

A game theory application of a cruise value chain – the case of China

Cruise value chain

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Abstract

Purpose – Regardless of the facts showing a booming Chinese cruise market, cruise operations in China are very different from the current practices of the two major cruise markets – the US and the Mediterranean Sea. This study aims to quantify pricing strategies and possible incentive mechanisms of cruise operations in China.

Design/methodology/approach – Using optimization in economic-based game theory, the complexity of the pricing strategies and interaction and/or possible coordination within the cruise value-added chain can be captured.

Findings – The results show that a coordinative pricing strategy with Shapley profit redistribution within the value-added chain offers benefits to both cruise passengers and service suppliers. With two subsidy scenarios, one to the passenger and the other to the travel agent, a cooperative pricing strategy outperforms other strategies and successfully increases market shares and total revenue.

Originality/value – The advantages of coordination between participants in cruise value chain are quantified. Effective strategies for attracting players participating in cruise value chain are designed. This paper will provide market participants with strategies to enhance their decision-making processes.

Keywords Game theory, Vertical integration, Cruise supply chain, Port subsidy, The benefit distribution

Paper type Research paper

1. Introduction

The cruise industry is considered one of the fastest growing segments in the shipping industry. Cruise lines with extended off/onshore activities along with entertainment on board provide extraordinary experiences to customers in keeping with the sustainable long-term growth of the tourism. Since 1980, the cruise ship industry has experienced a passenger growth of 7.2 per cent annually. The number of cruise passengers across the world has



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increased from 15.62 million in 2007 to 23 million in 2015 (Florida-Caribbean Cruise Association FCCA Cruise Industry Overview 2015).

The Cruise Line International Association has published a recent report showing Asia cruise trends show a booming Asian market. In between 2013 and 2016, there is a 12 per cent growth in the number of ships deployed in Asia, 22 per cent growth in the number of cruises and voyages within Asia, 13.6 per cent expansion in annual operating days and 29.3 per cent increase in annual passenger capacity. Even though the cruise market in China is considered a relatively new form of recreation, China is the driver of passenger growth in Asia, adding 770,000 more cruise travellers, creating a 66 per cent annual growth rate in 2012. In 2015, China has provided approximately 1.1 million passengers, with 986,000 passengers coming from mainland China. Growing business can be observed from the increased frequency of calls, new facility terminals, various travel packages with unique shore excursions, different destinations, activities such as barge trip, kayaking and better rail and road connections. Currently, there are seven cruise lines operating 12 cruise routes in Asia. Growing business in terms of new entrants of cruise companies with similar services and packages has created fierce competition for the cruise market.

Regardless of the facts showing a booming Chinese cruise market, cruise operations in China are very different from the current practices of the two major cruise markets – the USA and the Mediterranean Sea. In the USA, major cruise companies operate under an oligopolistic market structure. Cruise companies negotiate the contracts with the cruise ports for terminal and facility usage, dedicated services and/or connection to ground transportation and parking with considerable bargaining power. Often times, cruise ports provide incentives to the cruise companies in exchange for a longer operating contracts, more frequent number of calls or a greater number of passengers. Without sufficient incentives, cruise companies can easily reduce or move operations and leave the cruise ports hanging. However, this is not the case in China. Specialization of cruise operation in Chinese ports can rarely be seen. Major ports may have one or two multipurpose terminals that can handle cruise operations. With limited physical space for cruise terminals, ports that are willing to serve cruise lines have more bargaining power than the cruise companies that differ from the US and the Mediterranean. The ports dominate the game in selecting which cruise lines will be served with which cruise facilities and cruise terminals, as well as determining the frequency of calls by each cruise line. That means the typical pricing and/or cooperation models applied to the USA and Mediterranean Sea may not be suitable for China.

Another interesting fact comes from the regulatory side. In the USA, customers who are interested in going on a cruise have multiple alternatives from which to choose when purchasing a cruise package. They can use online booking from the cruise line's official websites and/or from the popular travel webpages, such as Expedia and Travelocity. They can also use a travel agent who offers personalized advice with a variety of combined packages of ship types, itineraries, dining plans and cabin selections. Depending on the customer's needs, booking online or through travel agents has its own pros and cons but the option remains available for the cruise passengers. However, in China, there is no direct booking mechanism. Customers must find a travel agent. This affects cruise line's pricing and market strategies.

Given the uniqueness of the Chinese cruise operations with the ports they serve, we tailor a game theory model to demonstrate the interaction of key players in the cruise line value-added chain in a quantitative game theory. The features unique to the Chinese cruise market include the following:

- Cruise port dominates the game in selecting which cruise lines can use the port, its facilities and its terminals, as well as determine the frequency of calls that the cruise line can make at the port.
- No direct access for cruise passengers to book and/or arrange itinerary from the online travel sites. Cruise travelers must go through travel agency to book and/or purchase pre-determined packages.

Value chain or value-added chain analysis is applied to assess the relationship between different economic drivers within a given scope of a product or service. While the scope of the value chain application could be as small as the various stages of a production line served within a firm, it can be broadly defined as seen in the marine sustainability and agricultural applications (Irvine, 2015). “A broad approach to value chain analysis starts from the production system of the raw materials and moves along the linkages with other actors and enterprises engaged in trading, processing, assembling, transporting, etc. This broad approach examines all of the activities of a single enterprise, as well as all of the backward and forward linkages from the raw materials to final consumer” (Rosales *et al.*, 2017). Revisiting the complete value-added chain in cruise line recreation includes cruise passengers, crew, travel agencies, cruise lines and cruise ports; the biggest challenge for the cruise industry is to offer the best experience for passengers in a constantly changing environment that requires quick response to provide high-quality services. Thus, the cruise value-added chain integrates the various upstream and downstream business operations.

Generally speaking, the value-added chain in cruise recreation is company oriented. The upstream firm/customer coordination covers passengers and the cruise port, whereas the downstream cooperation includes the travel agency. An efficient and undisrupted production chain can improve the quality of the cruise services and the individual competitiveness of the value chain members in the entire system. However, conflict of interests exists between the members of the chain. Lack of cooperation and cohesion may lead to inefficiency along the entire value chain. Hence, the key to the cruise value chain management lies in the mechanism appropriate distribution of the profit among the members. One way to do that is through a properly structured pricing strategy. Various pricing strategies used by cruise companies can increase profitability and improve occupancy rate. Efficient allocation of resources in the value chain can reduce operating costs. In this study, we quantify pricing strategies and possible incentive mechanism in the Chinese cruise business operation. With an economic approach using optimization in the game theory, the complexity of the pricing strategies and interaction within the cruise value-added chain can be captured.

