An Optimization Model to Help Cruise Companies to Evaluate their Offer in a Basin

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Abstract: This work focuses on the problem of evaluating and improving a current offer, when the market changes due to either new customers demands or new actions of competitors. A model for evaluating the current offer of cruise itineraries is proposed. A case study related to the Mediterranean sea cruise offer is presented. Offers have been compared in terms of demand satisfaction, revenue, costs, accessibility and appealing values that are important information that can help the decision maker to choose the best offer in accordance with the trend of the demand, the future business development and the future companys strategies. The current situation due to COVID-19 pandemic represents an extreme case that poses new decision problems and requires different analysis due to very high level of uncertainty. The present paper can furnish useful insights for facing some of the emerging decision problems but it is dedicated to help decision makers in evaluating the cruise offer when changes occur in a single market or in a limited area.

1 INTRODUCTION

The worldwide cruise ship tourism account for about 2 percent of the world tourism markets revenue, about 1.22 trillion (Statista, 2018). Over a ten-year period (from 2007 to 2017), the world demand for cruising has increased of about 69 percent passing from 15.9 million passengers to 26.8 million, as stressed in the Cruise Lines International Association report (CLIA, 2018), and the capacity deployed by the cruise industry has followed a similar growth, with 19 new ships in 2020. In the last decades, cruise ship tourism has represented the most dynamic segment of the tourism involving many groups of stakeholders: from the demand side customers and tourists, from the supply side travel agencies, carriers and providers of tourist services, and finally, tourist destinations and regulatory systems (Chen et al., 2016).

The health emergency due to COVID-19 has changed these trends and forecasts for 2020 and 2021. The health emergency forced cruise companies to stop their ships and to re-organise their offer.

Since the production of the cruise industry output has a great impact (also in terms of new jobs and incomes) on the global economy, it is really important a rapid re-start of the cruise sector. Companies have defined health and safety measures protocols for being able to offer their cruises on the market. New operative procedures derived by international health authorities have been adopted and must be continuously modified in accordance with new authorities guidelines. As a consequence it is required to reorganize cruises, to analyse constantly new distribution of the cruise demand from the world markets and to re-evaluate the cruise offer.

The definition of the cruise itineraries offer is a long process involving three planning levels: a long, a medium and a day by day plan.

Given the planning horizon, usually ten years, and the global long term strategy defined by the company, the main decisions of the long term plan consist in the assignment of the available ships belonging to the fleet to the different basins of the world in which the company offers its services. Seasons, specialties of the different geographical areas, dry docks related to the ordinary and no-ordinary maintenance of the ships may be considered at this level, together with past results in terms of operative margin and customer satisfaction degree, competitive analysis and business development.

The medium level (at basin level) focuses on each basin and a planning horizon of generally less than one year (i.e. a season). For each ship assigned to the basin are defined the duration and the homeport of its itineraries. These decisions are again guided by the demand forecasting for the markets linked to the

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basin.

Finally, there is the day by day planning (at itinerary level). At this level each itinerary of each ship of a basin is detailed, starting from the duration and the homeport determined at the previous level. Each itinerary is characterized by a schedule, which is the arrival time at each port and the departure time. Note that the schedule has an impact on the activities offered and sold to customers when the ship arrives at ports, but also on the activities offered on board during the dock at ports and during navigation.

Each itinerary is defined in such a way to grant guest safety, to maximize the customer satisfaction and the revenue, and minimize total costs.

At the end of this three level decision process the cruise offer is defined. This decision process is rolling and each year is updated to include a new year.

Generally, cruise companies have two main objectives: to gain new clients among those that usually do not choose a cruise and to offer attractive and desirable itineraries for maintaining repeater clients. In fact, the cruise customers are usually loyal/repeater clients, and the company has to propose them new and different destinations, new and unique experiences. For doing that, new itineraries must be suggested and the cruise offer must constantly updated. On the other hand, for reaching new market segments, the cruise industry has to offer different cruise products. In (Ward, 2005) a classification of ocean cruises into ten different categories is presented, together with a lifestyle classification that distinguishes standard, premium, luxury cruises (Barron and Greenwood, 2006). A detailed analysis on cruise tourism motivation, preference, intention and competitiveness is reported in (Chen et al., 2016).

