

Impacts of Revenue Management on Japan's Domestic Market

by

Takeshi Eguchi

M.E., Energy Conversion
Kyushu University, 1991

Submitted to the Department of Aeronautics and Astronautics
In Partial Fulfillment of the Requirements of the Degree of
Master of Science in Transportation

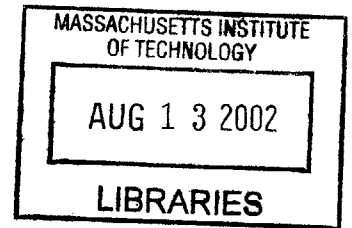
at the

Massachusetts Institute of Technology

June 2002

© 2002 Massachusetts Institute of Technology
All rights Reserved

AERO



Signature of Author.....

.....
Department of Aeronautics and Astronautics
May 14, 2002

Certified by.....

.....
Peter Paul Belobaba
Principal Research Scientist
Department of Aeronautics and Astronautics
Thesis Supervisor

Accepted by.....

.....
Wallace E. Vander Velde
Professor of Aeronautics and Astronautics
Chair, Committee on Graduate Students

Impacts of Revenue Management on Japan's Domestic Market

by

Takeshi Eguchi

M.E., Energy Conversion
Kyushu University, 1991

Submitted to the Department of Aeronautics and Astronautics
In Partial Fulfillment of the Requirements of the Degree of
Master of Science in Transportation

Abstract

Revenue management, which consists of differential pricing and seat inventory control, has been proven as an effective tool for revenue increase in numerous domestic and international markets. However, due to the existence of group passengers and differences in characteristics between the Japanese and other markets outside of Japan, it is difficult for Japanese airlines to recognize that revenue management methods will bring them a certain amount of revenue increase if applied to domestic operations. In order to answer the question, an investigation of the impact of revenue management on Japan's domestic market is made in this thesis.

This thesis first covers the characteristics of the market by describing the external and internal components, showing examples of the current business process Japanese airlines use. In preparation for the modeling of group bookings, parameters to describe the behavior of group bookings are presented using data collected from airlines. Based on the parameters and current group booking process, the group passengers booking process is modeled and the model's framework is used for simulation.

The Passenger Origin-Destination Simulator (PODS), originally designed to simulate for individual passengers, is modified to incorporate the group booking process, and used for the investigation. Leg-based seat inventory control, Fare Class Yield Management (FCYM) using Expected Marginal Seat Revenue (EMSRb) algorithm, is used as a new revenue management method, and it is proven as an effective tool in gaining revenue in Japan's domestic market. In addition, it is found that low airline preference affects airline revenue gain, and causes a revenue loss in the case of a low preference airline using FCYM with other airlines simultaneously. The result of simulation with different demand settings suggests that revenue gain by using FCYM increases from 2 to 5% for a dominant carrier as load factor goes up from 72% to 78%, in which only the dominant carrier only uses FCYM. Finally, simulation of the new settings with the forthcoming integration of Japan Air Lines and Japan Air System is tested, and the result also suggests revenue increase as a result of applying FCYM.

Thesis Advisor: Dr. Peter P. Belobaba

Title: Principal Research Scientist, Department of Aeronautics and Astronautics

Acknowledgements

First, I would like to thank Dr. Peter Belobaba, my thesis advisor, for giving me the right direction for this research work, and sharing with me his precious time to read my awkward thesis draft.

And I would like to thank my sponsor, All Nippon Airways, whose financial support has made my study at MIT possible. Of all ANA people, I truly thank for Mr. Yoshiaki Hiroki to give me a chance to study at MIT, and many colleagues in Revenue Management Team for giving me very useful advices. Without their support, not a page of my thesis would have been written.

I would also like to thank Dr. Craig Hopperstad for his assistance in making the special version of PODS used in this thesis.

I was very fortunate to have many mentors at MIT from whom to learn how to use PODS. Many thanks go to Alex Lee, Emmanuel Carrier, and Andrew Cusano. You are always welcome if you come to Japan (but be sure to fly ANA!).

In addition, I especially thank for Patrick McGuire for sacrificing his weekend to proofread my work, and Mr. Kenji Oba for giving me a confidence to face many difficulties.

I cannot forget to thank my classmates at MIT, Derek Lee, Wilson Tandiono and Yoosun Hong, who though much younger than I, took care of me very well. In their company, I sometimes forgot my age and enjoyed nights in Boston.

Finally, but most importantly, I would like to thank my wife, Yasuko, for her support over the years and my son, Masayuki, for his love. Here in Boston, I discovered profoundly the importance of family and friends. I will not forget my life in Boston.

Table of Contents

Chapter 1	Introduction.....	13
1.1	Setting, Purpose, and Motivation.....	13
1.2	Structure of Thesis	14
Chapter 2	Introduction to Japan’s Domestic Market	16
2.1	External components of the market	16
2.1.1	Geographical characteristics of Japan.....	16
2.1.2	Transportation policy change – From regulation to deregulation.....	18
2.1.3	General parameters of the Japan’s domestic market.....	20
2.2	Internal components of the market	23
2.2.1	Airline	23
2.2.2	Airport.....	30
2.2.3	Network structure.....	31
2.2.4	Passengers	33
2.2.5	Travel agents	34
2.3	Summary	35
Chapter 3	Current Revenue Management Practice Employed	36
3.1	Differential Pricing	36
3.1.1	Published Fares	37
3.1.2	Unpublished Fares	38
3.1.3	Relationship between demand segment and fare products	40
3.2	Yield Management.....	42
3.2.1	General characteristics of current yield management.....	43
3.2.2	Explanation of each yield management component	44
3.3	Summary	55
Chapter 4	Literature Review	56
4.1	Revenue Management.....	56
4.1.1	Price Differentiation.....	56
4.1.2	Yield Management.....	60
4.1.3	Seat Inventory Control.....	62
4.1.4	Traffic Flow (O-D) Control	77
4.2	Group Bookings in Japanese Market	82
4.2.1	Background.....	82
4.2.2	Past Research	84
4.2.3	Group Seat Inventory Control.....	85
Chapter 5	Analysis of Group Passengers Demand	89
5.1	Types of group passengers	89
5.2	Characteristics of Group Demand.....	91
5.3	Ad Hoc Group Analysis.....	94
5.4	Series Group Analysis.....	97
Chapter 6	Modeling Booking Process for Group Passengers	101
6.1	Overview of PODS	101
6.1.1	Background.....	101
6.1.2	Architecture.....	102
6.1.3	Simulation Inputs	105

6.1.4	Simulation Outputs	105
6.2	Modeling booking process for group passengers.....	106
6.2.1	Overview of Group booking process	106
6.2.2	Group Request Generation.....	107
6.2.3	Group Request Allocation.....	112
6.2.4	Calculate Actual Bookings and Reallocation.....	115
6.3	Summary	120
Chapter 7	Analysis of Impacts of Revenue Management.....	121
7.1	PODS9DJ.....	121
7.1.1	Major modification to PODS9DJ.....	121
7.1.2	Input parameters.....	123
7.2	Impacts against current market condition	129
7.2.1	Base Case	129
7.2.2	Revenue Management method change by a single airline	130
7.2.3	Two airlines change methods.....	137
7.2.4	All airlines change methods.....	142
7.2.5	Sensitivity analysis - Airline Preference	143
7.2.6	Results with different load factor settings	145
7.2.7	Summary	148
7.3	Impacts of 'after the integration' scenario	149
7.3.1	Market used.....	149
7.3.2	Base Case Result.....	150
7.3.3	Revenue Management methods change by a single airline	151
7.3.4	All airlines change methods.....	154
7.3.5	Summary	155
Chapter 8	Conclusions.....	156
8.1	Summary	156
8.2	New Research Direction	158

List of Figures

Figure 2-1	Market growth in 1988-2000 (1988=100%).....	22
Figure 2-2	Operating Revenue Growth 1988-2000 (1988=100%).....	25
Figure 2-3	RPM Growth 1988 – 2000 (1988 = 100%).....	26
Figure 2-4	ASM Growth 1988 – 2000 (1988 = 100%)	27
Figure 2-5	Yield change in 1988 – 2000	28
Figure 2-6	Load Factor 1988-2000.....	29
Figure 2-7	Unit Revenue 1988-2000	29
Figure 2-8	Stage length distribution over top 150 routes	31
Figure 3-1	Business passenger demand and fare product relationship.....	41
Figure 3-2	Leisure passenger demand and fare product relationship.....	42
Figure 3-3	Seat Inventory Control.....	46
Figure 4-1	Base case.....	58
Figure 4-2	Differential pricing.....	58
Figure 4-3	Solution for distinct fare class inventories.....	70
Figure 4-4	Solution for nested fare class inventories	71
Figure 4-5	EMSR solution for nested three class	73
Figure 4-6	EMSRb applied to four-fare class.....	77
Figure 4-7	Example of network (BOS-YVR-HKG).....	78
Figure 4-8	Overview of stakeholders for travel package.....	83
Figure 5-1	Cumulative booking curves for ad hoc and series group request	91
Figure 5-2	Distribution of number of group requests per flight.....	94
Figure 5-3	Histogram of the size of ad hoc group	95
Figure 5-4	Relative frequency distribution of utilization rate	96
Figure 5-5	Distribution of number of group requests per flight.....	98
Figure 5-6	Histogram of the size of series group request.....	99
Figure 5-7	Distribution of utilization rate for series group request.....	100
Figure 6-1	Architecture of PODS	102
Figure 6-2	PODS flow chart for a single trial (revised from Zickus (1998)).....	104
Figure 6-3	Overview of group booking process.....	106
Figure 6-4	Request Generation Flow.....	107
Figure 6-5	Allocate requests to flight.....	113
Figure 6-6	Booking Allocation	116
Figure 7-1	Booking curves for business and leisure passengers	127
Figure 7-2	Scenario 1. Revenue change over Base case	132
Figure 7-3	Scenario 2. Revenue change over Base case	134
Figure 7-4	Scenario 3. Revenue change over Base case	136
Figure 7-5	Scenario 1. Revenue change over Base case	137
Figure 7-6	Scenario 2. Revenue change over Base case	139
Figure 7-7	Scenario 3. Revenue change over Base case	141
Figure 7-8	Revenue change over Base case, all airlines use FCYM.....	142
Figure 7-9	AL2 revenue change over Base case of each preference.....	144
Figure 7-10	Case 1. Revenue change, Airline 1 uses FCYM	146
Figure 7-11	Case 2. Revenue change, Airline 2 and 3 use FCYM.....	147
Figure 7-12	Case 3. Revenue change, All airlines use FCYM	148

Figure 7-13	Scenario 1. Revenue change over Base case	151
Figure 7-14	Scenario 2. Revenue change over Base case	153
Figure 7-15	Scenario 3. Revenue change over Base case	154

List of Tables

Table 2-1	Major parameters of the Japanese and the US domestic market (FY2000).....	21
Table 2-2	Domestic market in 1988 – 2000	22
Table 2-3	Domestic scheduled airlines as of 2000.....	23
Table 2-4	Major parameters for ANA, JAL, and JAS in 1990 - 2000	24
Table 2-5	Top 20 airports in 1998	30
Table 2-6	JAS flights from Haneda to Naha	33
Table 3-1	Typology of published fare products, spring 2001	37
Table 3-2	Typology of unpublished fare products, spring 2001	39
Table 3-3	Fare class table.....	46
Table 3-4	F243 Y compartment class, 8days before departure	49
Table 3-5	Seat inventory control table for Flight247, at 150 days before departure	50
Table 3-6	Travel packages applied to Flight 247	50
Table 3-7	Seat inventory control table for F247, at 80 days before departure.....	51
Table 3-8	Travel packages applied to Flight 247, at 30 days before departure.....	52
Table 3-9	Seat inventory control table, at 30 days before departure.....	53
Table 3-10	Travel packages applied to Flight 247, at 14 days before departure.....	54
Table 3-11	Seat inventory control table, at 14 days before departure.....	54
Table 4-1	Seat inventory control approaches	61
Table 4-2	Mapping of ODFs to Virtual Value Classes	79
Table 4-3	Virtual classes for BOS-YVR and YVR-HKG	80
Table 6-1	Example of group request (number of flights per day in the market = 14)	110
Table 6-2	Example of group request (number of flights per day in the market = 14)	112
Table 6-3	Example of aggregated group request.....	112
Table 7-1	Major changes of settings for PODS9DJ	123
Table 7-2	Summary of major market conditions.....	125
Table 7-3	Summary of fare classes	126
Table 7-4	Summary of restriction categories	126
Table 7-5	Emult, base fare multiplier and disutility cost coefficients used	129
Table 7-6	Base case result.....	130
Table 7-7	Scenario 1. Major parameter changes.....	132
Table 7-8	Scenario 2. Major parameter changes.....	135
Table 7-9	Scenario 3. Major parameter changes.....	136
Table 7-10	Scenario 1. Major parameter changes.....	138
Table 7-11	Scenario 2. Major parameter changes.....	140
Table 7-12	Scenario 3. Major parameter changes.....	141
Table 7-13	Major parameter changes – all airlines use FCYM	143
Table 7-14	Airline 2 loads change over Base case of each preference	145
Table 7-15	Summary of major market conditions.....	150
Table 7-16	Base case result.....	150
Table 7-17	Scenario 1. Major parameter changes.....	152
Table 7-18	Scenario 2. Major parameter changes.....	153
Table 7-19	Scenario 3. Major parameter changes.....	155

Chapter 1

Introduction

1.1 Setting, Purpose, and Motivation

Following deregulation, Japan's market has become gradually more competitive. For example, new airlines started their operation with discounted prices, forcing incumbent carriers to lower their fares. Also, once highly regulated prices, which had been required to have government authorization were now free to vary, leading airlines to set their own prices with regards to the characteristics of each route.