What we find is that coordinative pricing strategy with Shapley profit redistribution within the value-added chain offers benefits to both cruise passengers and service suppliers. With two subsidy scenarios, one to passenger and the other to travel agent, cooperative pricing strategy outperforms individual pricing strategies successfully increasing market shares and total revenue. With the integrated upstream and downstream structure, the model can further be extended to examine under what circumstance the vertical integration and/or coordination of a cruise supply chain can improve performance for all in the value-added chain, such as cruise ports, cruise companies and relevant service providers. Likewise, the model can be used to compare the differences in current cruise pricing strategies and practices in different continents. However, vertical integration and cooperative pricing strategies in some market such as the US and Europe are subject to anti-trust evaluation, so not every pricing strategy purposed for China will be available in those markets.

2. Literature

The cruise industry scholarly research increased recently. Studies can be found from a broader scale of demand and supply for cruise tourism, routing of cruise vessels and the economic impacts of cruise activities (Petrick and Li, 2006; Dwyer and Forsyth, 1998; Dwyer *et al.*, 2004; Chang *et al.*, 2016). Regional studies from either the port's perspectives or from the passenger's perspective is another stream of literature (Brida *et al.* (2013) for the Port of Cartagena, Colombia; Wang *et al.* (2014) for the East Asian ports, Castillo-Manzano *et al.* (2014) for Spanish ports, Esteve-Perez and Garcia-Sanchez (2015) for the Mediterranean ports and Sun *et al.* (2014) for Chinese ports.

The focus of this study is to provide a theoretical framework to showcase the features of Chinese cruise operations. At the same time, through a conceptual value-added chain, a guideline of a practical efficient pricing strategy that eventually leads to the best reallocation and redistribution of profit within the chain is reached. Local agents in the destination could generate tremendous added value for the whole cruise supply chain (Gui and Russo, 2011). This is a natural way for cruise lines to develop more efficient cruise chains involving local agents with intimate knowledge of the operation and regulation, and environment at the local destination (Véronneau and Roy, 2009). Many researchers have studied the integrated transport chain formed by the cooperation of multi-stakeholders upstream and downstream, e.g. Asgari *et al.* (2013); Clott and Hartman (2016) and Song *et al.* (2016). Firms turn attention to incremental value created from the coordination within the intricate network instead of holding separate function (Min and Zhou, 2002). When considering the fierce competition for shipping demand, competitive advantages of supply chain collaboration have been identified. Customer value created through the supply chain has successfully caught the attention of those in the discipline of value chain management, along with the concept of managing integrated services from suppliers to the end-customers for economic sustainability and high efficiency of the entire value chain (Fearne *et al.*, 2012).

Pricing strategy is important especially in the cruise industry. Service price is negatively related to customers' value perception of the cruise experience (Blas and Carvajal-Trujillo, 2014; Chua *et al.*, 2015). It is quite critical for stakeholders in the supply chain to adopt effective pricing strategy on customers' perceived value. (Al-Mudimigh *et al.*, 2004; Christopher and Gattorna, 2005). With semi-structured interviews to study Chinese tourism, Sun *et al.* (2011) reviewed revenue management in cruise industry comparing the differences between cruise lines and hotel revenue management. For example, each customer is priced separately and served by a travel agent in the cruise industry. That difference limits the scale of the traditional hotel pricing theory and it may not be able to be successfully applied to cruise industry. Ladany and Arbel (1991) proposed an optimal price discrimination policy to help cruise companies identify and extend potential markets. Based on the distinction of market segments between price-sensitive and price-insensitive customers, the competitive advantages of price discrimination strategy in cruise industry are investigated by Langenfeld and Li (2008). Comparative analysis is used to evaluate the effects of price discrimination and uniform prices on output and profit of cruise lines. Moreover, price discrimination strategy could bring considerable benefits to cruise lines with limited competition. Similarly, Petrick (2005) studied the discount pricing strategy to attract cruise passengers, and showed that price-sensitive passengers do respond positively to those marketing strategies and have a relatively positive cruise experience.

Discounts also affect the cruise customers' view of the cruise experience. Duman and Mattila (2004) pointed out that experienced cruise vacationers are more likely to use discount coupons. Discounting is considered an effective pricing strategy for sustaining long-term profitability. The cruise policy such as passenger tax-free shopping in Hainan

Island, China, is an attempt to fulfill expectations of Chinese tourists with high price sensitivity (Sun *et al.*, 2014). Integrated cruise service products through promoting cooperation among participants in cruise supply chain, including cruise lines, ports and onshore travel agents, serve as a good practice and guideline for the newly developed Chinese market. Chinese passengers may get more convenient cruise service, whereas a win-win situation for all stakeholders would be achieved.

3. Problem description

The cruise package sold in China combines cruise ship tourism and on-shore excursions. Through a pre-determined agreement and/or a contract, a travel agency assists potential cruise passengers directly to create their packages. Figure 1 shows a simplified structural model of the cruise supply chain. This model is the foundation for a two-stage Stackelberg game among the cruise port, cruise line company and travel agency.

The decision-making process is as follows: during the first stage of competition, the cruise port becomes a price leader in the cruise value-added chain. When the cruise company becomes a price follower, according to the market demand, the cruise port formulates the corresponding fees for ship calling at the port. To maximize the cruise port's own interest, the calling price p_c is decided by the unit variable cost c , which is combined with the cruise service cost and reception cost. Once it has the contract with the port, the cruise company then determines the price p_b based on the terminal and facility usage fees p_c , the unit variable cost c_v , and the fixed cost c_f for operation to maximize profit.

