

Pricing scheme of cruise based on the forecast

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Abstract. As the number of cruise passengers increases, the cruise companies develop rapidly in recent years. To create maximum revenue for the companies, it's become more important that how to make a reasonable price decision and absorb as many passengers as possible. In this paper, there are two models built to determine the optimal pricing scheme. The first is a model of multiplicative pickup, which is used to forecast predetermined number of cruise passengers in weekly voyage. The second is an exponential smoothing model, which is to help us forecast the predetermined price of various cabins in weekly voyage. Finally, according to the predetermined price and corresponding predetermined number of cruise passengers we can determine the expected maximum revenue.

1. Introduction

Cruise ship which is originated from Europe originally means transporting mail by ship, so it's mainly used in transportation rather than tourism. Recently, with the development of aeronautic technology, the cruise ship used in transportation largely disappears and modern cruise ship with a comprehensive tourism character has already gathered transportation, amusement, accommodation, catering and shopping in an integral whole.

Furthermore, cruise industry as a kind of modern tourism is one of the fastest growing industries with a growing rate above 10% in recent years. After building the "quantum of the seas" of Royal Caribbean International, cruise industry entered a completely new era of development in its history [1].

2. Analysis of Pricing and Revenue

Nowadays cruise companies mostly adopt the way of pre-ordering to sell tickets. To be effective, tourists should pre-order tickets from 14 to 0 weeks prior to departure of cruise ship. In order to forecast the revenue in weekly voyage, accordingly these companies refer to previous data containing predetermined number of cruise passengers and predetermined price from 14 to 0 weeks prior to departure[2]. There are various kinds of cabins in present cruise ships, generally divided into the first, second and third class cabin. Through making a reasonable price decision for various kinds of cabins, the companies can absorb as many passengers as possible and create maximum revenue.

In this paper, we use data of some cruise ship with 1200 cabins about predetermined number of cruise passengers and predetermined price of various cabins in recent weekly voyage to study the price decision. There are 250 first class cabins, 450 second class cabins and 500 third class cabins in this cruise ship. We establish the forecast models by part of predetermined number of cruise passengers, total predetermined number of cruise passengers and predetermined price of various cabins in 10 times voyage.

3. Predetermined Number Prediction of Various Cabins

3.1 Multiplicative Pickup model

Multiplicative Pickup is a method of forecasting future requirement based on the increasing percentage, which means increasing requirement in a finite time as a percent of previous total requirement, namely:

$$R_c^k(i) = \frac{X_{c-1}^k(i) - X_c^k(i)}{X_c^k(i)} \times 100\% \quad (1)$$

Where: $R_c^k(i)$ is the increasing percentage of NO. k class cabins of the i times voyage c weeks prior to departure. $X_{c-1}^k(i)$ is the previous total requirement of NO. k class cabins of the i times voyage c-1 weeks prior to departure. When there are the first, second and third class cabin., $k = 1, 2, 3$.

Where we can forecast the previous total requirement of NO. k class cabins of the n+1 times voyage c-1 weeks prior to departure by following formula.

$$X_{c-1}^k(n+1) = \frac{\sum_{i=1}^n R_c^k(i)}{n} \times X_c^k(n+1) + X_c^k(n+1) \quad (2)$$

Where: $X_{c-1}^k(n+1)$ is the previous total requirement of NO. k class cabins of the n+1 times voyage c-1 weeks prior to departure. $X_c^k(n+1)$ is the previous total requirement of NO. k class cabins of the n+1 times voyage c weeks prior to departure.

3.2 Solution method and calculation for model

To forecast the previous total requirement of NO. k class cabins of the n+1 times voyage in the week of number c-1, namely $X_{c-1}^k(n+1)$, we list the predetermined number in weekly voyage of some cruise ship with 250 first class cabins ($k=1$) as shown in Table 1. Through the known data we can forecast the data of $X_{c-1}^k(n+1)$ as shown in yellow, the forecasts of other kinds of cabins are the same with it[3].