A constant market analysis is required in such a way to immediately notice changes in the market demand; a change in the customers demand can be due to particular events in some countries, to actions realized by competitors and so on. The company has to verify if its current offer is able to face the new market demand.

Summarizing for the cruise company is really important to plan optimal space-time itineraries in such a way to maximize occupancy and expected revenue (Sun et al., 2011). Even if few papers deal with the optimal definition of an itinerary, the optimal plan space time itineraries is not at all discussed in the literature (at least for the authors knowledge). This work is a first attempt of both describing the decision process followed by cruise industries to define their cruise offer and defining a model to evaluate and, in case, improve the current cruise itineraries offer in a given basin (i.e. defining optimal space-time itineraries). Note that, this decision problem can be considered between the day by day planning and the cruise by cruise one. In fact, itineraries are the inputs data and the output is a set of itineraries to offer in a basin in a planning horizon as for example a season or 6 months.

The Covid-19 pandemic at the beginning of 2020 is a global event that has temporally and partially changed the decision process described above and the main objectives: companies have to attract clients and reassure them on safety in taking a cruise, and their main aim is to reduce the risks connected to the epidemic. Companies have to act at different levels: i) at itinerary level to grant safety, to dock available ports and to respect new rules emerging with the health emergency (in fact, new decision problems related to the definition of new reduced capacity of the ships, to the reorganization of activities on board are emerging); ii) at basin level for adapting the itineraries offer to the new demand; iii) at deployment level since global distribution of passenger will not remain the same in next few years.

The current situation due to COVID-19 pandemic represents an extreme case that poses new decision problems and requires different analysis due to very high level of uncertainty. The present paper can furnish useful insights for facing some of the emerging decision problems but it is dedicated to help decision makers in evaluating the cruise offer when changes occur in a single market or in a limited area. The pandemic is having its effects on the world market. The model here proposed, related to the cruise offer in a given basin, should be extended to include more than one basin for addressing some aspects and some new emerging problems.

The paper is organized as follows. Section 2 is devoted to the literature review, while Section 3 describes the problem under investigation and the proposed mathematical model. Results are discussed in Section 4 and conclusions outlined in the last section.

2 LITERATURE REVIEW

Even if studies about the cruise shipping are limited, recently some works are emerging in this field, in particular in the economic literature. (Sun et al., 2011) propose a concise review of the past research on cruise industry. They also discuss the importance of applying revenue management to cruise industry.

It is clear that good revenue management decisions are strongly dependent on accurate forecasting. Interesting forecasting methods are presented in (Sun et al., 2010). (Petrick, 2005) segments cruise passengers on the bases of their price sensitivity. In the cruise industry, each passenger should be priced and managed separately (Biehn, 2006). The cruise company has to plan optimal space-time itineraries in such a way to maximize occupancy and expected revenue (Sun et al., 2011).

Only few papers deal with itinerary design/optimization, optimal market segmentation, and demand infiltration (see for example, (Wang and Qu, 2016), (Ambrosino et al., 2018), (Mancini and Stecca, 2018)). The itinerary design, recently included by (Cusano et al., 2017) in the class of cruise supply, is a problem that received few attention, even if it has been recognized that it represents an important task having an impact on consumers satisfaction.

The importance of itinerary design is underlined by (Lee and Ramdeen, 2013) which performed a linear regression analysis to investigate the interaction of cruise ship itinerary on cruise ship occupancy rates. The regression model explained a significant proportion (23 %) of the variance in occupancy rates. (Chen and Nijkamp, 2018) presents a guide for ports marketing policies and cruise companies decisional process for ports selection and destinations. Tourists lengths of stay at destination is investigated being an important variable for estimating tourist consumption (Chen et al., 2019). Moreover, port locations and port networks affect the overall spending at port destinations and onboard services and experiences (Satta et al., 2015). Finally, the occupancy rates are influenced by the ports geography, the destinations and costs. (Sun et al., 2011) suggest the integration of the itinerary design and the revenue management, being a cruise a combination of transportation and accommodation. Integrating these two components, in fact, the cruise line companies can not only enhance revenue but increase customers satisfaction.