This is one of the unique features in the Chinese cruise market. Compared to the major cruise tourism in the Caribbean and Mediterranean areas where cruise companies have much of

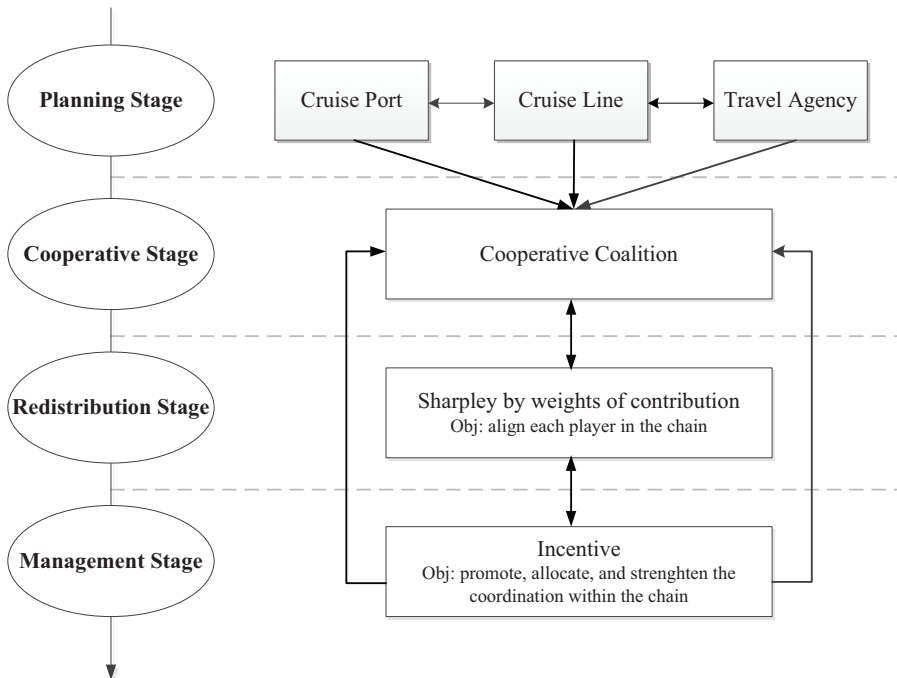


Figure 1. Simplified cruise value chain with travel agency, cruise line company and cruise port

the negotiation power in setting prices and arranging needed long-term contracts with the home ports, cruise in China is considered an additional add-on to the existing port operations. That is because port operations are centrally controlled by the government which determines the amount and type of traffic different from the USA or Europe. Usually with a cruise terminal and other needed facilities, a container port is ready for cruise activities. With limited access currently available for cruise operation, major cruise companies that want to extend their business in China have to work with the ports to receive the exclusive use of the terminal space. In that sense, the dominant role of the game is switching from the cruise line as we typically assume to the port authorities that equip well with needed infrastructure of cruise operation. Thus, the results of a two-stage leader–follower game will be much different if there is another dominant role in the decision-making process.

In the second stage, the competition occurs between the cruise line company and the travel agency. Cruise line company sets up the corresponding tourism product service portfolio based on the market demand. The decision variable, the shipping space underwriting price p_b , depends on the unit variable cost c_v , which is combined with the cruise service cost and reception cost. The travel agency supplies the cruise tourist resources to the cruise company. The travel agency determines the fare charged to the tourists based on cruise line company's exclusive sale price p_a , and then the cruise line company is responsible for providing the cruise products and services to the tourists.

The structure of the second-stage game, especially the role of the travel agent, is noteworthy when we model the current operation of Chinese cruise market. Compared to the North America and Europe where travellers have a great amount of online information through various of travel booking sites that combine services from airfares, hoteling, local transportation on/off shore excursion, etc., Chinese cruisers must rely on the services of travel agents. There is no direct access for cruise passengers to book and/or arrange itinerary from the online travel sites. Price comparison is within the range between different travel agents for the pre-determined packages but not for travel booking sites.

4. Cruise value chain pricing model

A three-player cruise value chain, including travel agency, cruise line and cruise port, is considered in this paper in a Stackelberg game. Section 4.1 provides the basic model settings, where participants in the cruise value-added chain determine their own prices individually to maximize own profit. In the first stage of the game, the cruise port is a price leader in the chain, and the cruise line company becomes a price follower. In the second stage, the cruise line company is a price leader, followed by the travel agency. After the model setting, we will show profit maximization in the cooperative game to capture the coalition of the entire value-added chain and how the revenues are redistributed back within the chain using Shapley value in Section 4.2.

4.1 Model settings

- (1) All parties in the coalition are assumed rational and pursue self-interests.
- (2) Prices in the cruise supply chain are:
 - p_b : wholesale ticket price underwriting from cruise company b to travel agency a ;
 - e_b : net income per person obtained by cruise company b to provide services such as on/offshore shopping and excursion and gambling at sea;
 - p_a : average retail price charged by travel agency;

- e_a : net income per person obtained by travel agency a to provide services such as shopping on shore; and
- p_c : cost per person due to calling on cruise port c .

(3) Costs in the cruise value chain are:

- c_v : the unit variable cost regarding the process of cruise navigation;
- c_f : the fixed cost in the process of cruise navigation; and
- c : the unit cost of cruise port c , when the cruise calls on cruise port c .

The market demand function is formulated as [equation \(1\)](#):

$$Q = \alpha - \beta \cdot p_a \quad (1)$$

where $\alpha > 0$, $\beta > 0$ and α , β are constant. α denotes maximized demand of tourists to purchase tickets in the cruise market. β denotes the price elasticity of demand, and the price is inversely proportional to the tourists.

In Stage 2, [equations \(2\)](#) and [\(3\)](#) are the profit for the travel agency and cruise company, respectively:

$$\pi_a = Q \cdot (p_a + e_a - p_b) \quad (2)$$

$$\pi_b = Q \cdot (p_b + e_b - p_c - c_v) - c_f \quad (3)$$

According to the first-order condition of [equation \(2\)](#), $\partial \pi_a / \partial p_a = 0$, travel agency sets up pricing strategy according to cruise line's move, which is shown in [equation \(4\)](#):

$$p_a^* = \frac{\alpha + \beta(p_b - e_a)}{2\beta} \quad (4)$$

In Stage 1, cruise company sets the wholesale price according to the cruise port's behavior. Combining travel agency's reaction function [[equation \(4\)](#)] and the first-order condition of cruise company, $\partial \pi_b / \partial p_b = 0$, the pricing mechanism of cruise company are obtained as [equation \(5\)](#):