Table 1. Actual and forecast predetermined number of first class cabin

Weeks before departure	1	2	3	4	5	6	7	8	9	10
14	0	1	0	0	2	1	2	0	0	1
13	1	2	3	0	5	3	4	0	0	4
12	3	4	6	3	10	6	7	4	1	8
11	9	8	10	5	15	11	9	6	5	11
10	12	13	16	9	21	16	15	10	9	13
9	17	20	23	18	31	24	21	22	20	23
8	31	39	37	33	48	32	33	39	38	36
7	54	61	59	53	62	55	51	61	63	52
6	83	85	88	81	79	76	83	82	81	83
5	10	102	111	103	108	99	102	106	109	106
4	13	136	136	141	134	131	142	133	141	138
3	16	170	173	184	171	168	193	170	181	177
2	16	178	201	205	193	190	213	188	200	196
1	17	184	210	210	200	196	220	194	206	201
0	17	184	213	212	201	197	221	195	208	203

We take predetermined number of the fifth voyage in 0 week prior to departure for example. First, use actual predetermined number in 1 and 0 week prior to departure of first four times voyages to calculate increasing percentage respectively. Then, calculate the mean of all increasing percentages. Finally, get the predetermined number of the fifth voyage in 0 week prior to departure[4]. The concrete process is as follows

$$X_0^1(5) = \left[\left(\frac{171-170}{170} + \frac{184-184}{184} + \frac{213-210}{210} + \frac{212-210}{210} \right) / 4 \right] \times 200 + 200 = 201 \quad (3)$$

To present the results clearly, we choose predetermined number of the second and sixth voyages in every week prior to departure to curve plotting. From Figure1, we can draw a conclusion that the predetermined number in weekly voyage generally appears a apparent "S" curve and the growth rate firstly increases to largest about in 10 weeks prior to departure and then decreases to 0.

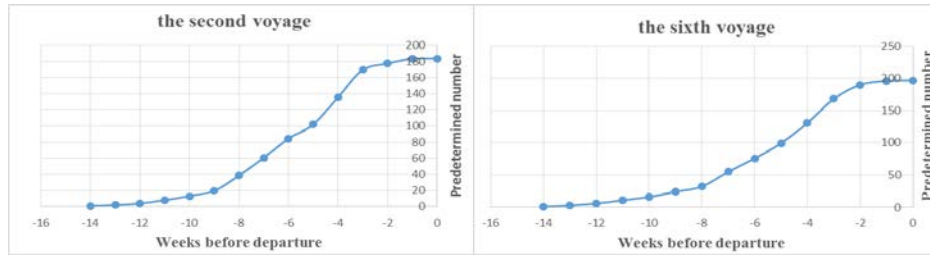


Figure1. Predetermined number of the second and sixth voyages

4. Predetermined Price Prediction of Various Cabins

4.1 Exponential smoothing model

Exponential smoothing is one of the most popular forecast methods of revenue management. With a stable and simple feature, it's generally utilized to get better prediction accuracy by less information. The essence of this method is smoothing predicted data according to time-sequence and get the change rule and trend to make a prediction. According to smoothing frequency, the method is subdivided into single exponential smoothing, double exponential smoothing and higher order exponential smoothing[5]. Considering that the higher order exponential smoothing is seldom used, we mainly introduce single exponential smoothing in this paper.

$$F_c^k(i+1) = \alpha T_c^k(i) + (1-\alpha)F_c^k(i) \quad (4)$$

Where: $F_c^k(i+1)$ is predicted value of the $i+1$ times voyage, namely smoothing value of the $i+1$ times voyage. $T_c^k(i)$ is actual value of the i times voyage. $F_c^k(i)$ is predicted value of the i times voyage. α is smooth coefficient, also known as weighting factor, and $0 < \alpha < 1$. According to experience judgment when $\alpha = 0.6$, our model have a high sensitivity.

If there are some determined data before actual value, the mean of them is used to be the initial value.

4.2 Solution method and calculation for model

To forecast the predetermined price of various cabins in weekly voyage, we list the predetermined price in weekly voyage of some cruise ship with 250 first class cabins ($k=1$) as shown in Table 2. Through the known data we can forecast the data of $F_c^k(i+1)$ as shown in yellow, the forecasts of other kinds of cabins are the same with it.