Such varying fares are beneficial to both customers and airlines as low fares can stimulate more demand theoretically. However, little passenger increase can be seen so far, as currently published fares do not seem to be low enough to stimulate significant demand increase, and such discount fares are applied only to low demand flights.

To make things worse, as none of Japan's airlines are using revenue management properly, discount tickets are sold with no booking limit and no restriction in order to fill such low demand flights. It is likely that airlines give too much benefit in the forms of low fares to passengers whose willingness to pay is much higher than the discount fares.

Another concern is that the way airlines sell discount tickets will become standard way unless revenue management is introduced to Japan's domestic market and proved to be a valuable tool for gaining more revenue. Consequently, introduction of revenue management is crucial and the evaluation of impacts of revenue management is important to accelerate such introduction.

In order to evaluate the impacts of revenue management on a typical Japanese domestic market, a computer tool called the Passenger Origin-Destination Simulation (PODS), developed at

Boeing¹, is used in this thesis. Impacts are measured by evaluating revenues of each airline and analyzing the yield change caused by passenger distribution.

Some research questions that are to be examined are as follows:

→ How can we model and implement the group passenger behavior into PODS?

Since PODS was designed to use demand as an aggregate of individual passengers, which is not suitable for simulating Japan's domestic market, modeling group passenger demand and the booking process for such passengers plays a vital role in obtaining fruitful results.

→ How can we simulate current market with PODS?

In order to simulate current market conditions, such as passenger distribution to each airline as well as fare class structure, we need to modify the parameters that affect these conditions in the simulation.

→ How will the merger of airlines affect the market?

Two major players in the market, Japan Airlines and Japan Air System are reported to merge their operation in 2004, so that it is useful at this point to simulate the results of such integration together with the implementation of Revenue Management for future analysis.

1.2 Structure of Thesis

As a prelude, Chapter 2 and 3 describes the characteristics of the Japanese domestic market. Chapter 2 describes the overview of Japan's domestic market, general aspects of the market, external and internal components are explained. Based on the understanding of such aspects, major parameters of the market, such as Enplanements, Revenue Passenger Miles (RPM), Available Seat Miles (ASM), are reviewed. Chapter 3 describes the current revenue management practice used by Japanese airlines, focusing on the fare structure and seat inventory control.

¹ Hopperstad (1997).

Chapter 4 describes the literature review of past research for revenue management and the group booking process. Two components of the revenue management, differential pricing and yield management are reviewed in some detail, and a brief review of the group booking process is made later on.

Chapter 5 shows the analysis of the major sources of variation in group passenger demand, which has been defined by Svrcek² as the number of group requests, the size of each individual group request, and the utilization rates associated with a group request. Sample data submitted from an airline is used to set the characteristics of such parameters.

Chapter 6 provides a brief description of the Passenger Origin-Destination Simulator (PODS), and explains how this is modified to include the function to handle group passengers' demand and booking process.

Chapter 7 first describes the specific PODS modification used in this simulation. Some input parameters are calibrated using an iterative approach, and a baseline result that simulates the current market is shown. The impacts of the implementation of revenue management are tested under the current market condition. After that, the integration of airlines in the market is simulated.

Finally, in Chapter 8, a summary of findings and contribution of the thesis are described, and further research directions are proposed.

² Svrcek (1991), Section 4.2.

Chapter 2

Introduction to Japan's Domestic Market

To understand the impact of the introduction of revenue management on Japan's domestic market, one should understand the characteristics of this market first. For this reason, external components of the market, such as geographical characteristics of Japan, as well as other transportation modes, such as the high-speed train (Shinkansen), are explained briefly. In addition, the change of transportation policy towards deregulation is another important component that has significantly influenced the current market changes. Based on the understanding of external components, general parameters of the market, such as Enplanements, Revenue Passenger Miles (RPM), and Available Seat Miles (ASM), are reviewed to describe the market. Finally, internal components of the market including airlines, airports, and network structure are explained to understand the market from different viewpoints.

2.1 External components of the market

2.1.1 Geographical characteristics of Japan

Japan is a small country compared to the United States. The land area is 372,000 square kilometers, which is merely 4% of the whole United States³. Also, most of Japan is mountainous, so land for habitation is limited. Therefore, population density is quite high, 340 people per square kilometer, whereas in the United States, it is 30 people per square kilometer. Such high density within a small land mass suggests that the demand for air travel by air is not as great as in

³ Statistics Bureau & Statistics Center (2002).

the United States. In fact, the total number of passengers enplaned in FY2000 was 93 million⁴, while it was 611 million in United States⁵⁶.

The mountainous terrain of Japan is a good advantage for airlines, since other forms of transportation need to detour around the area. However, the evolution of high-speed railroad called the Shinkansen has been a strong threat to airlines. In 1964, the Shinkansen started its service from Tokyo to Osaka (319mi) within 4 hours, while the conventional rapid train took 6.5 hours. It took only an hour to fly between these two cities, but due to the time-consuming transportation from the airport to the city center, the total travel time was almost 3 hours, making air travel less competitive. In addition, a one-way fare from Tokyo to Osaka was 7,000 yen by air, but the Shinkansen was able to set the fare at 5,030 yen, which is 28% lower, and this made the Shinkansen more attractive. Travel time and lower fares significantly impacted the number of passengers using air travel. As a result of competition, the load factor for the Tokyo-Osaka flights decreased from 90% to 60% in 1964, and airlines were forced to reduce their flight frequencies. Not only was this main route affected, other air routes of shorter distances were also damaged by the Shinkansen. For instance, airlines had 8 flights a day from Tokyo to Nagoya (174mi), but they withdrew all the flights as air travel could not compete with the Shinkansen in terms of travel time and fare⁷. It is interesting to note that the same situation is currently occurring in Europe with airlines stopping their service from Paris to Brussels (about 174mi) because the European high-speed train, TGV, provides competitive services⁸.

Another geographical aspect is that Japan consists of 4 main islands and other small islands. Railroads and highways can be a substitute for air travel unless they are not connected by rail or road, as is the case for small islands. Due to the short travel time by air compared to by ship, air routes connecting small islands to main islands are indispensable. Air travel is especially

⁴ Ministry of Land, Infrastructure and Transportation (2001).

⁵ Bureau of Transport Statistics (2002).

⁶ The population of Japan is 127 million while it is 249 million in the United States, so the number of trip per person (enplanements/population) is calculated as 0.73/year for Japanese and 2.45/year for American. This also supports the low air travel demand among Japanese compared to the US people.

⁷ Sugiura (2001), pp. 61-66.

⁸ Sugiura (2001), p. 151.

important for carrying perishable foods and for emergencies, even if there is not enough demand to keep the airline operating at a profit.

2.1.2 Transportation policy change – From regulation to deregulation

Highly regulated period (50's-mid of 80's)

Before deregulation began, there was a rule called 1970-72 Rule to regulate the airline industry. This rule, also referred as the “Aviation Constitution,” formed by a cabinet resolution in 1970, was implemented in 1972⁹. This 1970-72 Rule consists of 3 parts, segmentation of industrial structure, capacity adjustment among airlines, and cooperation among carriers. Of the three, the segmentation of industrial structure was the most important part for the airline industry. The industry was segmented to three parts and given to specific airline as follows:

- International routes and a few domestic trunk routes -Japan Airlines (JAL)
- Domestic trunk and local routes -All Nippon Airways (ANA)
- Domestic local routes -Japan Air System (JAS)

Under this system, competition among the three carriers was almost nonexistent, and airlines enjoyed their near-monopolistic position on most routes with regulated fares. However, this golden age for airlines came to an end in 1985 when Japan and US agreed to expand their bilateral relationship. Multiple airlines were allowed to enter into service across the Pacific, and it was infeasible to keep the 1970-72 Rule, as international routes were not only open to JAL any more.

First phase of deregulation (1986-1994)

In 1986, the advisory committees of the Ministry of Transportation (MOT) that is now the Ministry of Land, Infrastructure and Transportation (MLIT), made a set of recommendations as follows:

⁹ Sugiura (2001), pp. 68-72.

- Allowing multiple airlines in international market
- Encouraging competition in the domestic market
- Privatization of JAL

As a result, ANA started scheduled international flights in 1986, and JAS started its first international flights in 1988. As for the domestic market, MOT implemented “double or triple tracking” – the practice of two or three airlines being allowed servicing, based on passenger volume. Routes with at least 700,000 passengers per year were permitted to operate with two airlines, and routes with at least 1 million passengers per year were permitted to operate with three airlines.

Airlines took this opportunity and began a real competition they have not before experienced; and the number of passengers in the market increased due to the increased supply. The relaxation of the regulation in terms of supply stepped up further by lowering the hurdle for double and triple tracking. In 1992, hurdles were lowered from 700,000 to 400,000 passengers per year for double tracking, and from 1 million to 700,000 passengers per year for triple tracking. In 1996, they were cut further to 200,000 and 350,000, respectively. Finally, this regulation was abolished in 1997, and airlines are now free to enter into any market¹⁰. In fact, double tracking routes increased from 11 routes to 37 routes since October 1990, and from 6 to 25 for triple tracking routes.¹¹

Second phase of Deregulation (1994-Today)

In a second phase of deregulation, fares and new entrants were the main subjects to consider. Under regulation, one single fare for each route was allowed to avoid “unnecessary price competition,” and the fare was calculated based upon the “appropriate” cost incurred by “efficient management.” However, those terms used to explain the reason for regulation, as well as fairness of the calculation of fare, are not clear enough to prove that such regulation is good for the market, in terms of consumer benefit. In fact, it has been proved by US deregulation that

¹⁰Sugiura (2001), p. 109.

¹¹ Ministry of Foreign Affairs (1999), 4-2.

the wide range of differential pricing as a result of deregulation brought significant benefit increase throughout the market.

Consequently, MOT started the relaxation of regulation in terms of fares gradually. In December 1994, a revised Civil Aeronautics Law came into force, allowing airlines to make discount domestic fares up to 50% without explicit MOT approval, and airlines started selling advance purchase tickets with 30% discounts. Together with the enhancement of slots for Haneda airport, such freedom to set the price leads the way for the new airlines to enter with deeply discount fares. In 1998, Skymark Airlines, and Hokkaido International Airline (Air Do) started their operations. Finally, in 2000, price deregulation ended up with the enforcement of a revised Civil Aeronautics Law, discontinuing any rules to regulate price¹².

2.1.3 General parameters of the Japan's domestic market

Table 2-1 represents the major parameters for the Japan's domestic market in fiscal year (FY) 2000, compared to those of the US domestic market. The market size is significantly smaller than the US market, but some interesting facts can be observed by reviewing the proportion for each factor.

First, the number of enplanements in the Japan's domestic market is 15.2% of the US market, but the proportion of Revenue Passenger Miles, and Available Seat Miles are 9.7% and 10.9% respectively, suggesting that the stage length for the Japan's domestic market is much shorter than the US market. In fact, total miles flown is 5.5% of US market, and most of the stage length is around 400 miles. Detailed network structure is described later.

Second, the number of departures for the Japanese domestic market is 7.9% of the US market, smaller than the ratio of enplanements, indicating that the aircraft used in the Japan's market is larger than the US market. It is supported by the fact that a significant number of B747s can be seen at Haneda airport, and such a sight is rare in the US, except for some major international airports.

¹² Sugiura (2001), pp. 109-111.