(Cusano et al., 2017) review works published in the last two decades. Moreover, the authors analyze the organization of cruise itineraries in the Mediterranean Sea and highlight the dual role of excursions used by cruise companies to differentiate services and by the port cities to promote themselves. In (Rodrigue and Notteboom, 2013) is stressed the role of the itineraries in the appeal of a cruise service. (Wang and Qu, 2016) deal with a Cruise Service Planning (CSP) Problem, which consists in determining cruise transport services, i.e. the assignment of some predefined sequences of ports to a set of ships, in order to maximize total profit, while considering berth availability and the effect of decreasing marginal profit. The main point of a cruise service design is the ability to offer to the customer a various set of itineraries including different kind of destinations.

In (Ambrosino et al., 2018) a mathematical formulation for determining a new itinerary maximizing revenue, customers satisfaction, while minimizing operative costs has been proposed. The customer satisfaction is one of the main issue to consider. It depends on different aspects, for example the accessibility and the appealing of the destinations achievable from the port. The (Wang et al., 2014) analysis shows that the category tourism attractions is the most considerable issue taken in consideration when a cruise ship is selecting a port of call location. In their results the category connectivity and agility ranks second. The aim of itinerary design is to determine when to depart and return, what duration, which destinations and what fare structure to adopt.

(Mancini and Stecca, 2018) face the tour planning problem defining a fixed number of tours (a tour for each available vessel) that must be repeated in a given planning horizon in such a way to minimize fixed and variable costs related to the ports and to fuel consumption. The authors propose a model for solving the tour planning problem that is a rich vehicle routing problem and propose a Large Neighborhood Search based matheuristic for solving it. The problem under investigation is similar to the CSP introduced in (Wang and Qu, 2016) and differs from that studied in (Mancini and Stecca, 2018) for the fact that, each vessel is not obliged to repeat the same tour during the planning horizon and for the objective function considered when defining the tours (itineraries) to offer. In this paper, the offer is defined by selecting a number of itineraries among a set of potential ones, each one with a given set of characteristics as better explained in the following section.

3 THE CRUISE ITINERARY OFFER

As already introduced, this work aims at evaluating a cruise offer and improving it by choosing what itineraries offer in a given basin during a planning horizon, for example a season. We suppose that all itineraries have the same duration, thus the planning horizon under investigation can be split into a certain number of time periods each one having length equal to the itinerary duration (i.e. 7 days = a week, that is the most common, as reported in (CLIA, 2018)). Given a basin with its ships and a set of markets with a positive cruise demand for each period of the planning horizon, given a set of itineraries designed to satisfy the cruise demand of the markets of the basin, the problem consists in selecting the itineraries to offer in each period of the planning horizon in such a way to maximize the revenue, the customers satisfaction, the accessibility and minimize the operative costs, while satisfying some requirements.

The itineraries among which to choose for defining the offer are characterized by a sequence of visited ports, a cost, a revenue, an appealing and an accessibility value. Moreover, each itinerary is able to satisfy a given amount of the demand of the markets of the basin.

When defining the cruise offer, the requirements to take into consideration may be different for the cruise companies but are generally related to:

- the demand to satisfy: the chosen itineraries must satisfy the cruise demand of each market involved in the basin under consideration and of each time period;
- the maximum number of itineraries that can be offered in the whole planning horizon, that is limited:

  - by the number of ships deployed in the basin;

  - for commercial and organizational reasons;
- the maximum number of itineraries that can be offered in each time period of the planning horizon, that is limited:

  - by the number of ships deployed in the basin and available in each time period;
- the repeatability of the itineraries in the whole planning horizon, due to commercial and organizational reasons; when an itinerary is chosen:

  - it must be offered for a certain number of consecutively period of times;

  - it can be offered again, but there is a limitation to the number of times the same itinerary can be re-offered;
- the maximum number of times a port can be present in the itineraries offered in each time period.