$$p_b^* = \frac{\alpha + \beta(e_a - e_b + p_c + c_v)}{2\beta} \quad (5)$$

As the price leader in the chain, the cruise port charges service fees to maximize profit [[equation \(6\)](#)]. The pricing strategy of port is shown as [equation \(7\)](#):

$$\pi_c = Q \cdot (p_c - c) \quad (6)$$

$$p_c^* = \frac{\alpha + \beta(e_a + e_b + c - c_v)}{2\beta} \quad (7)$$

Thus, we can obtain the equilibrium prices and total demand as below:

$$\begin{cases} p_a^* = \frac{7\alpha + \beta(-e_a - e_b + c + c_v)}{8\beta} \\ p_b^* = \frac{3\alpha + \beta(3e_a - e_b + c + c_v)}{4\beta} \\ p_c^* = \frac{\alpha + \beta(e_a + e_b + c - c_v)}{2\beta} \end{cases} \quad (8)$$

$$Q^* = \frac{\alpha + \beta(e_a + e_b - c - c_v)}{8} \quad (9)$$

The optimal profit of all participants in the cruise value chain are obtained as [equation \(10\)](#), and the total profit of the cruise chain is the sum of all players [\[equation \(11\)\]](#):

$$\begin{cases} \pi_a^* = \frac{(\alpha + \beta \cdot (e_a + e_b - c - c_v))^2}{64\beta} \\ \pi_b^* = \frac{(\alpha + \beta \cdot (e_a + e_b - c - c_v))^2}{32\beta} - c_f \\ \pi_c^* = \frac{(\alpha + \beta \cdot (e_a + e_b - c - c_v))^2}{16\beta} \end{cases} \quad (10)$$

$$\Pi^* = \frac{7(\alpha + \beta \cdot (e_a + e_b - c - c_v))^2}{64\beta} - c_f \quad (11)$$

4.2 Value chain coordination and profit redistribution

To capture the coalition of the value-added chain with travel agency, cruise company and cruise port in a cooperative way, the profitability of the cruise supply chain is shown in [equations \(12\)](#), and the superscript C represents the cooperation situation:

$$\Pi^C = Q \cdot (p_a + e_a + e_b - c_v - c) - c_f \quad (12)$$

According to the first-order and second-order conditions, $\partial \Pi^C / \partial p_a = 0$, $\partial^2 \Pi^C / \partial^2 p_a = -2\beta < 0$, we find that the revenue of the cruise value chain is a concave function with the following solution, including optimal retail price [\[equation \(13\)\]](#), optimal market demand [\[equation \(14\)\]](#) and total revenue of cruise chain [\[equation \(15\)\]](#):

$$p_a^{C*} = \frac{\alpha - \beta(e_a + e_b - c - c_v)}{2\beta} \quad (13)$$

$$Q^{C*} = \frac{\alpha + \beta(e_a + e_b - c - c_v)}{2} \quad (14)$$

$$\Pi^{C^*} = \frac{(\alpha + \beta \cdot (e_a + e_b - c - c_v))^2}{4\beta} - c_f \quad (15)$$

$$c < p_c < p_a + e_a + e_b - c_v \quad (16)$$

$$p_c + c_v - e_b < p_a < p_a + e_a \quad (17)$$

When the cruise port determines the pricing strategy within a chain, using conditions obtained in [equations \(16\) and \(17\)](#), the profit level of the entire chain remains steady. However, the profitability of each participant in the chain will be affected by changes in wholesale and port prices, p_b and p_c . From [equations \(8\) and \(13\)](#), we map the optimal solution of pricing and comparing to the results of the two-stage game. Hence, we propose that:

- P1.* Cooperation strategy reduces retail price of cruise service for passengers. At the same time, total revenue of cruise chain is improved.

Proof.

Comparing the equilibrium retail price in two scenarios, cooperative scenario and independent decision-making scenario, it could be shown that $p_a^* > p_a^{C^*}$ [[equation \(18\)](#)]:

$$p_a^* - p_a^{C^*} = \frac{3\alpha - 3\beta(-e_a - e_b + c + c_v)}{8\beta} > \frac{\beta(p_a + e_a + e_b - c - c_v)}{8\beta} > 0 \quad (18)$$

And then, market demand and cruise chain revenue could also be proved, that is $Q^* < Q^{C^*}$ and $\Pi^* < \Pi^{C^*}$.

It will be beneficial for the participants in the chain to adopt the coordination pricing to reduce the quoted price of the whole chain and increase the number of tourists served. Not only does ensuring the service quality of the entire chain, coordination pricing strategy will avoid double counting of the added-value in chain.

However, whether the chain can survive in the long term may depend on how to rationally redistribute profit back to each player participating with the value-added chain. It is a matter of stable cooperation. The Shapley value is commonly used for solving cost allocation, revenue sharing, assignment and partnership dissolution problems according to participants' contributions to the coalition ([Moulin, 1992](#); [Pérez-Castrillo and Wettstein, 2001](#); [Petrošjan and Zaccour, 2003](#); [Macho-Stadler et al., 2007](#)). It has been applied widely to various industries. Examples can be seen by [Dubey \(1982\)](#) for airport with runways catered to different-sized airplanes, [Tan and Lie \(2002\)](#) for cost allocation for users in electric power systems, [Narayanam and Narahari \(2011\)](#) for effective diffusion in social networks and [Yu et al. \(2014\)](#) for carbon emission reduction quotas.

In the field of supply chain, [Bartholdi and Kemahlioğlu-Ziya \(2005\)](#); [Kemahlioğlu-Ziya and Bartholdi \(2011\)](#) and [Zhang and Liu \(2013\)](#) demonstrated that Shapley value allocations were guaranteed to motivate participants to respond positively to coordinate in the supply chain. [Raghunathan \(2003\)](#) used Shapley value concept to analyze the expected manufacturer and retailer shares of the surplus generated from information sharing. [Rosenthal \(2008\)](#) developed a model to fairly quantify transactional price in vertically integrated organizations. Results showed that Shapley value allocation was appropriate for perfect information throughout the supply chain. [Leng and Parlar \(2009\)](#) analyzed the

allocation problem of cost savings from sharing demand information among supply chain participants. Gao *et al.* (2017) proposed the variations of Shapley value as the solution to uncertain coalitional game where players' payoffs were seen as uncertain variables.