Table 2-1 Major parameters of the Japanese and the US domestic market (FY2000)

Parameters	Japan Domestic	US Domestic	Japan/US (%)
Enplanements (000)	92,962	610,756	15.2%
Revenue Passenger Miles (000)	49,620,179	509,877,902	9.7%
Available Seat Miles (000)	78,353,989	717,124,646	10.9%
Load Factor (%)	63.3%	71.1%	89.0%
Departures	668,161	8,462,608	7.9%
Miles Flown (000)	301,182	5,464,004	5.5%
Hours Flown (Hour)	861,348	13,337,188	6.5%

Source: MLIT (2001), Bureau of Transport Statistics (2002)

The last parameter to mention is the load factor. US domestic market achieved a high load factor of 71%, but it is 63% for the Japan's domestic market. It is mainly due to the recent recession, and further discussion as to the impact of recession is presented later.

Table 2-2 shows the domestic market in 1988-2000. As shown in the right side of the table, Japan's economy soared in the early 90s but fell into a long-lasting recession. To illustrate the trend, Figure 2-1 shows the rate of change in 1988-2000 compared to the 1988 data.

Despite the long-term recession, represented as the low rate of increase of GDP, the total number of enplanements keeps increasing, as well as RPM. It can be explained by the increase of supply, which is measured by ASM as well as the decrease of yield, both triggered by deregulation begun in 1986. As explained, deregulation of supply that started in 1992 boosted the ASM increase, and it almost doubled in 2000 compared to 1988. In addition to deregulation, the expansion of Haneda airport and the openings of some new local airports made it possible to achieve such a rapid increase.

Table 2-2 Domestic market in 1988 – 2000

Year (Fiscal)	Enplane- ments (000)	Index (‘88 =100)	Revenue Passenger Miles (000)	Index (‘88 =100)	Available Seat Miles (000)	Index (‘88 =100)	Load Factor	Rate of Growth (‘88=100%)	Index YIELD (JPY) (‘88 =100)	GDP (BILL JPY)	Index (‘88 =100)	
'88	52,945	100	25,544,793	100	39,538,769	100	64.6%	100%	34.69	100	387,834	100
'89	60,120	114	29,298,228	115	41,725,929	106	70.2%	109%	35.08	101	416,905	107
'90	65,252	123	32,084,047	126	44,083,816	111	72.8%	113%	34.80	100	450,532	116
'91	68,687	130	34,399,083	135	48,355,053	122	71.1%	110%	35.02	101	474,627	122
'92	69,687	132	35,227,021	138	53,111,622	134	66.3%	103%	34.64	100	483,189	125
'93	69,584	131	35,499,009	139	57,571,845	146	61.7%	95%	33.62	97	487,528	126
'94	74,547	141	38,091,429	149	62,266,737	157	61.2%	95%	32.36	93	492,266	127
'95	78,101	148	40,405,305	158	66,549,383	168	60.7%	94%	31.21	90	501,960	129
'96	82,131	155	42,914,531	168	68,937,410	174	62.3%	96%	30.34	87	515,249	133
'97	85,552	162	45,520,937	178	72,084,216	182	63.1%	98%	28.84	83	520,177	134
'98	87,910	166	47,226,658	185	76,334,204	193	61.9%	96%	27.59	80	514,456	133
'99	91,589	173	49,315,226	193	77,184,461	195	63.9%	99%	26.72	77	513,682	132
'00	92,962	176	49,620,179	194	78,353,989	198	63.3%	98%	28.04	81	510,839	132

Source: MLIT (2001), Airline annual report

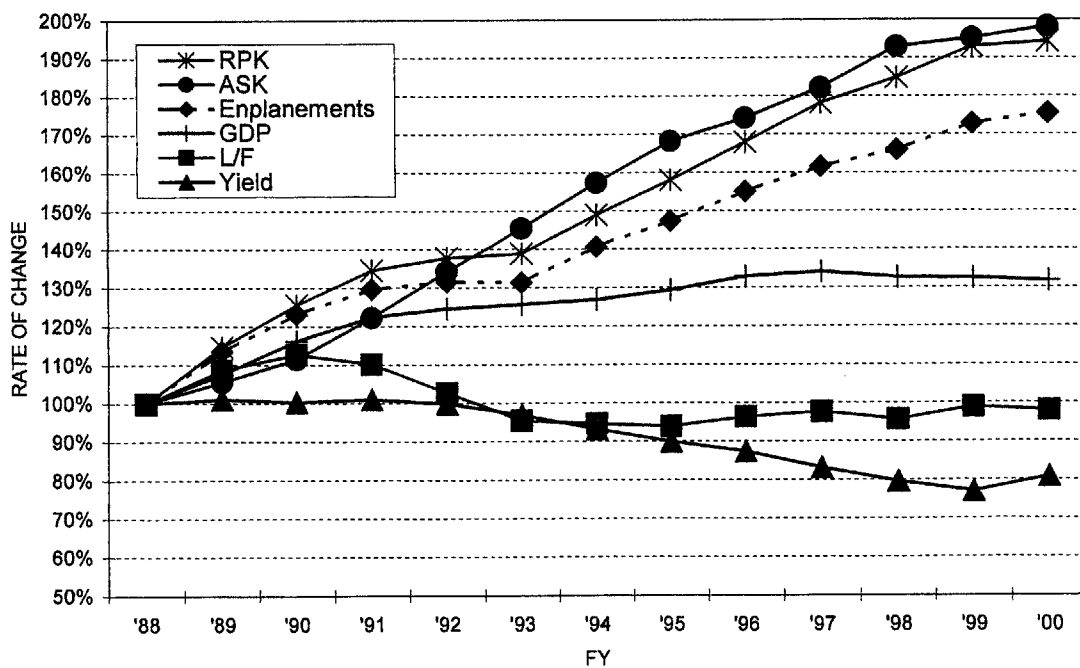


Figure 2-1 Market growth in 1988-2000 (1988=100%)

As for yield, airlines were forced to decrease their fares before deregulation to stimulate the demand between 1992 and 1993, and the downward movement was accelerated by the deregulation begun in 1994. However, in 2000, the yield changed directions, with airlines are free to set higher prices in peak periods. It seems that the market demand is inelastic for such increases at this moment, but it is worth monitoring what has happened in 2001.

Load factor increased to 72.8% in 1990, but dropped to 60.7% in 1995. Seemingly it is due to recession, but it is also due to increased supply. It has been recovering slightly since 1995, owing to the slowly recovering economy as well as the slowed growth of ASM. Further review of the parameters, compared by airline, is presented later.

2.2 Internal components of the market

2.2.1 Airline

Table 2-3 summarizes the scheduled airlines in Japan in 2000. There are 18 airlines that operate scheduled flights, but 3 major airlines and their company groups carry 99% of enplanements. In fact, the top three airlines, ANA, JAL, and JAS cover 86% of total Enplanements and 90% of RPM. It is therefore reasonable to define them as ‘major players’ in this market. In order to present the growth of each airline, Table 2-4 shows the major parameters of these three airlines in 1990, 1995, and 2000.

Table 2-3 Domestic scheduled airlines as of 2000

AIRLINE	ENPLANEMENTS (000)	%	RPM (000)	%
ALL NIPPON AIRWAYS (ANA)	39,408	42.4%	21,646,061	43.6%
JAPAN AIRLINES (JAL)	20,215	21.7%	12,213,393	24.6%
JAPAN AIR SYSTEM (JAS)	20,322	21.9%	10,640,615	21.4%
AIR NIPPON (ANA Group)	6,075	6.5%	2,259,924	4.6%
JAPAN TRANSOCEAN AIR (JAL Group)	2,354	2.5%	1,165,708	2.3%
SKYMARK AIRLINES	860	0.9%	552,863	1.1%
AIR DO	645	0.7%	358,464	0.7%
JAL EXPRESS (JAL GROUP)	843	0.9%	338,069	0.7%
JAPAN AIR COMMUTER (JAS GROUP)	1,356	1.5%	282,249	0.6%
NAKANIHON AIRLINE (ANA Group)	206	0.2%	52,334	0.1%
J-AIR (JAL Group)	142	0.2%	38,429	0.1%
RYUKYU AIR COMMUTER (JAL Group)	202	0.2%	27,610	0.1%
HOKKAIDO AIR SYSTEM (JAS Group)	148	0.2%	25,945	0.1%

AMAKUSA AIRLINE	81	0.1%	10,318	0.0%
NEW CENTRAL AIR SERVICE	36	0.0%	3,409	0.0%
AIR HOKKAIDO (ANA Group)	26	0.0%	2,399	0.0%
ORIENTAL AIR BRIDGE	34	0.0%	2,063	0.0%
KYOKUSIN AIR	8	0.0%	325	0.0%
Total	92,962	100.0%	49,620,179	100.0%

Source: MLIT (2001).

Table 2-4 Major parameters for ANA, JAL, and JAS in 1990 - 2000

A/L	Parameter	'90	'95	'00
ANA	Operating Revenue (000 JPY)	570,153,000	594,326,000	595,627,973
	RPM (000 Passenger-mile)	16,407,707	18,834,928	21,345,236
	ASM (000 Seat-mile)	22,743,319	30,604,149	33,925,503
	Unit Revenue (JPY/ASM)	25.07	19.42	17.56
	Yield (JPY/RPM)	34.75	31.55	27.90
	L/F (%)	72.1%	61.5%	62.9%
JAL	Operating Revenue (000 JPY)	252,307,000	279,906,000	289,800,000
	RPM (000 Passenger-mile)	7,594,049	9,353,322	10,469,614
	ASM (000 Seat-mile)	10,079,971	15,777,573	15,753,310
	Unit Revenue (JPY/ASM)	25.03	17.74	18.40
	Yield (JPY/RPM)	33.22	29.93	27.68
	L/F (%)	75.3%	59.3%	66.5%
JAS	Operating Revenue (000 JPY)	217,441,600	267,109,000	305,102,000
	RPM (000 Passenger-mile)	5,883,110	8,375,907	10,469,857
	ASM (000 Seat-mile)	8,219,965	13,938,024	15,753,263
	Unit Revenue (JPY/ASM)	26.45	19.16	19.37
	Yield (JPY/RPM)	36.96	31.89	29.14
	L/F (%)	71.6%	60.1%	66.5%
TTL	Operating Revenue (mil JPY)	1,039,901,600	1,141,341,000	1,190,529,973
	RPM (000 Passenger-mile)	29,884,865.76	36,564,157.24	42,284,707.08
	ASM (000 Seat-mile)	41,043,254.82	60,319,746.43	65,432,075.81
	Unit Revenue (JPY/ASM)	25.34	18.92	18.19
	Yield (JPY/RPM)	34.80	31.21	28.16
	L/F (%)	72.8%	60.6%	64.6%

Source: ANA, JAL, and JAS Annual Report

Operating Revenue

Figure 2-2 shows the operating revenue growth during 1988-2000. For all three airlines, revenue grew significantly during 1988-1991, before the prolonged economic downturn that began in 1992. However, the growth for each airline is different after 1992. ANA, which has the largest market share, could not increase operation revenue unlike the other two airlines. This is because deregulation enabled the other two airlines to enter ANA's dominant routes, and initiate fare competition against it.

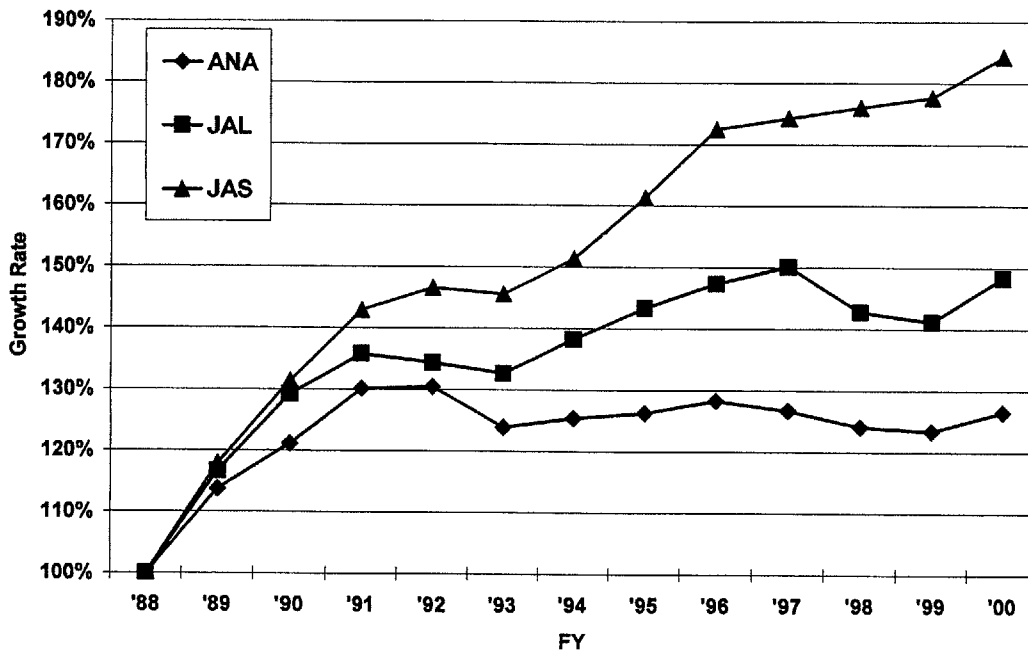


Figure 2-2 Operating Revenue Growth 1988-2000 (1988=100%)

JAL made moderate growth owing to deregulation, but JAS made significant growth as it increased its flights by entering into the major segment of the market, domestic trunk routes, and JAS has not suffered the impact of fare deregulation compared to other airlines, as competition among local routes, its base, were not severe.