Table 2. Actual and forecast predetermined price of first class cabin

Weeks before departure	1	2	3	4	5	6	7	8	9	10
14	151	1580	1610	1550	1530	1600	1520	1530	1590	1520
13	153	1580	1650	1620	1570	1610	1590	1610	1650	1590
12	172	1700	1730	1640	1690	1720	1690	1690	1740	1660
11	175	1740	1730	1690	1760	1800	1730	1680	1790	1660
10	175	1860	1770	1840	1880	1840	1860	1780	1860	1770
9	177	1860	1780	1890	1900	1850	1860	1850	1860	1790
8	190	1950	1830	1960	1970	1940	1930	1970	1900	1870
7	192	1960	1830	1960	1990	1930	1950	1970	1920	1870
6	194	1950	1830	1850	1960	1900	1840	1930	1830	1840
5	196	1950	1950	1910	1970	1900	1810	1840	1820	1849
4	195	1930	1930	1870	1880	1820	1810	1870	1792	1821
3	177	1990	1800	1860	1900	1860	1760	1820	1744	1772
2	173	1820	1720	1760	1810	1710	1674	1733	1659	1686
1	166	1720	1800	1810	1720	1685	1650	1708	1634	1661
0	161	1650	1790	1690	1658	1624	1589	1647	1573	1601

We take predetermined price of the fifth voyage in 0 week prior to departure for the first example. Use actual predetermined price in 0 week prior to departure of first three times voyages to calculate the fourth actual predetermined price $T_0^1(4)$. Utilize smooth coefficient and expectant predetermined price in 0 week prior to departure of the fourth voyage $F_0^1(4)$ to calculate forecast of the fifth voyage, namely $F_0^1(5)$. The concrete process is as follows:

$$T_0^1(4) = \frac{1610+1650+1790}{3}; \quad F_0^1(5) = 0.6 \times T_0^1(4) + (1-0.6) \times F_0^1(4) = 1658 \quad (5)$$

According to actual and forecast predetermined price in 0 week prior to departure of the fifth voyage, we can get the forecast predetermined price of the sixth voyage by following formula. Through the definition of exponential smoothing, in the formula, $T_0^1(5)=F_0^1(4)$.

$$F_0^1(6)=0.6 \times T_0^1(5) + (1-0.6) \times F_0^1(5) \quad (6)$$

5. Maximum revenue based on cumulative optimal values

To create maximum revenue, the total revenue model is divided into several part modules which all need to achieve optimization. Indeed, the solution of maximum revenue is influenced by many constraints so that it is by no means a simple accumulation of the optimal values[6]. In this context, we use as many optimal values which meet conditions as possible to accumulate.

According to different weeks prior to departure of the cruise ship, we divide the total revenue model into 15 modules from which we need to calculate the every voyage revenue and select the maximum revenue. Finally, accumulate every maximum revenue as well as consider the conditions to get total maximum revenue.

Through the analysis about predetermined number and price of above sections, we give the calculating method of every voyage revenue as follows:

$$Y_c = \max \{ \Delta X_c^k(i) \cdot F_c^k(i) \} \begin{cases} \Delta X_c^k(i) = X_c^k(i) - X_{c+1}^k(i) & c = 0, 1 \dots 13 \\ \Delta X_c^k(i) = X_c^k(i) & c = 14 \\ i = 1, 2 \dots 10 & k = 1, 2, 3 \end{cases} \quad (7)$$

The total maximum revenue is shown as follows:

$$Z_k = \sum_{c=0}^{14} Y_c \quad (8)$$

Where: Y_c is voyage revenue in c weeks prior to departure, $\Delta X_c^k(i)$ is incremental predetermined number of every week, $F_c^k(i)$ is predetermined price in c weeks prior to departure of the i times voyage, Z_k is the total maximum revenue by accumulation of the optimal voyage revenue.

In this paper, we list data of some cruise ship with 1200 cabins about predetermined number of cruise passengers to study the price decision. And there are 250 first class cabins, 450 second class cabins and 500 third class cabins in this cruise ship. For this reason, the constraint of this model is that the predetermined number of cruise passengers are no more than corresponding cabins.

6. Summary

In this paper, we study the expected maximum revenue of cruise ship based on multiplicative pickup and exponential smoothing models. Through establishing two forecast models of predetermined number and price in weekly voyage of various cabins, we get the pricing scheme by which the method of cumulative optimal values to get expected maximum revenue of cruise ship is proposed. Furthermore, according to a limited number of cabins and bounded price range, the final maximum revenue can be determined.

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