights	Rank
Port infrastructure and facilities	0.288	Berth facilities	0.287	0.083	4
		Navigation facilities	0.207	0.060	11
		Cruise terminal facilities	0.245	0.071	7
		Green terminal facilities	0.260	0.075	6
Port regulations and services	0.221	PSC	0.371	0.082	5
		Cruise service function	0.317	0.070	8
		Port charges	0.312	0.069	9
Port-city development plans	0.332	City's history and culture	0.333	0.111	2
		Green port hinterland transport system	0.326	0.108	3
		Onshore tourism programme	0.341	0.113	1
Port geography and climate	0.158	Port location	0.316	0.050	12
		Port-city climate	0.279	0.044	13
		Natural resources	0.405	0.064	10

Notes: The local weight of each criterion or sub-criterion is derived from expert judgement and pairwise comparison, the global weight of a sub-criterion is derived by multiplying the local weight of the sub-criterion by that of the corresponding criterion

Table 6.
Results of the FAHP ($n = 9$, samples are cruise operators)

Criteria	Local weights	Sub-criteria	Local weights	Global weights	Rank
Port infrastructure and facilities	0.293	Berth facilities	0.267	0.078	4
		Navigation facilities	0.246	0.072	9
		Cruise terminal facilities	0.254	0.074	7
		Green terminal facilities	0.233	0.068	12
Port regulations and services	0.240	PSC	0.296	0.071	10
		Cruise service function	0.295	0.071	10
		Port charges	0.409	0.098	1
Port-city development plans	0.232	City's history and culture	0.332	0.077	5
		Green port hinterland transport system	0.349	0.081	3
		Onshore tourism programme	0.320	0.074	7
Port geography and climate	0.235	Port location	0.415	0.098	1
		Port-city climate	0.317	0.075	6
		Natural resources	0.268	0.063	13

Notes: The local weight of each criterion or sub-criterion is derived from expert judgement and pairwise comparison, the global weight of a sub-criterion is derived by multiplying the local weight of the sub-criterion by that of the corresponding criterion

Table 7.
Results of the FAHP ($n = 8$, samples are governmental officials)

design onshore tourism programme can bring extra cruise service value-added and attract tourists' interests. Generally, they are good at designing such a programme and relatively emphasized this sub-criterion. Although "port-city climate" is ranked as the last, this is a relative comparison ranking and it does not mean this sub-criterion is not important. Also,

Criteria	Local weights	Sub-criteria	Local weights	Global weights	Rank
Port infrastructure and facilities	0.275	Berth facilities	0.267	0.074	8
		Navigation facilities	0.249	0.069	9
		Cruise terminal facilities	0.245	0.067	10
		Green terminal facilities	0.239	0.066	12
Port regulations and services	0.226	PSC	0.351	0.079	5
		Cruise service function	0.278	0.063	13
		Port charges	0.371	0.084	3
Port-city development plans	0.225	City's history and culture	0.332	0.075	7
		Green port hinterland transport system	0.298	0.067	10
		Onshore tourism programme	0.370	0.083	4
Port geography and climate	0.275	Port location	0.289	0.079	5
		Port-city climate	0.345	0.095	2
		Natural resources	0.366	0.100	1

Table 8.
Results of the FAHP ($n = 9$, samples are academics)

Notes: The local weight of each criterion or sub-criterion is derived from expert judgement and pairwise comparison, the global weight of a sub-criterion is derived by multiplying the local weight of the sub-criterion by that of the corresponding criterion

the governmental officials preferred "port charges" and "port location" (both are ranked the highest) but not "natural resources" (ranked the lowest). In Taiwan, port governmental officials regularly review and organize their port charges and terminal and port policies to provide attractive cruise port service. Therefore, they relatively emphasize these two sub-criteria. For academics, most of them thought "natural resources" is the most important but "cruise service function" is the least important. It can be observed that government officials and academics have different opinions in "natural resources". To our best knowledge, it can be explained that it is difficult for port governmental officials to control or change "natural resources" in their daily works, and therefore, they provide a low importance score averagely. For Academics, they might adopt a comprehensive perspective to evaluate a cruise port and thought good natural resources can play an important role in the cruise port development and provide a relatively higher importance score averagely.