And in 2000, operating revenue turned an increase, as airlines were free to set fares, and all of them raised the upper limit to obtain more revenue.

RPM and ASM

Figure 2-3 and Figure 2-4 show the growth of RPM and ASM in 1988-2000, respectively. The increase of RPM is somewhat like the increase of operating Revenue, but due to the decrease of yield, the rate of growth for RPM is much larger than that of operating revenue. As for ASM, seemingly, each airline has a different policy for enhancing networks in recent years. JAS, for example, is still expanding its network, but others are making little movement or decreasing their networks.

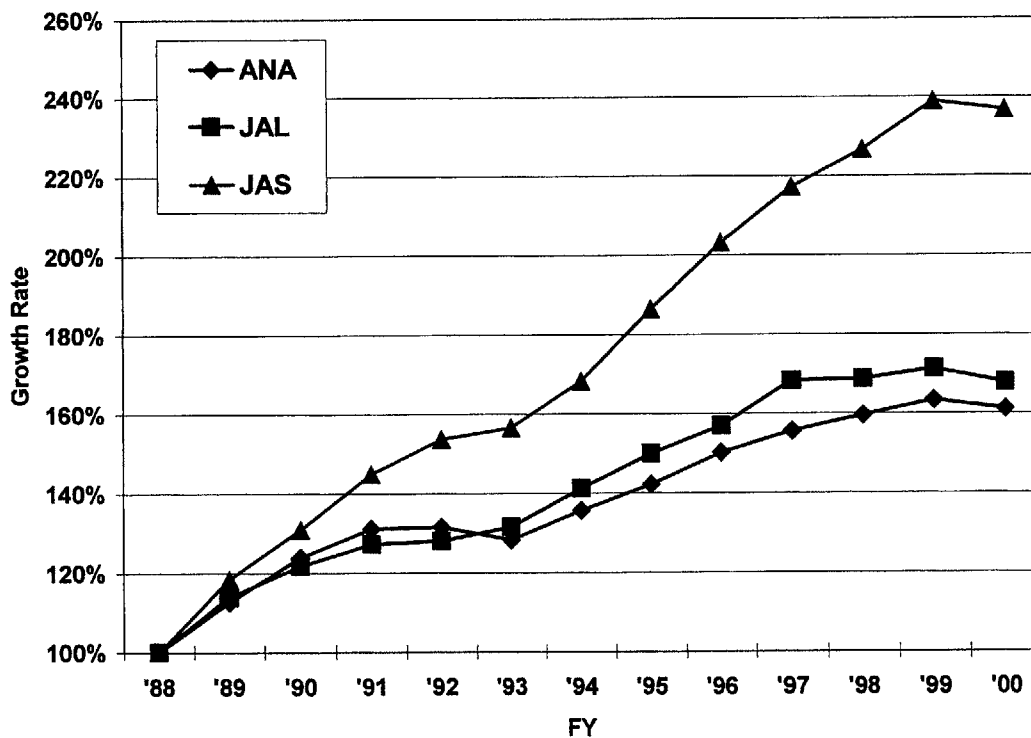


Figure 2-3 RPM Growth 1988 – 2000 (1988 = 100%)

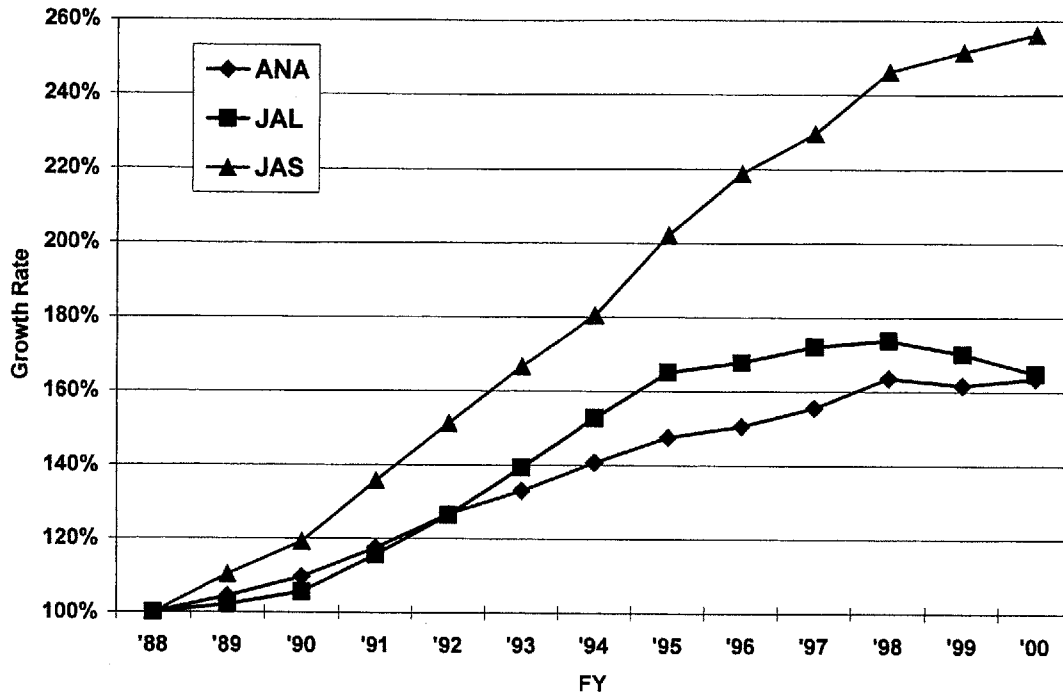


Figure 2-4 ASM Growth 1988 – 2000 (1988 = 100%)

Yield

Figure 2-5 shows the yield change from 1988 to 2000. In the beginning of the competition, yield for each airline is significantly different, and JAS has the highest yield in 1988, followed by ANA and JAL. It suggests the fact that passengers using local routes, which JAS dominated during this period, paid higher fares than passengers using trunk routes, where only ANA and JAL were permitted to fly, and faced harsh competition.

The difference between ANA and JAL in terms of yield can be explained by the difference in network structure, as ANA operated both trunk routes and local routes, whereas JAL operated trunk routes only. However, since competition among three airlines began with fare deregulation, the difference between yield was reduced, and every yield decreased. Nevertheless, in 2000, all airlines increased their yield again as airlines were free to raise upper limits, and set more discount ticket to keep passengers attention away from upper limit increase. JAL in particular increased yield to 27.68 JPY/Mile in 2000, a 7% increase from the previous year, while other airline yields increased by 4-5%.

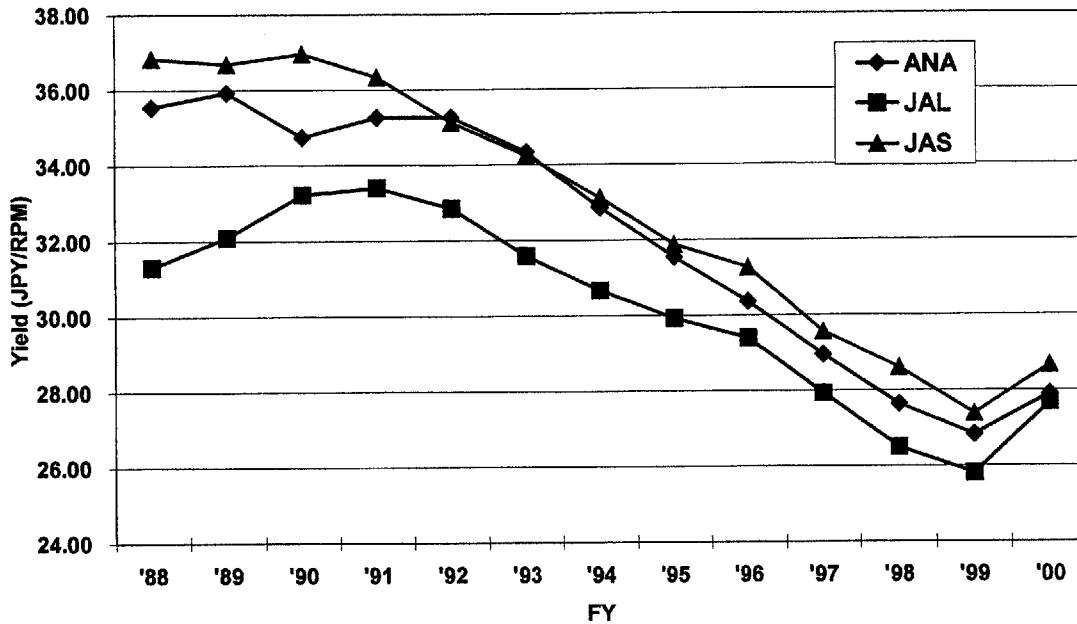


Figure 2-5 Yield change in 1988 – 2000

Load Factor and Unit Revenue

Figure 2-6 shows the load Factor in 1988 – 2000. Like yield, the load factor for each airline is moving independently in recent years. JAL’s load factor is worthy of particular attention, as it grew constantly from 1995 to 2000 (except 1998, heavy economic downturn and new entry). Together with the highest yield increase, JAL achieved the highest unit revenue in 2000 (See Figure 2-7).