For what concerns the limitation for ports, it is defined by the cruise company differently depending on each port: the company assigns to each port an appealing class and thus, in accordance with the appealing class of the ports, defines the limitation.

Finally, the number of ships available in each time period can be less than the number of ships assigned to the basin due to, for example, planned dry docks.

3.1 The Optimization Model

The mixed integer 0/1 linear programming model for solving Cruise Itinerary Offer Problem (CIOP), together with the useful notation, are here below introduced. Let be:

- T the set of periods of time in which is divided the planning horizon;
- M the set of markets;
- I the set of available itineraries that can be selected for the offer;
- P the set of ports belonging to the different itineraries of set I;
- Q the set of appealing classes of the ports of set P;
- d_{mt} demand to satisfy in market m, in time period $t, \forall m \in M, \forall t \in T$;
- o_{im} demand of market m, satisfied by itinerary $i, \forall m \in M, \forall i \in I$;
- r_i revenue of itinerary $i, \forall i \in I$;
- c_i costs of itinerary $i, \forall i \in I$;
- ap_i appealing value of itinerary $i, \forall i \in I$;
- ac_i accessibility value of itinerary $i, \forall i \in I$;
- $b_{ip} = 1$ if port p belongs to itinerary i, $\forall p \in P, \forall i \in I$;
- s_t^{max} maximum number of itineraries that can be offered in time period $t, \forall t \in T$;
- i^{max} maximum number of itineraries that can be offered during the whole planning horizon;
- n_i maximum number of time the itinerary i can be offered during the planning horizon, $\forall i \in I$;
- μ maximum number of time an itinerary can be re-planned in the cruise offer during the planning horizon;
- r_{pq} maximum number of time port p, having appealing belonging to the appealing class q, can be offered in each time period, $\forall p \in P, \forall q \in Q$;
- $g_{qp} = 1$ if appealing value of port p belongs to the appealing class $q, \forall p \in P, \forall q \in Q$;
- α, β weights used in the objective function.

The decision variables are the following:

$y_i \in \{0,1\}$ $\forall i \in I, y_i = 1$ if itinerary i is selected;

$x_{i,t} \in \{0,1\}$ $\forall i \in I, \forall t \in T$, $x_{i,t} = 1$ if itinerary i is selected for being offered in time period t;

$j_{i,t} \in \{0,1\}$ $\forall i \in I, \forall t \in T$, $j_{i,t} = 1$ if itinerary i is offered starting from time period t.

MIN

$$\sum_{t \in T} \sum_{i \in I} (r_i - c_i) x_{it} + \alpha \sum_{t \in T} \sum_{i \in I} ac_i x_{it} + \beta \sum_{t \in T} \sum_{i \in I} ap_i x_{it} \quad (1)$$

subject to

$$\sum_{t \in T} x_{it} \leq |T| y_i \qquad \forall i \in I \qquad (2)$$

$$\sum_{i \in I} o_{im} x_{it} \geq r_{mt} \qquad \forall m \in M, \forall t \in T \tag{3}$$

$$\sum_{i \in I} y_i \leq i_{max} \tag{4}$$

$$\sum_{i \in I} x_{it} \leq s_t^{max} \qquad \forall t \in T \tag{5}$$

$$x_{it} - x_{it-1} \leq j_{it} \qquad \forall i \in I, \forall t \in T - \{t_1\} \tag{6}$$

$$x_{it} \leq j_{it} \qquad \forall i \in I, \forall t \in T : t = t_1 \tag{7}$$

$$\sum_{t \in T} j_{it} \leq \mu y_i \qquad \forall i \in I \tag{8}$$

$$x_{it} + x_{it+1} + x_{it+2} + x_{it+3} \geq 4 j_{it} \qquad \forall i \in I, \forall t \in T : t < |T| - 3 \tag{9}$$

$$\sum_{i \in I} b_{ip} x_{it} \leq m_{qp} + M(1 - g_{qp}) \qquad \forall i \in I, \forall p \in P, \forall q \in Q \tag{10}$$

Equation (1) represents the objective function that is the maximization of weight sum of operative margin, appealing and accessibility. Constraints (2) define variables y_i, indicating if itinerary i is offered in some periods of the planning horizon.