4.2.2 Weight comparisons of all questionnaire participants. When combining the all 26 experts' questionnaire data, the results of the FAHP (Table 8) show that port infrastructure and facilities (0.278) are the most important criterion, followed by port-city development plans (0.263), port infrastructure and facilities (0.239) and port geography and climate (0.220). With regard to the sub-criteria, berth facilities (0.261), port charges (0.359), onshore tourism programme (0.345) and natural resources (0.342) are, respectively, the most important sub-criteria of the four criteria. The results reveal that the three most important sub-criteria overall are the onshore tourism programme (global weight 0.091), the city's historical and cultural features (0.087) and the green port hinterland transport system (0.085) [6].

The result that sub-criterion "onshore tourism programme" is ranked as top one can be explained by the fact that the basic port infrastructure and facilities, port regulation and service are similar in Taiwanese ports. Various onshore tourism programmes (e.g. city's attraction and customerized tour activities) can play an important role and attract passengers' interest and consequently affect cruise companies' port selection and sailing planning. Regarding sub-criterion "cruise service functions", Taiwanese port authorities and

other port service operators (e.g. cruise agents) can offer standardized and qualified service. Hence, we are convinced that questionnaire experts might thought this sub-criterion is ranked the last although it is important (Table 9).

When comparing Tables 5, 6 and 8, there is an argument that the cruise operators valued "port-city development plans" is the most important criterion (0.332). Oppositely, the government officials thought criterion "port-city development plans" is the least important. This criterion is ranked as 2nd when combining all experts' opinions. Thus, cruise operators pay more attention to port-city service content than governmental officials. Generally, cruise operators are experts in tour planning and marketing, and port governmental officials have always focussed on port infrastructure and service regulation. Therefore, their opinions exist in significant differences. After synthesizing three groups' opinions, criterion "port-city development plans" still play 2nd important role within these four criteria and reveal the city's characteristics, transport system and onshore tourism programme should not be ignored.

A summary of the pairwise comparison of the four ports based on the relative importance of the criteria and sub-criteria is given in Table 10. Keelung port is ranked as the best cruise port in Taiwan owing mainly to its higher scores of preference value for port infrastructure and facilities and for port geography and climate. Based on the preference values, Kaohsiung, Taichung and Hualien ports are ranked as the second, third and fourth best ports, respectively.

Finally, the finding that the weights of criteria and sub-criteria in this paper are close can be explained by comparing the weights of three groups of experts (including cruise operators, governmental officials and academics). These groups might have different opinions on each criterion and sub-criterion. These criteria and sub-criteria are cited from previous studies and they might play important elements of developing a cruise port. Therefore, these criteria or sub-criteria might exist more close weight scores. Similar cases can be found in Wang *et al.* (2016a, 2016b) and Dozic *et al.* (2018).

Criteria	Local weights	Sub-criteria	Local weights	Global weights	Rank
Port infrastructure and facilities	0.278	Berth facilities	0.261	0.073	9
		Navigation facilities	0.247	0.069	11
		Cruise terminal facilities	0.242	0.067	12
		Green terminal facilities	0.250	0.069	10
Port regulations and services	0.220	PSC	0.348	0.077	7
		Cruise service function	0.293	0.064	13
		Port charges	0.359	0.079	6
Port-city development plans	0.263	City's history and culture	0.331	0.087	2
		Green port hinterland transport system	0.324	0.085	3
		Onshore tourism programme	0.345	0.091	1
Port geography and climate	0.239	Port location	0.340	0.081	5
		Port-city climate	0.318	0.076	8
		Natural resources	0.342	0.082	4

Notes: The local weight of each criterion or sub-criterion is derived from expert judgement and pairwise comparison, the global weight of a sub-criterion is derived by multiplying the local weight of the sub-criterion by that of the corresponding criterion

Table 9.
Results of the FAHP ($n = 26$)

Port	Port infrastructure and facilities	Port regulations and services	Port-city development plans	Port geography and climate[a]	Preference value	Ranking
Keelung	0.281	0.255	0.255	0.270	0.266	1
Taichung	0.232	0.233	0.240	0.257	0.240	3
Kaohsiung	0.239	0.267	0.281	0.245	0.258	2
Hualien	0.248	0.245	0.224	0.228	0.236	4