The Shapley value focuses on the research of multi-player cooperation under the profit distribution mechanism, which provides a solution to a cooperative game. $N = \{1, 2, \dots, n\}$ is called player set, a collection of decision-makers in the cooperation, where $i \in N$ represents the i th player. It is supposed that the coalition S is considered any non-vacant set in N , and $S \subset N$. $|S|$ represents the number of players in coalition S . To maximize the sum of the apportionment of the union in the game, the members in the union can reach a binding agreement to declare a unified collective action and choose an agreed-upon strategy. We assume that once a union is formed, it will remain stable for the whole process. The grand collection has N members, if $\forall S \subset N$ has a real function $V(S)$, which meets the following two conditions: $V(\emptyset) = 0$ and $V(S_1 \cup S_2) \geq V(S_1) + V(S_2), (S_1 \cap S_2 = \emptyset)$. Then, $V(S)$ is defined as the characteristic function.

The characteristic function essentially describes the benefit obtained by various cooperation strategies. Benefits of all participants derived from cooperative decision are greater than the sum of participant's benefit in independent decision-making scenario, which guarantees that it is optimal for all players to participate in cooperation. The vector $X_i(V)$ represents the distribution of total benefits assigned to the i th player in a cooperative scenario. The distribution proportions should meet several theorems:

- The potential distribution does not depend upon the sequence of the how players form the coalition.
- The sum of individual benefit is equal to the coalition benefit.
- There is no benefit allocated to the player who has no contribution to the coalition.
- The invariance of the linear transformation.

The distribution results are in line with fairness and equity, according to players' contribution. Shapley proved that $X_i(V)$ [equation (19)] is the only distribution solution to the cooperation:

$$X_i = \sum_{S \subset S_i} w(|S|) \cdot [V(S) - V(S - \{i\})], \quad i = 1, 2, \dots, n \quad (19)$$

Where, $|S|$ is the number of coalition includes player i , and $w(|S|)$ is the weighting factor, $w(|S|) = \frac{(n-|S|)!(|S|-1)!}{n!}$.

We adopted the concept of Shapley value to address the excess profit distribution problem among players in cruise value-added chain on the basis of each participant's contribution.

Table 1 provides detailed information of all possible coalitions involving cruise port c , where let $\zeta = \alpha + \beta(e_a + e_b - c - c_i)$ to simplify expressions.

In Table 1, there are four possible coalitions involving cruise port, namely, individual coalition, agency-cruise port coalition, cruise line-port coalition and grand coalition with all players. First, we take the coalition $\{b, c\}$, cruise line and cruise port have formed a coalition without travel agency, as an example to illustrate the computation rules of $V(S)$ for a coalition S , which is equal to cooperative profit here. Travel agency who does not join the coalition continue to make pricing decision to maximize self interest in terms of profits, whereas cruise line and cruise port set the price for travel agency to maximize total profits. It is worth mentioning that travel agency and port do not have direct relationship without

Table I.
Profit distribution of
cruise port c

| S | $\{c\}$ | $\{a, c\}$ | $\{b, c\}$ | $\{a, b, c\}$ |
|-----------------------|-------------------------|-------------------------|-------------------------------|-------------------------------|
| $V(S)$ | $\frac{\xi^2}{16\beta}$ | 0 | $\frac{\xi^2}{8\beta} - c_f$ | $\frac{\xi^2}{4\beta} - c_f$ |
| $V(S - \{c\})$ | 0 | $\frac{\xi^2}{64\beta}$ | $\frac{\xi^2}{32\beta} - c_f$ | $\frac{\xi^2}{16\beta} - c_f$ |
| $V(S) - V(S - \{c\})$ | $\frac{\xi^2}{16\beta}$ | $\frac{\xi^2}{64\beta}$ | $\frac{3\xi^2}{32\beta}$ | $\frac{3\xi^2}{16\beta}$ |
| $ S $ | 1 | 2 | 2 | 3 |
| $W(S)$ | 1/3 | 1/6 | 1/6 | 1/3 |

cruise line to create a coalition, thus $V(S)$ in the case $\{a, c\}$ is zero. Second, the expected marginal contribution of cruise port to the coalition in each case is the difference of $V(S)$ and $V(S - \{c\})$. Third, a weighted average of cruise port's marginal contribution is seen as his Shapley value. Thus, the distribution proportion of total benefits to cruise port c is computed as $X_c = \frac{37\xi^2}{384\beta}$.

Similarly, the other two players, cruise lines and travel agency, would also gain extra benefit from involving a stable coalition, which could be, respectively, calculated through Shapley method. The redistribution proportions of cruise line and travel agency are $X_b = \frac{43\xi^2}{384\beta} - c_f$ and $X_a = \frac{\xi^2}{24\beta}$, respectively. Detailed information related to coalitions involving cruise lines and travel agency is shown in [Tables AI](#) and [AII](#) in [Appendix](#). Hence, it is proposed that:

- P2.* Cooperative strategy offers the incremental benefit to all participants in the cruises value chain using Shapley redistribution rule once a stable coalition is formed.

Proof.

The equilibrium results in two scenarios, independent pricing versus coordinative pricing, are shown in [Table II](#). From *P1*, we can see the advantages of the cooperative game in terms of the overall performance and revenue. In [Table II](#), the cooperative advantages are further illustrated when we compare the indicators of individual profits versus the coordinative pricing. It is shown that coordinative pricing strategy is the proper strategy for all participants in the cruise value-added chain. Profits within the coalition in the cooperative game are superior to the individual pricing scenario referring to pursuing self-interests. The cooperation among participants in the cruise value chain remains stable because each player benefits from a cooperative way. As for a cruise value chain, a situation of mutual beneficial status of redistribution for travel agency, cruise line and cruise port would be created with Shapley method.