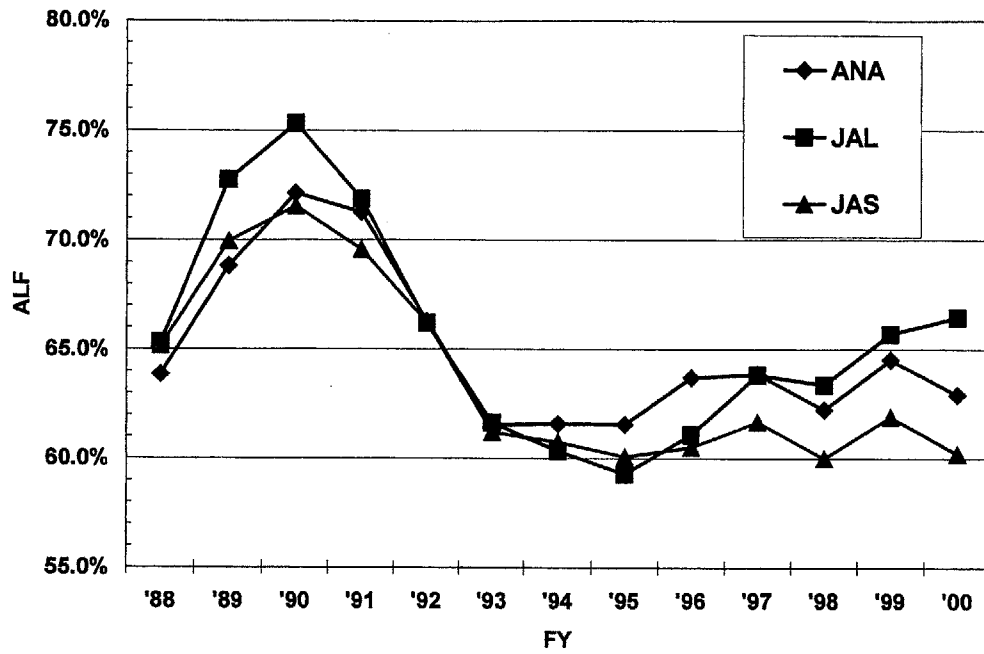


Figure 2-6 Load Factor 1988-2000

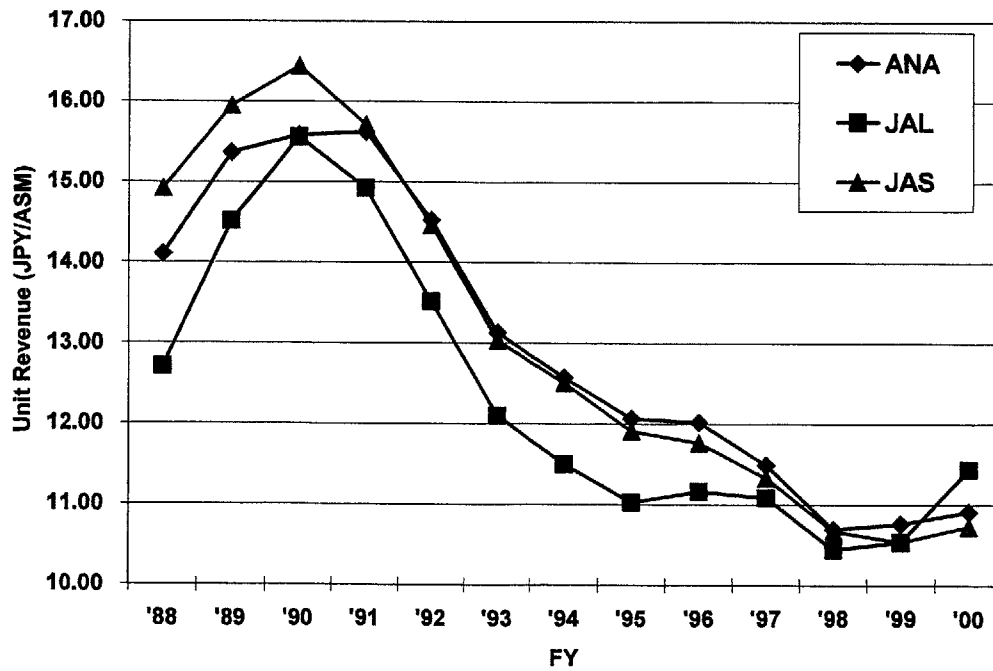


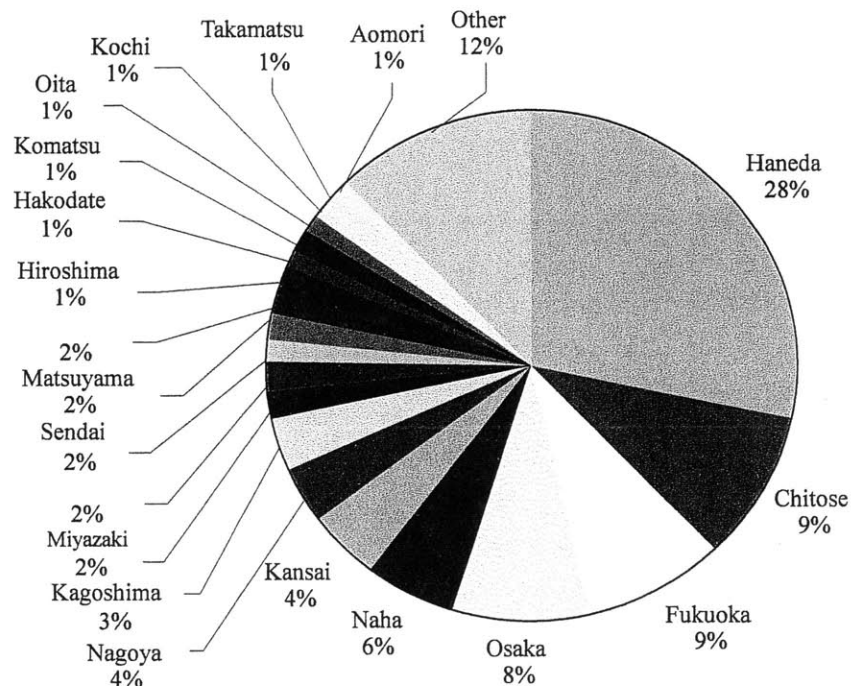
Figure 2-7 Unit Revenue 1988-2000

2.2.2 Airport

Currently, there are 87 airports for scheduled flights in Japan, but 88% of the traffic is concentrated in the top 20 airports. Table 2-5 shows the distribution of passengers who used the top 20 airports in 1998. Haneda owns 28% of the total traffic, followed by Chitose, one end of the world's busiest route, Haneda-Chitose. Osaka, Japan's second largest center has two airports, Osaka, and Kansai, and the sum of airports rises to 12%. As seen through the pie chart, the greatest concern for airlines in terms of airports is how many slots can they obtain at Haneda airport. The government regulates slot allocation, and slots newly created by runway expansion and operating hour extensions, are allocated to airlines that 'contribute to the improvement of the nationwide network'. Therefore, airlines need to keep unprofitable local routes just to demonstrate their contribution.

Table 2-5 Top 20 airports in 1998

Airport	Passengers
Haneda	51,417,312
Chitose	17,082,082
Fukuoka	15,608,193
Osaka	15,115,789
Naha	10,210,571
Kansai	7,846,913
Nagoya	6,504,522
Kagoshima	6,045,220
Miyazaki	3,403,409
Nagasaki	3,121,969
Sendai	2,836,773
Matsuyama	2,747,570
Kumamoto	2,740,446
Hiroshima	2,685,973
Hakodate	2,492,926
Komatsu	2,403,308
Oita	2,021,435
Kochi	1,903,590
Takamatsu	1,547,745
Aomori	1,546,147
Other	22,090,849
TTL	181,372,742



Source: MLIT (2001).

2.2.3 Network structure

The Japan's domestic market is different from the US market from a network standpoint. Three points that represent the characteristics of the network structure are as follows:

Short range, short flight time

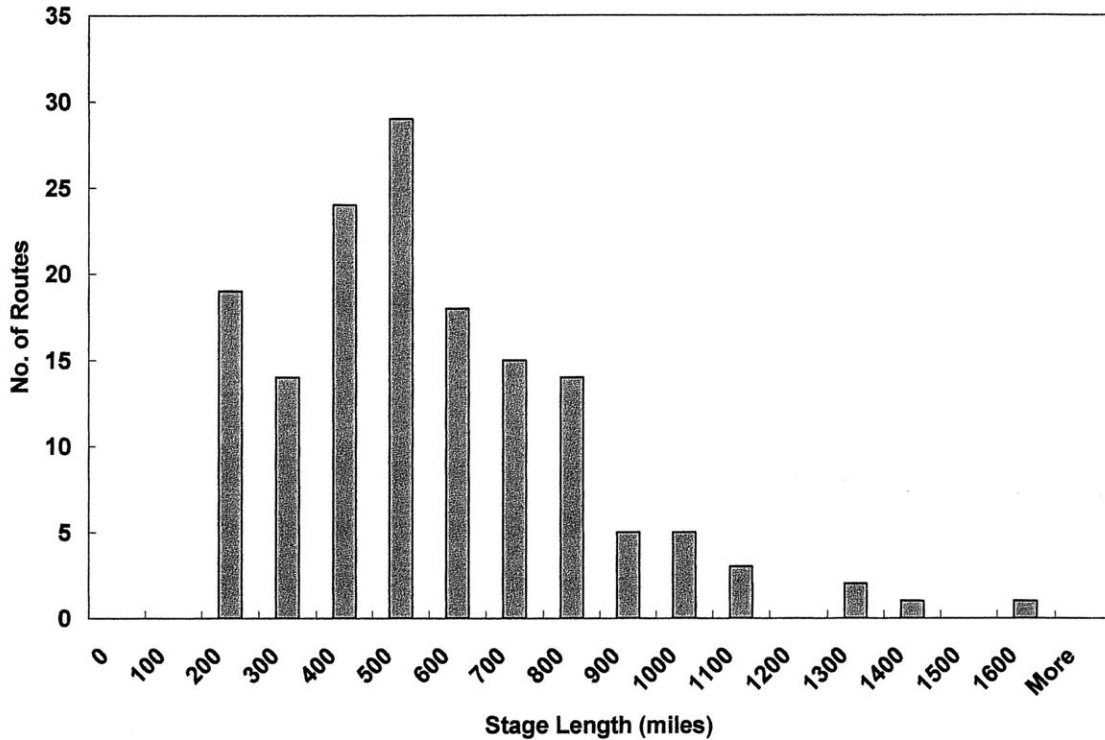


Figure 2-8 Stage length distribution over top 150 routes¹³

There are 306 routes in this market, and the average stage length is 473 miles. Of all routes, 95% of passengers use top 150 routes. Figure 2-8 shows the stage length distribution for those routes. The average stage length is 503 miles, which is approximately the same as the distance from Chicago to Washington DC (589 miles). The average length per departure for the US domestic market is calculated at 646 miles using figures in Table 1, so that the stage length is shorter than for the US. Moreover, since there is a significant number of connecting passengers in the US

¹³ MLIT (2001).

market but a small number in the Japanese market, distance in terms of Origin – Destination for the US market might be much longer than the Japanese market. The same thing can be said of flight time.

High concentration on specific routes

As explained in 2.2.2, nearly one-third of the domestic traffic concentrates at Haneda airport. In fact, 48 out of the top 150 routes are to/from Haneda airport, and 59.7% of all passengers used those routes in 2000. Osaka and Kansai airports, major airports in Osaka area, are in second place and 38 routes use those airports, but 18 % of passengers (excluding passengers to/from Haneda) use those routes¹⁴.

Non hub and spoke structure

Currently, no airport in Japan operates as a hub airport. There are several explanations for this situation.

The first reason is the short distance. The majority of the stage lengths fall within the range of 300 to 800 miles, and flight time for such a range varies from one to two hours. Consequently, given such short flight time, passengers using connecting flights are not large in number as it will take at least 30 minutes for transit and this transit time significantly increases total travel time in this market environment.

The second reason to address is the pricing structure. No airline applies any discounts on connecting flights, and passengers using connecting flights must pay the sum of the fare for each leg. Given longer flight times, less convenience resulting from transit, and higher fares, there is no incentive to use connecting flights unless there is no choice.

The third component to describe is the schedule. Due to their indifference to connecting flights, airlines make little effort for schedule coordination. Assume there is a passenger traveling from Tokyo (Haneda) to Okinawa (Naha), for example. If he decides to use a JAS flight departing in the morning, the passenger can choose from flights in Table 2-6.

¹⁴ MLIT (2001).

Table 2-6 JAS flights from Haneda to Naha

Direct Flights		Connecting Flight (Haneda-Osaka-Naha)			
Total duration: 2 hr 25 min		Total duration: 4 hr 15 min			
Price: 34,500 Yen		Price: 47,000 Yen			
		First leg		Second leg	
Flt	Dep. – Arr.	Flt	Dep. – Arr.	Flt	Dep. – Arr.
F551	0740 - 1015	F201	0650-0750	F715	0910-1115
F553	1010 - 1240				
F555	1145 - 1415				

Source: JAS Timetable (Aug. 2001)

As shown, the passenger can choose 3 direct flights but can use only one connecting flight with a higher fare and a longer travel time, as the passenger has to wait at Osaka airport for 1 hour 20 minutes.

The last factor to mention is the lack of practice for the complex O-D network structure. As shown above, airlines need to set the price in order to stimulate the connecting passenger demand, and coordinate the schedule accordingly. However, as they have no experience and no management tools to handle such complex structures, they might hesitate to start seeking connecting passengers unless they have no other way to increase their revenue.

2.2.4 Passengers

Passengers can be classified according to three types: individual business passengers, individual leisure passengers, and group passengers. Individual business passengers use airlines for business trip, and tend to be more sensible to the convenience of the flight than the fare. Conversely, individual leisure passengers use airlines for sightseeing, visiting relatives or friends and so on, and tend to focus on the fare level. The individual leisure passenger is more flexible than the business passenger in terms of schedule and route.

The third segment, group passengers, is passengers who travel as a group of more than five. Some group passengers plan their trip by themselves, and ask a travel agent to book their flight and accommodation. Other group passengers use a travel package that a travel agent has made and buy such a package. In either case, the travel agent handles such group requests and books

the flight, so that the role of travel agent is an important factor to consider in the behavior of group passengers. Further analysis of passenger types is described later.

2.2.5 Travel agents

As introduced above, travel agents are playing an important role in the Japanese industry. Under a heavily regulated environment in which airlines are not allowed to set fares and change their network, all they can do to compete with others is to increase frequency and to improve in-flight service, as well as to stimulate demand.

However, increasing frequency is not easy with slot limitations, and improvement of in-flight service is much too easy for competitors to follow. Especially, given that only one airline operates a specific route, such airline can do nothing other than try to create more demand. As a result, travel agents and airlines cooperate and have joint promotions to induce demand. For example, ANA uses Snoopy as an image character for ski trips to Hokkaido, in northern Japan, to create leisure demand in winter, where less leisure demand was seen before.

Other important thing airlines have done is to sell tickets to travel agents with special discount prices. GT (Group Tour) and IT (Inclusive Tour) fare were used to set lower prices than normal fares even before deregulation, and travel agents could plan low price tours, and make all-inclusive packages to stimulate demand.

In addition, airlines use travel agents to smooth the demand variation caused by seasonality. Travel agents make contracts with airlines that they will receive some amount of override commission after they have booked a certain number of passengers. Therefore, travel agents sold tickets even in off-season by lowering ticket prices, as the revenue from the override commission covers the revenue decrease.