Notes: [a]For geography consideration, it could involve hinterland transportation system, port and neighbour city's attractions, etc. For climate consideration, Taiwan is a small island and the climate situation (e.g. temperature, humidity, etc.) might exist a little variation among four ports but the variation might be not significant. Above two factors (geography and climate) might be a subjective opinion and weight score consequently might be different for each expert. For example, some experts thought Keelung has better weight score in geography and climate, as it is close to Taipei and can visit modern city attractions. On the other hand, some experts thought Hualien has better weight score in geography and climate, as Hualien locates at East coastal and can offer natural landscapes. Our final weights are summarized from 26 experts' opinions and we believe it can reduce subjective opinion difference for each expert

Table 10.
Summary of cruise port comparison

It is noted from Table 10 that these weight values are close. It can be explained that these 26 experts have different professional fields (including cruise operators, governmental officials and academics) and different preferences for four criteria and alternatives (including Keelung, Taichung, Kaohsiung and Hualien port). Also, based on the official report of TIPC [7], these four ports have achieved basic requirements (e.g. port infrastructure and facilities, port regulations and services, port-city development plans and port geography and climate) of developing cruise industries. Synthesizing these experts' preferences might result in smaller weight value differences in the analysis eventually. It is important that such a result reveals that four criteria are all quite important but unavoidably exist differences in ranking. For four ports comparisons, although Keelung port is ranked as the best port, the other three ports (Taichung, Kaohsiung and Hualien) are also suitable for developing cruise ports in Taiwan and these ports have potentials of development [8].

The reason why Keelung port has attracted more passengers can be explained by the fact that this port is benefited by its good port location and governmental resources investment. The Keelung port, located on the northern coast of Taiwan, has attracted 84% of all cruise visits to Taiwan cruise ports in the year 2018 and is a cruise homeport in Taiwan [9]. Homeports are those ports where a cruise voyage starts and ends. Homeports are closely associated with major economic benefits because passengers stay longer around home ports. This port is equipped with good passenger terminal facilities and its location is close to the Taipei city (about 25 km), which has many attractions and sightseeing resources for international travelers such as Taipei 101 building, national palace museum, Yehliu Geopark, Yang Ming Oceanic Culture and Art Museum, as well as a good reputation for its green mass-rapid-transit system and city culture.

Also, the Keelung port can play a transshipment hub in various cruise line trips such as:

- Keelung-Ishigaki Island-Okinawa-Keelung;
- Keelung-Miyako Island-Keelung;
- Keelung-Fukuoka-Pusan–Keelung;

- Keelung-Nagasaki-Lishui-Jeju Island-Keelung; and
- Keelung-Kagoshima-Nagasaki-Keelung.

The Fly-cruise trips are as follows:

- Keelung-Nagasaki-Pusan-Lishui-Keelung;
- Keelung-Jeju-Pusan-Keelung;
- Hong Kong-Keelung; and
- Taoyuan international airport – Pusan Gimhae international airport-Pusan-Hakata-Maizuru-Kanazawa-Sakaimiatao-Pusan-Pusan Gimhae international airport-Taoyuan international airport.

In sum, in general, the first stop of international travelers for sightseeing would be Taipei city, which is the political and economic centre in Taiwan and Keelung port has enjoyed excellent natural location advantages (main path of the Northeast Asia route) and governmental travel resource investment for constructing one important homeport in Northern Taiwan area in the past based on the official report of TIPC [10]. Therefore, Keelung port has been selected for favourable cruise port from the perspective of cruise passengers and cruise operators in Taiwan.

Compared with the other three ports, the Keelung port has a higher FAHP model score for the port geography and climate criterion and local tourism operators and cruise passengers have sufficient time to arrange onshore city sightseeing programmes. Also, as shown in Table 8, the three sub-criteria of the criterion "port-city development plans" (onshore tourism programme, city's history and culture and green port hinterland transport system) are viewed as the most important sub-criteria and the Keelung port has the highest preference value in these sub-criteria (Table 10). This can be explained by two reasons. First, Keelung Port is located at the heart of the city and it is easy to access the public transport. For example, Keelung Railway Station (1.1 km), Taipei Railway Station (31.2 km), Nangang High-Speed Railway Station (21.7 km), Taipei Songshan Airport (23.3 km) and Taoyuan International Airport (63 km). Convenient transportation facilities can provide cruise passengers to quickly visit Taipei and northern Taiwan coastal attractions (e.g. Keelung Miaokou Night Market (1.5 km), Taipei 101 building (28.5 km), Yehliu Geopark (15.8 km), National Palace Museum (29.2 km). Second, Keelung port is equipped with two cruise terminals (E2 and W2 terminal) and offers sufficient passenger service facilities (currency exchange and tax refund counter, Wi-Fi, duty-free shop, restaurants, nursery room and storage room, etc.) and convenient customer services. These advantages contribute to Keelung port achieving its high ranking.