5. Built-in incentives policy for cruise

Cruise ports usually adopt specific market strategies and incentives to attract cruise callings and enhance competitiveness, for example, tax rebate on supplies of the

Table II.
Comparison of
independent pricing
and coordinative
pricing

| | Independent pricing | Coordinative pricing |
|-------------------------------------|----------------------------------|------------------------------------|
| Equilibrium market demand Q | $\frac{\zeta}{8}$ | $\frac{\zeta}{2}$ |
| Profit for travel agency π_a | $\frac{\zeta^2}{64\beta}$ | $\frac{\zeta^2}{24\beta}$ |
| Profit for cruise company π_b | $\frac{\zeta^2}{32\beta} - c_f$ | $\frac{43\zeta^2}{384\beta} - c_f$ |
| Profit for cruise port π_c | $\frac{\zeta^2}{16\beta}$ | $\frac{37\zeta^2}{384\beta}$ |
| Benefit of cruise value chain Π | $\frac{7\zeta^2}{64\beta} - c_f$ | $\frac{\zeta^2}{4\beta} - c_f$ |

Note: Detail calculation is based on request

international cruises and a visa-free policy for the international transit tourists (Department of Transportation, 2014). Not only the policy tools can be creative but also the implementation and initiatives can be seen in different institutional level from the province level to a port-city level. For example, if ports in Hainan are chosen to be the home port for cruises, a certain subsidy is given back to the cruise by voyage (Hainan Province, 2015). Similar subsidy from port to cruise line is observed in the port of Xiamen when it announced in December of 2015 that the maximum subsidy for the cruise company per voyage is approximately \$600,000 yuan. Additional incentive is given to the cruise passengers of \$150 yuan per person. To support Nansha in planning the cruise development in a three-year timeframe, a total investment of \$90m yuan is announced by Guangzhou in December 2016. Furthermore, it rewards new cruise companies to increase the variety of cruise line voyages, and to promote the development of travel agencies in cruise business.

5.1 Analysis of the incentive mechanism

This is done to see the impact of the potential policies or more specifically if those policies can live up with the expectations to align the coordination and the cooperation of the upstream and downstream enterprises in the cruise value chain. Chinese ports are operated in public ownership, thus port authorities adopt subsidy policy on behalf of government authorities. Compared to service suppliers, travel agency and cruise lines, passengers are often identified as the subject for the port authority to give incentives.

When port authority plans to adopt subsidy policy to improve the competitiveness, they could offer incentives to passengers or the service suppliers. Thus, we are going to provide two sciences:

- (1) incentives to cruise passengers; and
- (2) incentives to travel agents.

5.1.1 Scenario 1. First, demand side, cruise passengers, is chosen to be the subject of incentives. If a passenger books a cruise package from the travel agency, he/she could

get discount or unit subsidy Δd from port authority. Here, superscript Δd is used as Scenario 1.

Sequentially, all players in the cruise chain make pricing decision. The cruise port is a price leader, whereas the cruise line becomes a price follower. Then, travel agency sets the retail price according to the wholesale price provided by cruise lines. The sequential decision problem is shown as follows [equations (20)-(22)]:

$$P_c : \pi_c^{\Delta d*}(p_c) = \max_{p_c \geq 0} \pi_c^{\Delta d}(p_c) \tag{20}$$

$$P_b : \pi_b^{\Delta d*}(p_b) = \max_{p_b \geq 0} \pi_b^{\Delta d}(p_c^*, p_b) \tag{21}$$

$$P_a : \pi_a^{\Delta d*}(p_a) = \max_{p_a \geq 0} \pi_a^{\Delta d}(p_b^*, p_a) \tag{22}$$

where the revised profit for all participants in the cruise value chain is shown as equation (23):

$$\begin{cases} \pi_c^{\Delta d} = Q \cdot (p_c - c - \Delta d) \\ \pi_b^{\Delta d} = Q \cdot (p_b + e_b - p_c^* - c_v) - c_f \\ \pi_a^{\Delta d} = Q \cdot (p_a + e_a - p_b^*) \end{cases} \tag{23}$$

It is worth mentioning that the market demand function is revised as equation (24) after subsidizing cruise passenger:

$$Q = \alpha - \beta \cdot (p_a - \Delta d) \tag{24}$$

The equilibrium price [equation (25)] is calculated with inverse solution method according to first-order conditions:

| | Independent pricing | Incentives to passengers ($\Delta d/person$) | Incentives to travel agency or cruise company $\Delta s/person$ | Cooperative pricing in a coalition |
|-----------------------------------|----------------------------------|---|---|------------------------------------|
| Equilibrium service price p_a | $\frac{8\alpha - \zeta}{8\beta}$ | $\frac{8\alpha - \zeta + 5\beta \cdot \Delta d}{8\beta}$ | $\frac{8\alpha - \zeta}{8\beta}$ | $\frac{2\alpha - \zeta}{2\beta}$ |
| Equilibrium market demand Q | $\frac{\zeta}{8}$ | $\frac{\zeta + 3\beta \cdot \Delta d}{8}$ | $\frac{\zeta}{8}$ | $\frac{\zeta}{2}$ |
| Profit for travel agency π_a | $\frac{\zeta^2}{64\beta}$ | $\frac{(\zeta + 3\beta \cdot \Delta d)^2}{64\beta}$ | $\frac{\zeta^2}{64\beta}$ | $\frac{\zeta^2}{24\beta}$ |
| Profit for cruise company π_b | $\frac{\zeta^2}{32\beta} - c_f$ | $\frac{(\zeta + 3\beta \cdot \Delta d)^2}{32\beta} - c_f$ | $\frac{\zeta^2}{32\beta} - c_f$ | $\frac{43\zeta^2}{384\beta} - c_f$ |
| Profit for cruise port π_c | $\frac{\zeta^2}{16\beta}$ | $\frac{\zeta^2 - (3\beta \cdot \Delta d)^2}{16\beta}$ | $\frac{\zeta^2}{16\beta}$ | $\frac{37\zeta^2}{384\beta}$ |

Table III. Comparison of subsidy policy and cooperative pricing strategy

$$\begin{cases} p_c^{\Delta d*} = \frac{\alpha + \beta \cdot (e_a + e_b + c - c_v - \Delta d)}{2\beta} \\ p_b^{\Delta d*} = \frac{3\alpha + \beta \cdot (3e_a - e_b + c + c_v + \Delta d)}{4\beta} \\ p_a^{\Delta d*} = \frac{7\alpha + \beta \cdot (-e_a - e_b + c + c_v + 5\Delta d)}{8\beta} \end{cases} \quad (25)$$

The comparison is presented in [Table III](#).

[Table III](#) Column 3 presents the results. Compared to the incentives to passengers, with independent pricing scenario, it shows that market demand increases, so does service suppliers' profit. As for the cruise price, passengers save travel cost after internalizing the incentive scheme, although retail service that passengers pay to travel agency is increased by $\frac{5 \cdot \Delta d}{8}$.