After deregulation, the situation has changed, and now airlines are trying to draw more passengers away from travel agents by setting sharply discounted ticket prices, and encouraging passengers to book using the internet. However, despite the effort airlines have made so far, it

seems that passengers using all-inclusive packages still keep using travel agencies, as they like to have everything arranged, including meals and hotels, “under one roof.”

2.3 Summary

A brief overview of the Japanese domestic market was presented. The geographic character of Japan, major transportation policy changes, and deregulation were explained to understand their impact on the market. Afterwards, general parameters of the market were described to understand the market quantitatively, by comparing the parameters with the US market. In addition, internal components of the market, such as airlines, airports, and network structures were introduced.

Chapter 3

Current Revenue Management Practice Employed

Revenue management, which consists of two components - differential pricing and yield management -, has been proven to be an effective strategy to increase revenue in a deregulated market. After completion of the deregulation process in 2000, Japanese airlines have been introducing revenue management to the Japanese domestic market gradually, using slightly differentiated fare products, as well as yield management based mainly on the experience and knowledge of the staff in the sales department. However, since a significant amount of group passengers are using package tours in the Japanese domestic market, identifying current revenue management practices that target passengers, including not only individual but also group passengers, is important to simulate the impact of revenue management.

In this chapter, current fare structures as well as yield management for individual and group passengers are reviewed. First, the differential pricing structure employed is described, and categorized with passenger segments. After that, the current practice of yield management is explained using examples.

3.1 Differential Pricing

Fares can be classified into two types. The first type is referred to as published fares, which appear in the timetable, and passengers can buy tickets at those fares. The second type is called unpublished fares, which are exclusively used for package tours and passengers cannot purchase tickets at those fares.¹⁵

¹⁵ It is prohibited by contract between travel agents and airlines for agents to sell tickets to their customers at unpublished fares, but some agents are in breach of contract and sell tickets as Air-Only tickets.

3.1.1 Published Fares

Table 3-1 shows the typical current pricing structure used at an airline. In general, restrictions applied to low fare products are less strict than products in the United States, so that such restrictions are not effective enough to block high willingness-to-pay passengers from using low fare products. A detailed explanation for each price is described below:

Table 3-1 Typology of published fare products, spring 2001

Fare Product	Restrictions on Purchase and/or Use	Approx. Price (% of Coach)
Super seat fare	None	Coach Fare + JPY3,200
Full coach fare	None	100%
Round-trip fare	Round-trip purchase required. Trip must be done within 90 days.	77-86%
Repeat fares	Multiple tickets for a route purchase required.	63-73%
Special flight fare	Applied for specific flights. Purchase until a day before departure. Non-rescheduling, cancellation/refund penalties. Limited seats.	47-86%
Advance purchase fare	21-60 day advance purchase required. Non-rescheduling, cancellation/refund penalties. Limited seats	50-75%
Bargain fare	Applied for all flights in specific period. 54-60 day advance purchase required. Non-rescheduling. Heavy cancellation /refund penalties. No seat limitation.	JPY 10,000 for all flights, which is approx. 21-50%
Other fares	Age, Physical condition.	45-63%

① Super seat fare and Full coach fare – Those fare products are targeted at both time-sensitive and insensitive to price passengers. Super seat fare is similar to business class fare in international flights, distinguished by services they receive from the airline. For example, super seat passengers check in at a special counter at the airport, and wider seats are provided together with hot meals and beverages. Full coach fare varies by season, and fixed amount of JPY 2,000 is added to all fares in high peak season. As all discounted fares described below are based on full coach fare, they also have seasonality.

② Round trip fare and Repeat fares – These types of fare products are targeted at both time-sensitive and price-sensitive passengers. Round trip fare is a traditional discount fare product and it existed even before deregulation. Repeat fare product category is especially targeted at business passengers who travel the same route frequently. In order to qualify for this fare product, passengers must buy four to six tickets at a time, and use those tickets within 90 days. This fare

product is non-transferable, otherwise it could be used as a discount ticket, but a new Repeat fare that is transferable has been introduced to stimulate group passenger demand.

③ Special flight fare – This fare product is targeted at price-sensitive and time-insensitive passengers, and it is applied to most flights in off-peak season, but to a limited number of flights in peak-season. The discount rate per each flight depends on the demand of the day, week, and year. For example, a high discount rate is applied to flights departing early in the morning or late in the evening, and discount rate for weekend flight is higher than the rate for weekday flights. The discount rate varies within a flight depending on the seasonality. For example, for the Tokyo (TYO) – Sapporo (SPK) route, a special flight fare is applied to all 28 flights with 64-71% of full coach fare during off peak period, but it is applied to 8 flights with reduced discount rate of 60-73% of full coach fare during high peak period.

④ Advance purchase fare – Like the special flight fare, this fare product is also targeted at price-sensitive but time-insensitive passengers. In addition, passengers who qualify for this fare product must fix their schedule, as this fare product requires 21-60 day advance purchase. Consequently, it is likely that leisure passengers can purchase tickets with this fare.

⑤ Bargain fare – This type of fare product is a sharply discounted fare and a flat JPY 10,000 fare is applied to every flight operating within a specific very low demand period. In order to make this product more attractive, no seat limitation is applied. However, a 54-60 day advance purchase is required, and 5,000 JPY, half of the fare, is charged as a cancellation penalty. As a result, passengers who can plan out their schedule are able to purchase tickets with this fare product.

⑥ Other fares- these types of fares are for specific passenger types, such as senior citizens, children under 12 years, and disabled passengers.

3.1.2 Unpublished Fares

The most significant difference between published and unpublished fares is that the unpublished fare product is applied to tickets sold as a part of package tour organized by travel agents, so that passengers are unable to recognize the price of the tickets they bought. Table 3-2 shows the unpublished fare structure used in an airline. Detailed explanation for each fare product is described below:

Table 3-2 Typology of unpublished fare products, spring 2001

Fare Product	Restrictions on Purchase and/or Use
Individual Inclusive Tour (IIT) Fare	<ul style="list-style-type: none"> → 1 minimum night stay at destination required → 1 to 4 passengers required → 14-365day advance reservation required → 14-60 day advance purchase required → Non rescheduling, non transferable, cancellation charge
Inclusive Tour (IT) Fare	<ul style="list-style-type: none"> → 1 minimum night stay at destination required → More than 5 passengers required → 14-365 day advance reservation required → 14-60 day advance purchase required → Non rescheduling, cancellation charge
Group Tour (GT) Fare	<ul style="list-style-type: none"> → More than 15 passengers required → 21-365 day advance reservation required → 21-60 day advance purchase required → Non rescheduling, cancellation charge

① Individual Inclusive Tour (IIT) Fare – As is recognized by its name, this fare product is applied to the package tour designed to meet diversified demands. In fact, 30% of passengers using package tours use this fare product, as they have a desire for more flexibility to the content of the package, such as the choice for hotels, meals, and schedule. Business passengers who need to stay at a specific destination anyway can use this fare product, but the advance purchase restriction that limits the flexibility of schedule prevents diverting business passengers from using this products.

This fare product is set with a range for each route, and the range changes depending on the seasonality. The fare is negotiated between the airline and the travel agent based on some parameters, such as:

- Individual passenger demand for the flight – The fare is set close to its minimum level for the package tour using low individual passenger demand flights, as airlines cannot induce demand unless they provide a low fare product to travel agents to encourage them to make discount package tours. On the other hand, a fare is set to its maximum level for a high individual passenger demand flight, as there is no need for airline to induce demand by providing a low fare product to travel agents.
- Capability of travel agents – The fare is set low for package tours assembled by nationwide travel agents that are capable of selling their products to a large number of customers. On the other hand, the fare is set high for small travel agents.

The negotiation takes place approximately six months before the package tour goes on the market, and no further negotiation is made except if actual demand is much lower than forecasted. In addition to the characteristics described above, IIT fare is reduced for multiple stop flights.

② Inclusive Tour (IT) Fare – This fare product is for package tours for which a travel agent needs more than 5 passengers to start off. Together with the advance purchase restriction, this restriction makes it difficult for individual passengers to use this fare product. Despite such a restriction, 60% of passengers using a package tour utilize this product. Like IIT fare, it is set with a range for each route, and the range varies with seasonality. The fare for each package tour is decided through negotiation between the airline and travel agent based on parameters described in IIT fare, and set approximately six months before the travel agent starts selling the product, which is one to six months before departure.

③ Group Tour (GT) Fare – Unlike above products, this fare product is for a large group, such as group passengers going to attend big conference, students, military, teams for national sports festivals and so on. At least 15 passengers are requested to start off the tour with this fare product, and coach fare is applied if the group turns out to be less than 15 passengers. Since it is targeted at not only leisure passengers but also business passengers, no minimum stay is required. And because the schedule for such large group is rigid and set well before the departure, they tend to book earlier than other group passengers. Consequently, a 21-365 day advance purchase restriction is applied, and the higher fare is imposed. Dissimilar to the above products, only one price is set for these products, and set approximately six months before departure.

3.1.3 Relationship between demand segment and fare products

Successful differential pricing depends on ways to identify different demands, therefore it is important to relate each fare product to each demand segment to evaluate how current products differentiate demand¹⁶.

¹⁶ Since the objective of group passenger can be categorized as leisure, individual leisure and group passenger are merged here as leisure passenger demand, whereas individual business passenger is treated as business passenger demand.

One of the traditional segments, business passenger demand, is further divided into four types with price sensitivity and time sensitivity as shown in Figure 3-1.

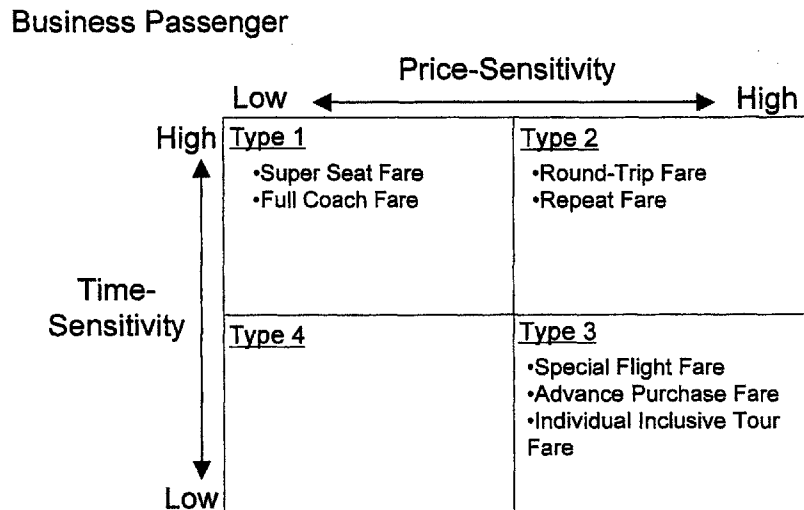


Figure 3-1 Business passenger demand and fare product relationship¹⁷

In this framework proposed by Belobaba, Type 1 passengers are insensitive to price but sensitive to schedule, so that Super Seat fare and other expensive prices shall be applied to such a demand. As type 2 passengers are sensitive to schedule but price sensitive, they purchase tickets with some restrictions not so difficult to achieve, such as Round-Trip and Repeat fares. With regards to type 3 passengers, they are flexible to adapt their schedule in order to buy discount tickets. They even may want to stay overnight to use an unpublished fare. Consequently, Special Flight fares, Advance Purchase fares, and Individual Inclusive Tour fares shall be applied to such passengers.

Another traditional segment, leisure passenger demand, is divided into four types according to size of group, price sensitivity, and association of travel agent as shown in Figure 3-2. Type 1 passengers are a small group, even individuals, and they are the least sensitive to the price among all leisure passengers who tend to be price sensitive. In addition, they don't need any assistance in planning their trip so that they can find accommodation, meals and so on. Visiting Friends and

¹⁷ Belobaba (1987), p. 25.

Relatives (VFR) passengers are included in this category. As a result, Bargain fare and Advance Purchase fare is applied to this category. Type 2 passengers are small group, but tend to be more price-sensitive than Type 1 passengers and need assistance of travel agents. Consequently, Individual Inclusive Tour Fare is applied to this category. Type 3 passengers are large group and price-sensitive, and the need the assistance of travel agents to arrange their trip. In this case, Inclusive Tour Fare matches this type of demand. Type 4 passengers are large group, and passengers attending conferences, and student groups attending national sports festivals are included this category. They don't always need to stay at their destination, so that the assistance of travel agents is somewhat less than the assistance needed for Type 3 passengers. However, they are less price-sensitive as their schedule is not flexible. For this type, Group Tour are is applied.