Taichung city has amazing coastal resources (e.g. Gaomei Wetland), national art resources (e.g. National Taichung Theater and National Taiwan Museum of Fine Arts), entertainment and shopping centre. In addition, the Taichung port is located on the western coast of Taiwan and might play the role of Port of Call for various cruise line trips such as Hong Kong-Taichung-Keelung, Xiamen-Taichung-Keelung, Keelung-Taichung-Kaohsiung, Keelung-Yonaguni-Keelung. Within four weight scores, Taichung port's rankings are fourth, fourth, third, second, respectively. The overall preference values are the third (Table 10).

Regarding the Kaohsiung port, it is located on the southern coast of Taiwan and might play a homeport in Taiwan. It offers ferry services and delicious seafood. The main cruise liner trips include Kaohsiung-Naahwa-Ishigaki Island-Kaohsiung, Ho Chi Ninh-Kaohsiung-Hong Kong, Keelung-Kaohsiung-Hong Kong, etc. Within four weight scores, Kaohsiung

port's rankings are third, best, best, third, respectively. The overall preference values are the second (Table 10).

Hualien, located on the eastern coast of Taiwan, has plentiful but different natural resources. It usually plays the role of the port of call and its main cruise liner trips include Ishigaki Island-Hualien-Keelung, Keelung-Hualien-Hong Kong, Hong Kong-Hualien-Kaohsiung, etc. Within 4 weight scores, Taichung port's rankings are second, third, fourth, fourth, respectively. The overall preference values is the fourth (Table 10).

There is a coincidence that the ranking of cruise port comparison are consistent with the ranking of the numbers of passenger arrivals during the year 2015 ~ 2018 (Tables 2 and 10). Therefore, the number of passengers is not the only determinant factor that affects cruise port ranking. It must comprehensively consider key criteria and then synthesize it.

5. Discussion and managerial implications

Although cruise port selection issues have been studied in various countries (Wang *et al.*, 2014), through a comprehensive literature review, our study focusses on Taiwanese cruise ports and adopted three groups of field experts and presents synthesize research findings. Using 26 expert opinions, results reveal that the most important criterion is port infrastructure and facilities, followed by port-city development plans, port geography and climate and port regulations and services. The number of three groups of field experts of cruise operators, government officials and academics is 9, 8 and 9, respectively. Thus, such nearly equal numbers of experts in each group can effectively reduce potential bias in our analysis results. It is argued that bias might exist among various field experts when filling the questionnaires. For example, the judgment of cruise operators may be affected by a rationality bias. Meanwhile, in the case of government officials, a policy bias may exist in their responses. Also, academic experts may have different analysis considerations based on their training and research and then exist an analysis bias.

All the studied ports are equipped with good cruise terminal facilities and can serve large cruise ships [11]. Keelung and Kaohsiung ports are set as homeports and consequently have a greater investment of port and tourism resources, including large cruise terminal facilities and passenger buildings [12]. For Keelung port, which is close to the Keelung city area, it is suggested that the port authorities could cooperate with the central government, Keelung city government and other stakeholders (e.g. customs, travel agents and city bus operators) to mutually develop cruise port reconstruct strategies. Also, acquiring and integrating more land areas to develop a waterside port environment through adjusting urban planning policies [13].

As the importance of the criterion "port infrastructure and facilities" is the highest and Keelung port has a higher weight score in this criterion, it is suggested to actively develop its niche market to strengthen the competitiveness of the cruise port. For example, some navy terminals are close to Keelung port and several historical warehouses are needed to be revitalized and reused (e.g. W2 and W3 terminal), Keelung port authorities (including Taiwan International Ports Corporation and Maritime Port Bureau) should actively negotiate with Keelung city government, Ministry of National Defense, other stakeholders (e.g. container and bulk terminal operators) and rethink how to integrate port resources and construct quick customs clearance services and friendly green port environment.

In sum, the national authority, local government, port authorities and cruise lines should actively cooperate and provide convenient, safe and quick cruise terminal facilities and service as follows:

- Assessing the current utilization of the berths of each port and deploying optimal cargo (including container and bulk) and passenger terminal deployment; and

- Strengthen on-shore services (e.g. travel information and English tour guide), functions (e.g. accessibility facilities in passenger building and feeder bus service) and amenities in the cruise terminal building.