Compared to cooperative pricing strategy, passengers could always gain greater benefit from subsidy policy. However, service suppliers receive lower profit, if the unit subsidy satisfies $\Delta d \in \left(0, \frac{(\sqrt{8/3} - 1)\zeta}{3\beta}\right)$. This policy to passengers has positive effect only in terms of the market size.

5.1.2 Scenario 2. [Table III](#) Column 4 presents the results if service travel agency or cruise lines are chosen as the subject of the incentive. We use travel agent as an example because at the equilibrium state, the effect of port authority subsidy to cruise lines is the same as to the travel agent. If travel agent increases the number of passengers served, he/she could receive rebate Δs per passenger from the port authority. Here, superscript Δs is used as Scenario 2.

The sequential decision problem is shown as follows [[equations \(26\)-\(28\)](#)]:

$$P_c : \pi_c^{\Delta s*}(p_c) = \max_{p_c \geq 0} Q \cdot (p_c - c - \Delta s) \quad (26)$$

$$P_b : \pi_b^{\Delta s*}(p_b) = \max_{p_b \geq 0} Q \cdot (p_b + e_b - p_c^* - c_v) - c_f \quad (27)$$

$$P_a : \pi_a^{\Delta s*}(p_a) = \max_{p_a \geq 0} Q \cdot (p_a + e_a - p_b^* + \Delta s) \quad (28)$$

The equilibrium price [[equation \(29\)](#)] is calculated according to the first-order conditions in [equation \(29\)](#):

$$\begin{cases} p_c^{\Delta s*} = \frac{\alpha + \beta \cdot (e_a + e_b + c - c_v + 2\Delta s)}{2\beta} \\ p_b^{\Delta s*} = \frac{3\alpha + \beta \cdot (3e_a - e_b + c + c_v + 4\Delta s)}{4\beta} \\ p_a^{\Delta s*} = \frac{7\alpha + \beta \cdot (-e_a - e_b + c + c_v)}{8\beta} \end{cases} \quad (29)$$

It can be seen that the retail service price $p_a^{\Delta s*}$ in this subsidy situation is equal to independent pricing scenario, so the market demand is also the same. Related solving

results, including market demand and individual profit, are shown in the fourth columns of Table III. It is ineffective for cruise port to improve comparative advantage with subsidy policy to cruise lines when port authority goes after individual profit maximizing. It is proposed that:

P3. Compared to the cooperative pricing strategy, incentive mechanism works only if

$\Delta d > \frac{(\sqrt[8]{\beta} - 1)\zeta}{3\beta}$ holds, implying that self-interest of each participant is dominated by the greater good from the coalition. Among two industry practices, rebate or discount to passengers is considered more effective than direct subsidy to cruise line and/or travel agency. The latter creates less impacts toward both market share and total profit.

Proof. The optimal results under various scenarios are shown in Table III. Compared with the results of cooperative pricing strategy, both travel agency and cruise company could derive extra benefit from subsidy offered to passengers under the condition of $\pi_a^{\Delta d^*} > \pi_a^*$ and $\pi_b^{\Delta d^*} > \pi_b^*$.

6. Conclusions

The increasing importance of coordination, cooperation and vertical integration may effectively impact performance for cruise lines, cruise ports and involved service providers. This paper studies the profit distribution from the perspective of the vertical integration of cruise product pricing in the cruise supply chain. The model can further be used to examine in what circumstance the integration and/or coordination live up with the expectation to improve performance for all involved parties. To realize long-term win-win situation and continuously sustainable operations in the cruise supply chain, we adopt independent pricing and cooperative pricing models to study the profitability of the cruise supply chain, including travel agency, cruise company and cruise port. The following conclusions are drawn from the research:

- In the cruise value-added chain, participants of cruises chain can set price independently or adopt pricing strategy in cooperation. Compared with independent pricing, the equilibrium retail prices from cooperative pricing cost less to cruise passengers. It implies that the social benefit is greater. Meanwhile, total revenue of cruise chain is improved in cooperative pricing strategy.
- To avoid the instability of the operation of the entire chain, the Shapley method is used for revenue redistribution. We conclude that cruise service suppliers, cruise line company and travel agency receive higher profit under the cooperative coalition model than independent pricing strategy focusing on individual self-interest.
- This paper evaluates the effects of cruise subsidy policy, including a quantitative analysis of the marketing effect while different members are selected as the subject of the subsidies. Comparing two subsidy scenarios, when passengers are given incentives, policy creates positive effects to improve cruise market size and to increase profit of individual participants in the chain. However, subsidy policy is not as effective as cooperative pricing strategy, if insufficient incentives are provided.

Further discussion regarding applying the game theory model can be done in multiple ways. First, a detailed value chain empirical analysis including survey of reposition timeline and schedule, operating contracts with the participants in the value-added chain, resupply cost breakdowns and revenue streams, etc. will provide more insights

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| Date | Vessel | Cruise line | Arrival-Departure |
|----------------|---------------------|----------------------|-------------------|
| 2 March, 2018 | Norwegian Joy | NCL | 06:00-16:00 |
| 3 March, 2018 | Quantum of The Seas | Royal Caribbean | 07:00-16:45 |
| 4 March, 2018 | Amadea | Phoenix Reisen | 12:00-20:00 |
| 5 March, 2018 | Oceania Nautica | Oceania Cruises | n/a |
| 6 March, 2018 | Norwegian Joy | NCL | 06:00-16:00 |
| 7 March, 2018 | Oceania Nautica | Oceania Cruises | n/a |
| 7 March, 2018 | Viking Sun | Viking Ocean Cruises | n/a |
| 8 March, 2018 | Quantum of The Seas | Royal Caribbean | 07:00-16:45 |
| 10 March, 2018 | Norwegian Joy | NCL | 06:00-16:00 |
| 10 March, 2018 | P&O Arcadia | P&O Cruises | n/a |
| 12 March, 2018 | Quantum of The Seas | Royal Caribbean | 07:00-16:45 |
| 14 March, 2018 | Norwegian Joy | NCL | 06:00-16:00 |
| 15 March, 2018 | Columbus | Cruise and Maritime | 12:00-20:00 |
| 17 March, 2018 | Quantum of The Seas | Royal Caribbean | 07:00-16:45 |
| 18 March, 2018 | Norwegian Joy | NCL | 06:00-16:00 |
| 22 March, 2018 | Quantum of The Seas | Royal Caribbean | 07:00-16:45 |
| 23 March, 2018 | Norwegian Joy | NCL | 06:00-16:00 |
| 24 March, 2018 | Norwegian Jewel | NCL | 07:00-19:00 |
| 25 March, 2018 | Majestic Princess | Princess Cruises | 07:00-19:00 |
| 25 March, 2018 | Star Legend | Windstar Cruises | 10:00 |
| 26 March, 2018 | Queen Elizabeth | Cunard Line | n/a |
| 26 March, 2018 | Quantum of The Seas | Royal Caribbean | 07:00-16:45 |
| 27 March, 2018 | ms Volendam | HAL | n/a |
| 27 March, 2018 | Norwegian Joy | NCL | 06:00-16:00 |
| 28 March, 2018 | ms Volendam | HAL | n/a |
| 29 March, 2018 | ms Volendam | HAL | n/a |
| 31 March, 2018 | Norwegian Joy | NCL | 06:00-16:00 |
| 31 March, 2018 | Oceania Insignia | Oceania Cruises | 08:00 |
| 31 March, 2018 | Quantum of The Seas | Royal Caribbean | 07:00-16:45 |