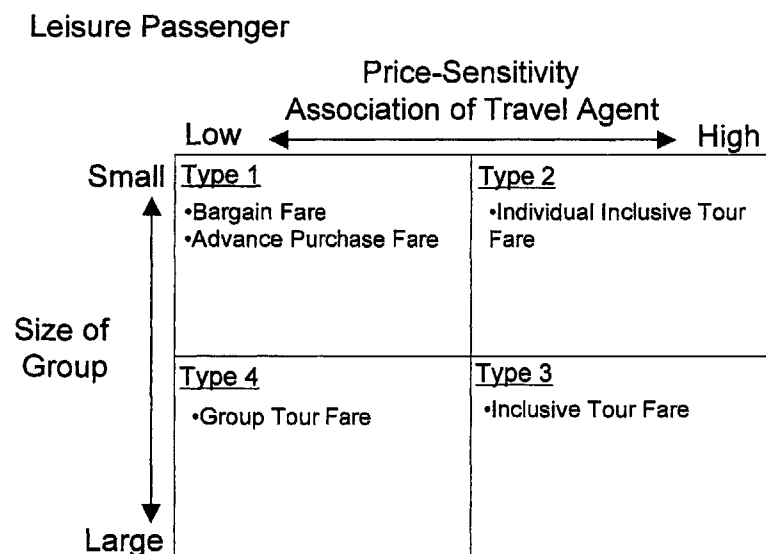


Figure 3-2 Leisure passenger demand and fare product relationship

3.2 Yield Management

In this section, the yield management employed in a typical Japanese airline is explained. General characteristics of current yield management are explained first, followed by some examples.

3.2.1 General characteristics of current yield management

Leg-based Control

As mentioned in the previous chapter, there are very few connecting passengers in the market due to the current characteristics of the market, such as short stage length, and no price difference between direct and connecting flights. Consequently, the seat inventory control is leg-based, in which the seat inventory allocation for each leg is independent of the seat inventory of other legs in their network.

Blocked seat allocation for individual and group passengers

Seat inventory for most flights is divided into two components, inventory for individual passengers buying tickets with published fare products, and inventory for group passengers buying tickets with unpublished fare products. The allocation for each inventory is based upon the demand forecast for each type of passenger. As a result, individual passengers whose yield is higher than group passengers may spill in the case where inventory for individual passengers is already full and there are no unused seats left in the group passenger inventory.

First Come First Serve Control

For published fare products, there is no seat limitation for low fare products unless it is a very high demand flight, so that there is no attempt to increase yield by limiting seats to low fare products. Also, due to the restriction applied, bookings with low fare products are made earlier than the bookings with high fare products. Consequently, given sufficient demand for low fares, it is unavoidable that low yield passengers displace high yield passengers. For unpublished fare products, it is also the case, and no seat limitation for low fare products is set unless passengers using GT fare, which is the highest among unpublished fare products, are likely to fill the allocated seats for unpublished fare products.

Judgment Based inventory Control

Revenue management department of Japanese airlines consists of a pricing group and seat inventory control group. The task of the pricing group is to set the price based on the demand forecast, and change prices as needed. The task for the seat inventory control group is to monitor

the booking trend for each route and make any changes for the allocation of capacity to each fare class. A support tool to calculate forecasted demand is provided, but group members are also using their knowledge and experience to make their decisions.

Manual overbooking control

Overbooking control is made manually, and based on past no-show data for the same month and same day of the week of the previous year, and recent no-show history. In addition, other parameters such as go-show passengers, characteristics of the route, and types of passengers are taken into consideration.

3.2.2 Explanation of each yield management component

Based on the general characteristics shown above, each component of yield management is described.

Demand forecast

Demand forecast is carried out every half a year for all flights. Demand for individual passengers are forecasted, and it is used to decide how many seats shall be allocated to individual passengers. Allocation for group passengers is set as the remainder of the capacity. The actual number of boarding passengers is forecasted, and the number of no-show passengers forecasted is added to calculate the final bookings. Based on the final bookings, a booking curve for each flight is decided, and is used to monitor the reservation status. If the actual number of bookings is over/under the forecasted bookings, analysts adjust the number of allocated seats for individual passengers manually. The following data for the previous year is required:

- Reservation data per month, route and fare class
- Economic index, such as GDP (Gross Domestic Product), CPI (Consumer Price Index)
- Price seasonality
- Full coach fare
- Super Seat Fare
- High Peak Period

Overbooking Control

As described, overbooking control at Japanese airlines rely on the judgment of human analysts to set the overbooking level, based on market experience and past no-show data. And due to a lack of manpower, overbooking control is limited only to inventory allocated for individual passengers, and for high demand flights. In case oversell occurs for group passengers, then some group passengers are removed to adjust the inventory, and put into non-direct flights or low demand flights close to the flight, or other flights that origin or destination is close to such flight¹⁸.

Basically, the authorized capacity is calculated as (authorized capacity)=(forecasted demand for individual passenger onboard)+(forecasted number of no-show passengers), but other factors are taken into consideration to decide the authorized capacity. Such factors are listed below:

- *Forecasted number of go-show passengers.* The number of go-show passengers is forecasted using data for last month, week, and so on. Especially, number of go-show passengers tends to be large for a high demand flight and huge in a peak period, so that authorized capacity must be reduced to reflect such passengers.
- *Possible alternatives if overbooked.* It will be a disaster for passengers who are denied boarding in the case where the flight is the last of the day and there is no alternative including taking the flight of another airline. In fact, such flights have a high no-show rate as business passengers tend to use them and they are flexible to the schedule, but analysts shall pay special attention to set authorized capacity for such flights.
- *Type of passengers booked.* By checking the Passenger Name Record (PNR) that contains the attributes of each passenger, analysts can adjust the forecast. For example, VFR passengers are less likely to be no-show passengers, as they mostly buy discount tickets that have a penalty for cancellation.

Seat Inventory Control

Figure 3-3 illustrates seat inventory control briefly. And before entering further detail, the aggregate of published and unpublished fares with control class is presented as Table 3-3.

¹⁸ Due to such a change of itinerary, a firm itinerary is not provided to passengers well in advance, but close to the departure date.

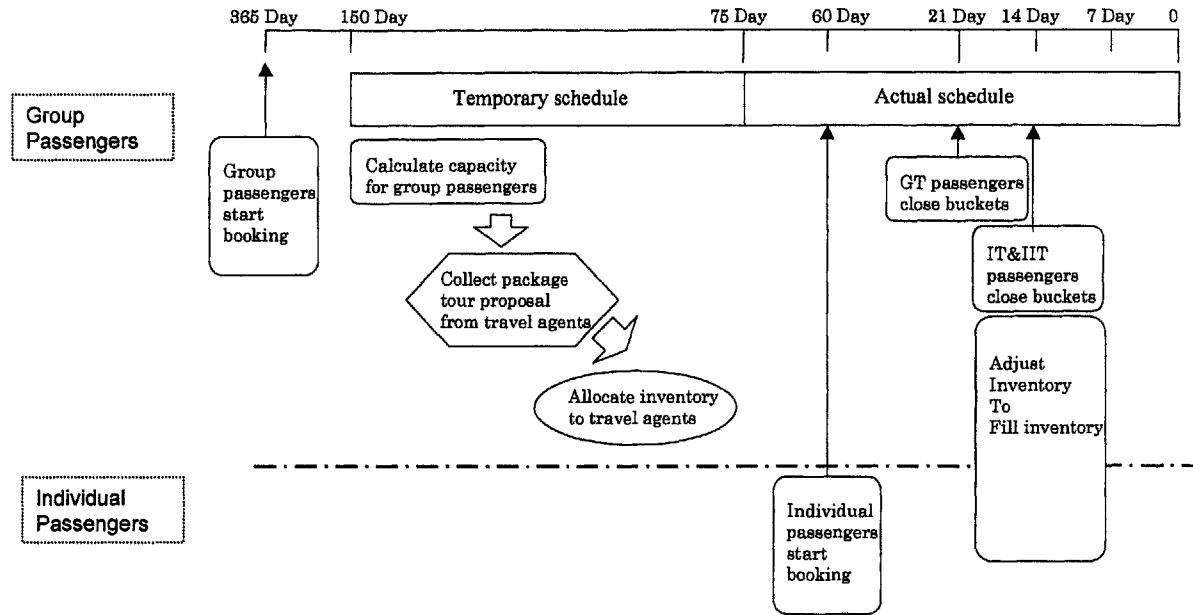


Figure 3-3 Seat Inventory Control

Table 3-3 Fare class table

Compartment Class	Control Class	Booking Class	Fare Class Code	Description	
S	#1	S	OW WT	One-way fare Round-Trip fare	
Y	#1	Y	OW	One-way fare	
			WT	Round-Trip fare	
			RP4	Repeat 4 fare	
			RP6	Repeat 6 fare	
			WR6	Wide Repeat fare	
			WE4	Weekend Repeat fare	
			OTH	Other fares	
	B W E X P J			OTH	Senior citizen fare
				TW	Special Flight fare
				AP21	Advance Purchase fare
#5	G M		GT	Group Tour fare	
			IT5	Inclusive Tour fare	
#6	I T U		IIT	Individual Inclusive Tour fare	
			IIT-2	IIT-2	
			IIT-3	IIT-3	

Detailed explanation for each column is described below:

- *Compartment Class.* It represents the distinct physical compartments on board the aircraft. S stands for Superseat Class cabin, which is a first class cabin. And Y stands for coach class cabin.
- *Control Class.* It represents the attributes of the passengers included. And booking limit is set to each control class. #1 represents the control class for individual passengers, and #5 and #6 are for group passengers. #2 to #4 are not used. And among group passengers, large groups are included in #5, and the rest is included in #6. For example, we have 288 seats in B767 coach cabin, and 200 seats are allocated to #1 class, and the rest of 40 seats are allocated to #5 and the rest of 48 seats are allocated to #6. Detailed explanation about allocation will be presented later.
- *Booking class.* It shall represent the group of fare products, which shall be nested and has a common booking limit.
- *Fare class code, description, and price.*

- Fare class code for Super Seat Class. There are 2 fare class codes in Super Seat Class.
- Fare class code for Coach Class. Most of the fares have been explained, but additional comments are made for better understanding.

Repeat fares, which are fares for multiple tickets for a route, are RP4, RP6, WR6, and WE4. The first two types, RP4 and RP6 are almost the same, but the number of tickets required to purchase is four and six, respectively. In addition, RP4 is not transferable, but RP6 is transferable so that small groups can use this RP6 fare. As for WR6 fare, it is designed for an open-jaw trip and it is transferable. And WE4 is limited for weekend use. With regards to the fare class code OTH in Y booking class, it includes various types of fares such as fares for children, disabled passengers and so on. P class is for mileage-rewarded passengers so that the price is zero, and J class is for internal use. P and J class are the only exceptions in that they have a booking limit.

- Fares for group passengers. They are included in Control Class #5 and #6, and some of the fare products have a range. Fares with a range, which is applied to travel packages, might be set close to the lower bound, in case:
 - Such a travel package is for a low demand flight, so that the air fare shall be set low to stimulate price sensitive passengers

- Airlines can expect a large number of passengers to use such travel packages so that they make some kind of volume discount on their airfare
- Competition among airlines for the route is tough and travel agents have a priority to choose airlines, so that airlines are forced to set their airfare as low as possible to compete

On the contrary, IT Fare applied to a travel package might be set close to the upper bound in the case where:

- Such a travel package has to use a high demand flight, so that airlines can set a high price
- An airline takes a dominant position in a specific market, so that the airline can control the price

Using the fare table described, two examples are presented to understand the current seat inventory control.

Example 1 - Flight expected to be filled by individual passengers

Flight 243, departing from Tokyo at 7:50 AM, and arriving at Fukuoka, a major local city in western Japan, at 9:35 AM, is popular among business passengers for its convenient schedule, and it keeps a high load factor filled with individual passengers. Since it is no use to allocate some seats of this flight to low yield group passengers, as it might lead to a displacement of high yield business passengers, no seat inventory allocation is made for group passengers for this flight. However, if there is a need from travel agents to use this flight for group passengers, then the seat controller within the revenue management staff can keep those group passengers' booking unconfirmed and monitor the actual bookings for this flight. If the demand for individual passengers is not so high as expected, then the group passengers' booking is confirmed. Table 3-4 shows the seat inventory control table for Flight 243 Y compartment class, at 8 days before departure.

Table 3-4 F243 Y compartment class, 8days before departure

FLT#	ETD	A/C	CAP	C/C	TBD	MAX	BKD	OPN	WL	BC
243	750A	B767	288	#1	288	290	150	140	0	YBWPJ
				#5	0	0	0	0	0	MG
				#6	0	0	28	-28	0	ITU

B767 is used for this flight, and its capacity is 288. TBD is a parameter to decide the number of seats allocated to each Control Class(C/C). In this case, analysts decided to allocate all seats to individual passengers, so that TBD for #1 is 288, while TBD for #5 and #6 are zero. And MAX is a parameter to decide the capacity allowed to accept reservation to each class¹⁹. No-show rate is applied, and MAX is set to 290 in this case. MAX is set manually based on analyst's experience and parameters such as no-show rate, go-show rate and so on, and it can be changed if the actual number of bookings is higher or lower than expected.