These provisions of the cruise port will effectively attract more cruise lines and passengers to visit/revisit cruise ports and increase more cruise economies and market benefits.

Regarding sub-criteria, the top three are the onshore tourism programmes, the city's historical and cultural features and the green port hinterland transport system. Therefore, enhancing onshore tourism programmes (e.g. effective transportation feeder services, travel deals and tour guide services) and city sightseeing resources (e.g. festival events for international travellers) are key to establishing an effective cruise niche market.

The model of 13 criteria is for policymakers and cruise operators to conduct assessments of cruise ports and, more importantly, to understand the potentials of ports for cruise tourism. A cruise port is favourable if it offers diversified experiences and world-class attractions. The model guides the direction for tourism products or packages to be developed.

The findings show that cruise tourism development does not fully align with cargo trade development. Trade is more related to large-scale manufacturing but cruise tourism is toward the domestic consumption of goods and services. These findings represent that the unique natural and cultural heritage offered by a cruise port is attractive. From the perspective of developing cruise ports (including Taiwan and other countries), decision-makers should re-think themselves' port-city characteristics (e.g. strengths, weaknesses, opportunities and threats analysis) and resources, then further develop effective competitive strategies for their niche markets. It is of utmost importance for port authorities to manage cruise tourism to preserve the natural and cultural heritage assets of a port and its region to sustain long-term vitality. So, cruise tourism may be good for some ports but not for some others.

6. Conclusions

This study identified the four criteria and 13 sub-criteria to evaluate four cruise ports in Taiwan. Based on 26 expert questionnaires, infrastructure and facilities is the most important criterion, followed by port-city development plans, port infrastructure and facilities and port geography and climate. Also, Keelung port is ranked as the best cruise port, followed by Kaohsiung, Taichung and Hualien port.

Managerial and policy implications based on the relative importance of the different criteria and sub-criteria can help guide decision-makers and assist in developing cruise ports for cruise-related operators and governmental divisions (e.g. cruise companies, cruise port operators, port constructors, travel agents, cruise information service providers, passengers and other stakeholders). Three future research avenues could be explored to increase our understanding of cruise tourism and the role of ports. First, other-related field experts' knowledge (e.g. cruise tour guides, customs officials, tourism agencies, etc.) and cruise customers' opinions can be collected in future research. Second, a future research study could be conducted with in-depth interviews to validate and extend the present research topic based on grounded theory (Mullai and Paulsson, 2011). Third, gambling has been excluded from this study but many port policy-makers consider on-shore gambling for cruisers. The marketing of gambling may or may not lead to the growth of cruise tourism, which would be addressed by further study.