Table IV.
Cruise port schedule
for Shanghai

Source: crew-center.com

| Date | Vessel | Arrival-Departure |
|-------------------|------------------|-------------------|
| 01 April, 2018 | Star Legend | 13:00-22:00 |
| 09 May, 2018 | Seabourn Sojourn | 10:00-20:00 |
| 19 October, 2018 | Viking Spirit | n/a |
| 16 November, 2018 | Viking Spirit | n/a |

Table V.
Cruise port schedule
for Dalian

Source: crew-center.com

towards the governing purposes. Meanwhile, the information gathered through the survey can be used toward the parameter setting to verify the cooperative game model obtained in this research.

We revisited the cruise port schedule for the major cruise home ports in China such as Shanghai, Sanya, Tianjin, Dalian, Qingdao and Xiamen to provide a case-based sensitivity analysis. This approach will assess the critical issues such as port investment with the involvements of private sectors, port congestion with the possible internal conflicts with the terminal utilization, and an important aspect such as the implications of further port subsidy policy. For example, when comparing the cruise port schedule of Shanghai in [Table IV](#) with the regional port in Dalian in [Table V](#), the former is more likely to have issue of congestion and internal competition of space, whereas the later may need to focus on the marketing and subsidy strategies to make the port cruise-friendly. Not only the call schedule, to maximize the regional economic impacts generated by the cruise activities, itinerary and travel packages offered by the travel agents, but also incentives toward the cruise companies can be examined.

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Appendix

Table AI provides the distributed benefit of cruise company b in the cruise value chain based on the Shapley method. This is the case most likely to show the features of the US cruise markets and the market in the Mediterranean Sea when cruise company is the one that dominates the chain with proper alignment of up/downstream service providers.

According to Table AI, the distributed benefit of Cruise Company b in the cruise supply chain is:

$$X_b = \frac{43\zeta^2}{384\beta} - c_f, \quad \zeta = \alpha + \beta(e_a + e_b - c - c_v)$$

Table AII provides the distributed benefit of Travel Agency a in the cruise value chain based on the Shapley method.

Here, we use the concept of Shapley value to address the excess profit distribution problem among players in cruise value added chain on the basis of each participant's contribution. According to Table I, the distributed benefit of Travel Agency a in the cruise supply chain is as below:

$$X_a = \frac{\zeta^2}{24\beta}, \quad \zeta = \alpha + \beta(e_a + e_b - c - c_v)$$

Table AI.
Profit distribution of
Cruise Company *b*

| <i>S</i> | { <i>b</i> } | { <i>a, b</i> } | { <i>b, c</i> } | { <i>a, b, c</i> } |
|---|-------------------------------|--------------------------------|-------------------------------|------------------------------|
| <i>V</i> (<i>S</i>) | $\frac{\xi^2}{32\beta} - c_f$ | $\frac{\xi^2}{16\beta} - c_f$ | $\frac{\xi^2}{8\beta} - c_f$ | $\frac{\xi^2}{4\beta} - c_f$ |
| <i>V</i> (<i>S</i> - { <i>b</i> }) | 0 | $\frac{\xi^2}{64\beta}$ | $\frac{\xi^2}{16\beta}$ | 0 |
| <i>V</i> (<i>S</i>) - <i>V</i> (<i>S</i> - { <i>b</i> }) | $\frac{\xi^2}{32\beta} - c_f$ | $\frac{3\xi^2}{64\beta} - c_f$ | $\frac{\xi^2}{16\beta} - c_f$ | $\frac{\xi^2}{4\beta} - c_f$ |
| <i>S</i> | 1 | 2 | 2 | 3 |
| <i>W</i> (<i>S</i>) | 1/3 | 1/6 | 1/6 | 1/3 |

Table AII.
Profit distribution of
participants in the
value chain

| <i>S</i> | { <i>a</i> } | { <i>a, b</i> } | { <i>a, c</i> } | { <i>a, b, c</i> } |
|---|-------------------------|-------------------------------|--------------------------|------------------------------|
| <i>V</i> (<i>S</i>) | $\frac{\xi^2}{64\beta}$ | $\frac{\xi^2}{16\beta} - c_f$ | 0 | $\frac{\xi^2}{4\beta} - c_f$ |
| <i>V</i> (<i>S</i> - { <i>a</i> }) | 0 | $\frac{\xi^2}{32\beta} - c_f$ | $\frac{\xi^2}{16\beta}$ | $\frac{\xi^2}{8\beta} - c_f$ |
| <i>V</i> (<i>S</i>) - <i>V</i> (<i>S</i> - { <i>a</i> }) | $\frac{\xi^2}{64\beta}$ | $\frac{\xi^2}{32\beta}$ | $-\frac{\xi^2}{16\beta}$ | $\frac{\xi^2}{8\beta}$ |
| <i>S</i> | 1 | 2 | 2 | 3 |
| <i>W</i> (<i>S</i>) | 1/3 | 1/6 | 1/6 | 1/3 |

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