Equations (3) are the demand constraints: in each time period t the demand of each market m must be covered by the selected itineraries. Equation (4) limits the number of itineraries to offer during the considered planning horizon, while the maximum number of itineraries that can be offered in each time period t is verified thanks to equations (5). Equations (6) and (7) define the variable j_{it} as the first time period in which the itinerary i is offered. During the planning horizon each selected itinerary can not be re-offered more than μ times as imposed by (8), but it must be offered for at least four consecutive periods, as required by (9). Constraints (10) impose the number of time a port p can be visited in each time period t; this limit depends on the appealing class of port p.

4 A CASE STUDY

The proposed model has been used to analyse the offer of a cruise company operating in the West Mediterranean basin. The model has been solved firstly for determining which itineraries to add to two itineraries already offered in the basin (Partially Fixed Offer - PFO), and secondly, for defining a Completely New Offer (CNO). The offer must be defined for a planning horizon of 12 periods (12 weeks). The maximum number of ships available during each week is equal to four, except for weeks 5 and 6 in which only three ships are available because of the dry dock planned for the fourth ship. The maximum number of itineraries to offer during the planning horizon is fixed equal to 6.

The set I of itineraries used to define the cruise offer has been obtained as the union of the set of itineraries already offered by the company and a set of new itineraries obtained by using the model proposed in (Ambrosino et al., 2018) for the cruise itinerary design problem. The ports situated in the West Mediterranean area are Savona, Ajaccio, Toulon, Marseille, Barcelona, Mahon, Palma, Ibiza, Valencia, Valletta, Palermo, Catania, Cagliari, Naples, Civitavecchia, Livorno, La Spezia. All the itineraries are characterized by homeport Savona, duration 7 nights, one day at sea, port stop of half day (i.e. the afternoon) in few cases, while generally is the whole day (morning and afternoon).

	Slot/Day	Day 0	Day1	Day2	Day3	Day4	Day5	Day6	Day7
Itinerary 1	Morning	Savona	Marseille	Barcelona	Palma		Civitavecchia	La Spezia	Savona
	afternoon	Savona	Marseille	Barcelona	Palma		Civitavecchia	La Spezia	Savona
	Evening								
	Night								
	Slot/Day	Day 0	Day1	Day2	Day3	Day4	Day5	Day6	Day7
Itinerary 2	Morning	Savona		Palermo	Valletta		Barcelona	Marseille	Savona
	afternoon	Savona	Napoli	Palermo			Barcelona	Marseille	Savona
	Evening								
	Night								

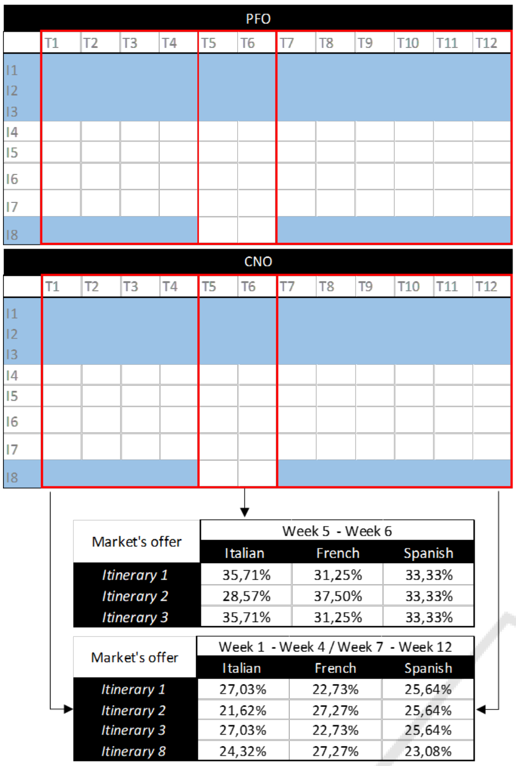
Figure 1: Example of two itineraries schedule.