Notes

1. As Keelung city is near Taipei city, many onshore travel agents can arrange Taipei's attractions for travellers for trips lasting up to 6 h.
2. Taichung city is near Nantou County and onshore travel agents can arrange Nantou's attractions for trips lasting up to 6-8 h.
3. Equation (1) is provided to explain a triangular fuzzy number concept, which can normalize and synthesize various experts' opinions when introducing the FAHP. When filling the relative importance pairwise comparison scores with a nine-point rating scale by Expert Choice software, the software will consequently provide CI value for each expert questionnaire. The questionnaire will be discarded if the CI or RI value is less than 0.1. Also, RI value is obtained through corresponding value in Table 4.
4. We believed these sufficient expert numbers and types can effectively reduce potential unreasonable priorities and information loss.
5. It might exist field experts in the cruise passengers. However, it is not easy to find such a field expert in the cruise customer group, as the number of cruise customers might achieve about 2,000 ~ 3,000 persons per call in a cruise port.
6. It should be noted that there are four sub-criteria for "port infrastructure and facilities" and other three criteria (port regulations and services, port-city development plans and port geography and climate) all only have three sub-criteria, respectively. Such a phenomenon has resulted in the local weights of "port infrastructure and facilities" (0.242 ~ 0.261) are significantly lower than the local weights of other sub-criteria (between 0.293 ~ 0.359). Thus, even the local weight of criterion "port infrastructure and facilities" is higher than those of other 3 criteria (port regulations and services, port-city development plans and port geography and climate), the global weight of sub-criteria "port infrastructure and facilities" (berth facilities, navigation facilities, cruise terminal facilities, green terminal facilities) has become lower than those of other sub-criteria and ranking.
7. Details can be found in "Taiwan's Port Linking Asia to the World" report (page 11 ~ 40). https://kl.twport.com.tw/Upload/C/RelFile/CustomPage/3527/b8181d54-8fbd-4197-ab6d-ae9402d80050.pdf.
8. Here we provide two cases that weight scores are close. First, is Dozic *et al.* (2018, page 173). This paper used FAHP to select passenger aircraft types and their weight scores were 0.1468 (ATR 72-500), 0.1605 (ATR72-600), 0.1146 (ERJ 190), 0.1142 (Q400 NG), 0.1521 (CRJ 700), 0.1430 (CRJ 900), 0.1388 (CRJ 1000), respectively. Second, is Wang *et al.* (2016b, p. 231). This paper used FAHP to select transport modes for Kinmen military logistics and their weight score were 0.3897 (mode A), 0.3372 (mode B) and 0.2732 (mode C), respectively.
9. Taiwan International Ports Corporation. https://www.twport.com.tw/chinese/
10. Details can be found in "Taiwan's Port Linking Asia to the World" report (page 5 and page 14). https://kl.twport.com.tw/Upload/C/RelFile/CustomPage/3527/b8181d54-8fbd-4197-ab6d-ae9402d80050.pdf
11. For example, Keelung port served two cruise ships (with a total of 10,000 passengers) on 21 April 2018. The main cruise operators in Taiwan are Star Cruises, COSCO and Princess Cruises. https://kl.twport.com.tw/chinese/News_Content.aspx?s=734C142E9E7FCC14&SMSU=10414262980B5C38
12. Cruise port information can be found on the Taiwan International Ports Corporation website at http://cruise.twport.com.tw/
13. These works might involve central government supports such as more land resources, Nava authorities negotiation for military facilities movement, etc.

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Appendix. Questionnaire

Section 1: Demographics information

Please tick one answer only for each of the following statements

1. What is your job title?

□ President/Director □ Senior Deputy director □ Division director

□ Supervisor □ Professor □ Associate Professor □ Assistant Professor

2. How old are you? □≦40 □ 41-50 □ 51-60 □ ≧61

3. What is your highest education qualification?

□ Bachelor □ Master □ Ph.D.

4. How many years have you worked in the cruise related industry?

□ 10-15 □ 16-20 □ 21-25 □≧26

Section 2: Pairwise comparison of criteria/sub-criteria

2.1 Pairwise comparison of criteria

Which criterion is more important criterion influencing the evaluation of cruise port, and how much more?

Circle one number per row: (1=Equal; 3=Moderate; 5=Strong; 7=Very strong; 9=Extreme)

A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	B
A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	C
A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	D
B	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	C
B	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	D
C	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	D

Note: A is Port Infrastructure and Facilities, B is Port Regulations and Services, C is Port-City Development Plans, D is Port Geography and Climate

(*continued*)

2.2 Pairwise comparison of Port Infrastructure and Facilities

Which sub-criteria is more important to criteria “Port Infrastructure and Facilities”, and how much more?

A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	B
A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	C
A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	D
B	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	C
B	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	D
C	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	D

Note: A is Berth Facilities, B is Navigation Facilities, C is Cruise Terminal Building , D is Green Terminal Facilities

2.3 Pairwise comparison of Port Regulation and Service criteria

Which sub-criteria is more important to criteria “Port Regulation and Service”, and how much more?

A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	B
A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	C
B	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	C

Note: A is Port State Control, B isCruise Service Functions, C is Port Charges

2.4 Pairwise comparison of Port-City Development related criteria

Which sub-criteria is more important to main criteria “Port-City Development”, and how much more?

A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	B
A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	C
B	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	C

Note: A is City’s Historical and Culture, B isGreen Port Hinterland Transport System , C is Onshore Tourism Programme

2.5 Pairwise comparison of Port Geography and Climate related criteria

Which sub-criteria is more important to factor “Port Geography and Climate”, and how much more?

A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	B
A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	C
B	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	C

Note: A is Port Location, B isPort-City Climate, C is Natural Resources

(*continued*)

Section 3 Alternatives comparison

When selecting the best cruise port, which port is better, and how much more?

A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	B
A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	C
A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	D
B	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	C
B	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	D
C	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	D

Note: A is Keelung port, B isTaichung Port, C is Kaohsiung Port, D is Hualien Port

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