Figure 1 sketches two itineraries of set I, showing the sequence of ports visited and the stop duration at ports.

The model has been implemented in Mathematical Programming Language (MPL, 2020) and solved by the commercial solver Gurobi 7.0.2.(Gurobi, 2020) on a PC Intel Core i3, 2.00 G Hz; 4 G RAM. The optimal solutions has been obtained within few seconds. The solved models have 200 variables and 770 constraints.

Figure 2 shows the two offers (PFO and CNO) defined when solving CIOP. Note that the two offers are equals: the itineraries already offered by the company have been chosen also in the CNO. Two other itineraries are then chosen for satisfying the demand of the the three markets here considered for the basin under investigation, i.e. the Italian, the French and the Spanish ones. Tables below Figure 2 report the percentages of the markets demand satisfied by each itinerary offered in the PFO and CNO (weeks of the time horizon are grouped depending on the itineraries selected, i.e. T1-T4, T5-T6 and T7-T12).

Moreover, for the above-defined groups of weeks, Figure 3 shows the comparison between the markets offer and the demand to satisfy. This comparison regards again the three markets under investigation. Note that imposing a minimum of demand to satisfy but no an upper bound, for each market the supply of every complete offer overcomes the minimum de-



Market's offer	Week 5 - Week 6		
	Italian	French	Spanish
Itinerary 1	35,71%	31,25%	33,33%
Itinerary 2	28,57%	37,50%	33,33%
Itinerary 3	35,71%	31,25%	33,33%

Market's offer	Week 1 - Week 4 / Week 7 - Week 12		
	Italian	French	Spanish
Itinerary 1	27,03%	22,73%	25,64%
Itinerary 2	21,62%	27,27%	25,64%
Itinerary 3	27,03%	22,73%	25,64%
Itinerary 8	24,32%	27,27%	23,08%

Figure 2: Market's offer of PFO and CNO.

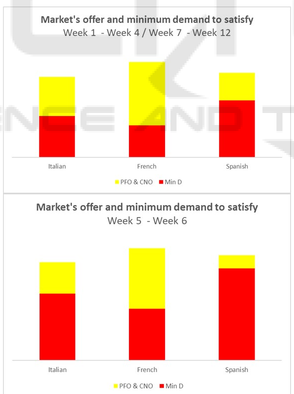


Figure 3: Market's offer and demand to satisfy.

mand to satisfy.

All the selected itineraries contribute equally to cover the markets demand. From Figure 3 we can note that the oversupply is lower in weeks 5 and 6 than in the other periods because of the lack of one of the four ship during this period. This kind of analysis is useful to enable the marketing department to adopt some pricing tools in such a way to increase the demand (for example for the French market). On the other hand, if it should be necessary to move a ship from a basin to another, this analysis could help to take the more appropriate decisions by evaluating the impact of the change on the markets.

4.1 Determining the Offers by using Different Criteria

In this subsection, we present a comparison of the cruise itineraries offers obtained by solving the CIOP by modifying the objective functions used in model (1)-(10), i.e. the criteria for the selection of the itineraries. In particular, the four cases have been considered: a) maximization of the appealing; b) maximization of the accessibility; c) maximization of the revenue; d) maximization of the operative margin. Figure 4 shows the offer changes in accordance with the objective function used (i.e. cases a)-d)), reporting both PFO and CNO. When using the maximization of the appealing as the criteria for selecting the itineraries to offer, the CNO is identical to the obtained PFO. This means that the itineraries already offered by the company perform very well in terms of appealing. When considering the other objective functions (i.e. b)-d)) the obtained offers are different. The reader can also note that when comparing the PFO obtained in the four cases, the offer determined by maximizing the accessibility and the revenue are equals (this fact is true also for the CNOs).

Figure 4: A comparison of PFO and CNO when varying the objective function.

A deeply analysis related to the offers depicted in Figure 4 is reported in the following graphs. The CNOs permit to obtain better results in terms of accessibility, revenue and operative margin. When maximizing the accessibility, the CNO permits to obtain higher accessibility, but also higher revenue and operative margin, while there is a small reduction in the appealing level, as shown in the graph of Figure 5 .

When maximizing the revenue, the CNO permits to obtain again higher revenue, and also higher accessibility and operative margin, while there is a small

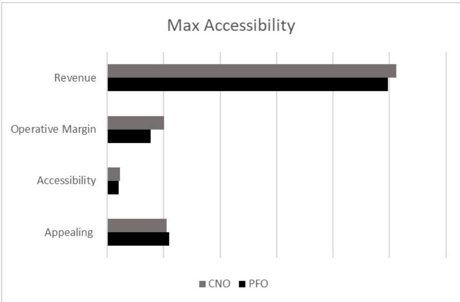


Figure 5: A graph comparing PFO and CNO when maximizing the accessibility.

reduction in the appealing level, as shown in the graph of Figure 6. The same situation arises when maximizing the operative margin, as showed in Figure 7.

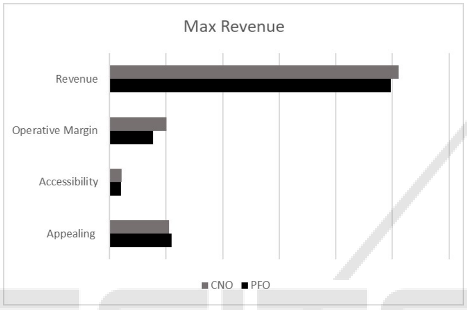


Figure 6: A graph comparing PFO and CNO when maximizing the revenue.

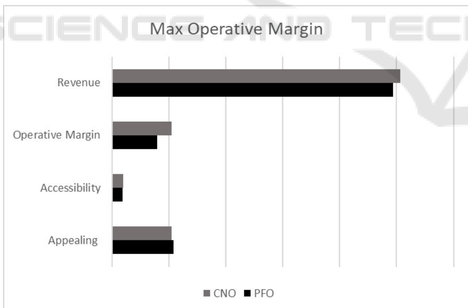


Figure 7: A graph comparing PFO and CNO when maximizing the operative margin.

4.2 Determining the Offers Maximizing the Revenue While Granting Certain Appealing Levels

The model has been used for defining the optimal offer in terms of revenue maximization, controlling the appealing level by a constraint.

If the company wants to maximize the revenue while granting offers characterized by a certain level of appealing, the proposed modal can be easily modified and solved.

In the following we report the results obtained in three cases: no constraints for the appealing level, and imposing two different levels (i.e. named A1, A2 and in ascending order). The comparison among the planned itineraries is reported in Figure 8 . Asking for higher values of appealing, the obtained solutions are characterized by a higher variability in the itinerary offered: the number of itineraries offered during the planning horizon increases from four to five. This is an important aspect characterizing the offer. The itinerary management department is not indifferent to the number of itineraries to manage. Moreover, also to move a ship from an itinerary to another one is not a preferred solution (i.e. this happen in PFO with appealing constraint $\geq$ A2 in correspondence of week 5 and 6).

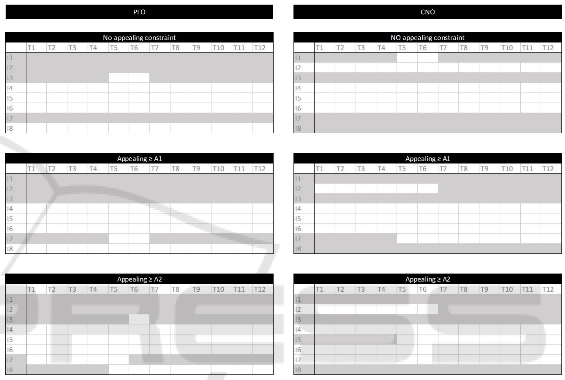


Figure 8: PFO and CNO Itineraries planned maximizing revenue while imposing different levels of appealing.

Comparing the appealing, accessibility and revenue values of the solutions reported in Figure 8, we noted that when the level of appealing is forced to increase, the other values decrease or remain almost stable for both PFO and CNO (see Figure 9). Moreover, The effect on the accessibility and revenue values is greater in case of partially fixed offer; this fact could evidence the necessity of modifying the current offer of the company for obtaining better results in terms of accessibility and revenue.

	Revenue		*Appealing*		*Accessibility*	
	CNO	PFO	CNO	PFO	CNO	PFO
No appealing constraints	100,0	97,3	82,2	85,7	103,1	93,4
Appealing ≥ A1	98,4	97,3	86,2	86,1	96,5	93,1
Appealing ≥ A2	98,0	97,1	86,8	86,8	93,5	92,5

Figure 9: PFO and CNO solutions maximizing the revenue while imposing different levels of appealing.

4.3 The Analysis on the Markets Offer and the Demand to Satisfy

Let us conclude with an analysis on the solutions in such a way to furnish important information to the cruise company. We compare the markets offer (determined for PFO and CNO) with the demand to satisfy, when the company aim is maximizing the revenue.

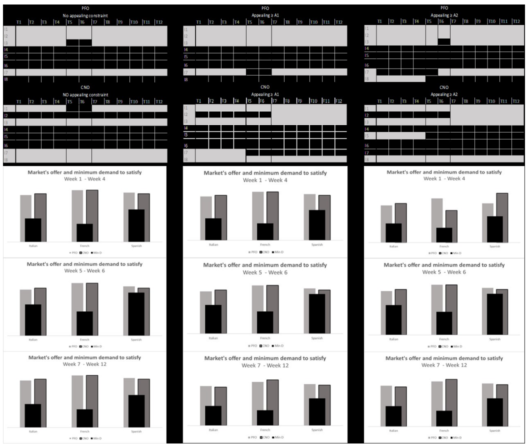


Figure 10: Markets offer and demand to satisfy.

This comparison realized for three types of offers (without the constraint for imposing a given appealing level, and imposing two different appealing levels A1 and A2 as explained before) has been done for each period of the time horizon characterized by the same set of itineraries to sell. Figure 10 shows the obtained results (PFO and CNO) for three periods (T1-T4, T5-T6 and T7-T12). The graphs show the comparison between the offer and the demand for the Italian, the French and the Spanish markets. Having a minimum demand to satisfy without an upper bound, for each market the supply overcomes the demand. The only indirect limitation of the markets offer is the maximum number of itineraries that can be offered for each period of time (i.e. each week). Note that the three offers are equals in weeks 5 and 6 in which the number of ships is limited for the dry docks. In weeks 7-12 the change in the market offer is derived when imposing an appealing level of A1, while in weeks 1-4 the change is evident when imposing the higher level of appealing. This different impact of the appealing level on the markets offer seems due to the ratio between the demand to satisfy and the global offer capacity. These graphs permit the company to choose the best offer taking into account also the trend of the markets demand.

The information related to the differences between the demand and the offer for each market can be used in order to adopt new marketing activities and pricing policies in such a way to increase the revenue and also to face market variations due to both competitors activities and customers behavior changes.

5 CONCLUSIONS

The mathematical formulation proposed in this paper permits to evaluate the current cruise offer in such a way to modify it, if necessary. It furnishes applicable solutions and represents a support during the cruise itinerary planning decision process. This approach to find and analyze different solutions can be used for deciding how to reply to market changes and also to some operative problems related to ships or ports temporally unavailable.

In this first attempt to face the cruise offer problem, some simplifying assumptions have been used. For example, the duration of the itineraries used for defining the cruise offer is considered constant and equal to seven days. In practice, it is possible to have itineraries characterized by different duration. The proposed model can be extended to admit itineraries of different length. Moreover it should be also modified for defining the offer in more than one basin.

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