BKD is the actual number of reservations in each inventory, and 150 seats are reserved for #1 and 28 for #6, meaning that 28 group passengers shall be accommodated on this flight. And they are confirmed now since current bookings for individual passengers are much lower than the forecasted figure that is 180, therefore 28 group passengers can be used to fill the gap between the forecast and actual demand. OPN shows unused capacity, so that it is 140 for #1 and -28 for #6, as no seat is allocated for #6 initially. However, the sum of OPN for each class shall not be less than zero, so that OPN for #1 should not be less than 28 since such seats are already provided to group passengers. WL shows the number of waitlisted passengers, and it is applied only for individual passengers. And BC shows the booking class used for this flight. The analyst keeps monitoring the reservation status for this flight until a day before departure, and transfers more inventory from individual passengers to group passengers if it becomes obvious that the demand forecast is overestimated, and if there is a need to allocate some seats for group passengers. The analyst must attend to the load factor of the flight, not the revenue gained from the flight, so that analyst pays little attention to the passenger mix.

Example 2 – Flight expected to have some group as well as individual passengers

¹⁹ The use of MAX for group passengers is different from individual passengers and it is explained in the following examples.

Flight 247, departing from Tokyo at 9:40 AM and arriving at Fukuoka at 11:25 AM, is less attractive to business passengers than Flight 243 in Example 1, so that analyst for this flight needs to provide seats to group passengers to increase load factor.

150 to 60 days before departure

Table 3-5 Seat inventory control table for Flight247, at 150 days before departure

FLT#	ETD	A/C	CAP	C/C	TBD	MAX	BKD	OPN	WL	BC
247	940A	B767	288	#1	200	200	0	200	0	YBWPJ
				#5	0	0	0	0	0	MG
				#6	88	88	0	88	0	ITU

During this period, what the analyst does first is to decide how many seats she shall keep for individual passengers. The physical capacity for Flight 247 is 288 as B767 is also used for this flight, and the analyst set the TBD for #1 as 200, based on the demand forecast and her past experience²⁰.

Since there is low individual passenger demand forecasted for this flight, the remaining 88 seats are allocated to group passengers. In order to fill 88 seats, the airline asked travel agents to create travel packages that make use of the flight. Three travel agents responded with travel packages, and the result is shown in Table 3-6.

Table 3-6 Travel packages applied to Flight 247

Name of company	Name of travel package	Number of passengers using travel package, estimated by travel agent	Utilization Rate (%)	Expected number of passengers onboard
Japan Tourist	Let's go to Fukuoka!!	80	30	24
All Nippon Travel	Gourmet in Fukuoka	30	60	18
	Spa in Fukuoka	40	25	10
Tokyo Travel	Historic Fukuoka	40	20	8
TTL		190		60

²⁰ It is calculated as deterministic.

Among three agents, Japan Tourist created a travel package and claim the package can attract 80 passengers. However, the utilization rate of this tourist, which is calculated as (Expected number of passengers onboard) / (Number of passengers using travel package estimated by travel agent) by using historical data, is 30%, so the analyst calculated the expected number of passengers onboard as 24. As for All Nippon Travel, they proposed two travel packages and the analyst uses a considerably higher utilization rate of 60% for the first package, since the ‘Gourmet in Fukuoka’ package is popular among travelers. Another package, ‘Spa in Fukuoka’ is newly created, so that the analyst set a relatively low 25% utilization rate for the package. The last one, Tokyo Travel, is a small company and less reliable, so the utilization rate for this company is set low as 30%. As a result, the total of expected number of passengers onboard is 60, so that 28 seats remained unused.

Based on the results shown in Table 3-6, and in order to show the example of a seat inventory control table within this time frame, Table 3-7 represents the seat inventory control table for Flight 247 Y compartment class, at 80 days before departure, right after the analyst input the result of Table 3-6 into a seat inventory control.

Table 3-7 Seat inventory control table for F247, at 80 days before departure

FLT#	ETD	A/C	CAP	C/C	TBD	MAX	BKD	OPN	WL	BC
247	940A	B767	288	#1	200	203	0	203	0	YBWPJ
				#5	0	0	15	-15	0	MG
				#6	88	218	190	28	0	ITU

Again, the TBD for #1 is set as 200, so that the remaining 88 seats are allocated to #6. Since #5 is a control class for big groups that tend to be ad-hoc²¹, all remaining seats are allocated to #6. And MAX for #1 is set as 203, meaning that they might have 3 no-show passengers. The MAX for #6 is set as 218, which is the sum of 190 package travelers and 28 remaining unused seats, to show the maximum number of reservations²². As for BKD, since the reservation for individual

²¹ For example, a large school excursion group is allocated to #5 class. And such large groups tend to book earlier, more than 150 days before departure and cancellation is rare, so that if a large group has made a booking then the number of bookings is deducted from the TBD of #6. In this case, if a large group makes 40 bookings, then 48 seats are allocated to TBD of #6 and travel agents share those seats accordingly.

²² It seems strange to display 218 since we will not have such huge number of bookings, but it is required as it is used to show OPN seats that are unused.

passengers starts 60 days before departure, there are no bookings in #1. As for #5, 15 bookings are made already, and confirmed. The total for #6 is 190, as travel agents claimed they would book 190 passengers on this flight. However, BKD for #6 at this time is defined as pseudo bookings, as no actual passenger is confirmed, and the final number of BKD is confirmed 14 days before departure. OPN for #1 is 203 since there is no booking, and it is -15 for #5 as MAX value is zero. For #6, the total set at 28, calculated as (218-190), meaning that there are 28 seats unused. However, since 15 seats are used to accommodate group passengers in #5 class, the actual number unused is 13 in this case.

60 to 15 days before departure

Reservations for individual passengers commence 60 days before departure so that the analyst monitors both individual passenger and group passengers booking status. As the departure date draws near, Table 3-6 is revised to reflect the latest status. Table 3-8 shows the latest booking status for travel packages at 30 days before departure.

Table 3-8 Travel packages applied to Flight 247, at 30 days before departure

Name of company	Name of travel package	Number of passengers using travel package, estimated by travel agent	Actual number of passengers booked	Number of bookings reported to the airline
Japan Tourist	Let's go to Fukuoka!!	80	10	80
All Nippon Travel	Gourmet in Fukuoka	30	32	32
	Spa in Fukuoka	40	5	40
Tokyo Travel	Historic Fukuoka	40	3	40
TTL		190	50	192

The first package, 'Let's go to Fukuoka!!' is less attractive than expected, and the actual number of passengers booked is 10. On the contrary, 'Gourmet in Fukuoka' is more attractive than expected, and actual number of passengers booked reached 32. As for the other travel packages, there are 5 and 3 passengers booked for 'Spa in Fukuoka' and 'Historic Fukuoka' respectively.

As a result, there are 50 confirmed bookings for group passengers. However, travel agents are not required to report accurate number of passengers booked until 14 days before departure, and because passengers booked might cancel their trip, they rarely report the actual number of bookings. But if the total number of bookings is more than estimated, then travel agents report the actual number (or more) to obtain more seats for the travel package. In this case, All Nippon Travel reported the actual number of passengers booked as 32, so that the total number of bookings reflected to seat inventory control table, changed from 190 to 192. Consequently, the seat inventory control table shown in Table 3-7 is updated as Table 3-9.

Table 3-9 Seat inventory control table, at 30 days before departure

FLT#	ETD	A/C	CAP	C/C	TBD	MAX	BKD	OPN	WL	BC
247	940A	B767	288	#1	200	203	100	103	0	YBWPJ
				#5	0	0	15	-15	0	MG
				#6	88	218	192	26	0	ITU

In this case, BKD for #1 is changed to 100 since reservations for individual passengers have started, so that the OPN is 103, meaning that 103 reservations can be accepted. And there is no change for #5. As for #6, BKD is 192 as explained, and the OPN is now 26, meaning that 2 seats are used to accommodate passengers who booked the ‘Gourmet in Fukuoka’ package.

14 days to 1 day before departure

At 14 days before departure, all travel agents must report the actual number of passengers by sending all names of passengers booked to airline. The final status for each travel packages is shown in Table 3-10.

Table 3-10 Travel packages applied to Flight 247, at 14 days before departure

Name of company	Name of travel package	Number of passengers using travel package, estimated by travel agent	Actual number of passengers booked	Number of bookings reported to the airline
Japan Tourist	Let's go to Fukuoka!!	80	22	22
All Nippon Travel	Gourmet in Fukuoka	30	32	32
	Spa in Fukuoka	40	5	5
Tokyo Travel	Historic Fukuoka	40	3	3
TTL		190	62	62

And this number of bookings is applied to the seat inventory control table as shown in Table 3-11.

Table 3-11 Seat inventory control table, at 14 days before departure

FLT#	ETD	A/C	CAP	C/C	TBD	MAX	BKD	OPN	WL	BC
247	940A	B767	288	#1	200	203	180	23	0	YBWPJ
				#5	0	0	15	-15	0	MG
				#6	88	88	62	26	0	ITU

At 14 days before departure, MAX for #6 is changed as TBD=MAX, and BKD is changed to 62. As a result, OPN for #6 is 26, meaning that there are 26 seats unused for #6 inventory. However, since 15 seats are used for #5 passengers, 11 seats remained unused. Such seats can be used as follows:

- A buffer to absorb spilled individual passengers, if individual passenger demand is more than forecasted.
- A buffer to absorb spilled group passengers from other flights on the same route.

Until a day before departure, the analyst works with colleagues to exchange information with regards to the unused seats, and tries to fill the cabin by allocating spilled passengers to other flights.

3.3 Summary

A brief overview of revenue management practice employed was presented. Seemingly, current practice requires a lot of manpower and experience to maintain and to react to uncertainties. However, we might have a certain amount of revenue loss caused by an inaccurate forecast of the demand, utilization rate, and it is of critical importance for Japanese airlines to incorporate scientific, not judgment based Revenue Management methods.

Chapter 4

Literature Review

In this chapter, a brief literature review of the past research with regards to revenue management and group bookings is presented. In the first section, a review of revenue management is presented with past research. Since we mainly focus on leg based revenue management, the EMSR (Expected Marginal Seat Revenue) method is explained in some detail.

In the second section, the business process of handling group bookings is presented with an explanation of stakeholders involved, such as travel agents and so on. Subsequently, past research for group bookings is reviewed briefly.

4.1 Revenue Management

In this section, the brief history of two major components of the revenue management, price differentiation and yield management, are described respectively. In each section, a brief review of past research is presented. Especially, current seat inventory control, EMSRb is explained in detail as it is widely used. And since there are few connecting passengers in the Japanese Domestic Market, traffic flow (O-D) control is reviewed in a nutshell. Readers are advised to refer to Belobaba (1998) for further detail, and past research such as Wei (1997), Bratu (1998) for an exhaustive review of O-D control.

4.1.1 Price Differentiation

Background

Before the 1970s, the fare structure for a route was simple, and was based on the distance between the pair of cities that the route connected, and the operating cost. Fares distinguished by compartment, such as first class fare and tourist (economy) class fare were the only choices in

those days. However, the excess capacity caused by the introduction of wide body aircraft in the 1960s, and the evolution of chartered flights with low fares, encouraged airlines to change their fare structure. Scheduled airlines introduced peak and off peak prices to change fares linked to the demand, and started to implement discounted fares with restrictions, such as excursion fares, group inclusive tour fares, and affinity/incentive group fares²³. Another example of discount fares is preferential fares, which are available only to passengers who meet certain requirements in terms of age (children, senior citizen discount), family kinship (spouse discount), and occupation (military, seamen discount)²⁴. However, such fares could be applied only to passengers who met those criteria, and the possibility of dilution, which passengers willing to pay higher fares would move to lower fares, was low.

In the 1970s, a new fare called APEX (Advance Purchase Excursion) was introduced to the international market, and it enabled passengers, who do not qualify for above the fares, to purchase discount tickets. Despite restrictions, such as minimum length of stay and required purchase of a round trip, almost one third of passengers used APEX in 1979. In the US domestic market, a similar type of fare was introduced in 1975²⁵, which led to a rapid spread of multiple fare options, which is now called differential pricing. Nowadays, such differential pricing is widely used among deregulated markets, and it is common that each passenger sitting in the same compartment class pays a different fare.

Concept of differential pricing

Figure 4-1 illustrates the relationship between cost, price and demand for a particular flight, in which all seats are used as a single class with single fare, and the capacity of the aircraft is 100. We might assume that it represents the typical airline under regulation in the 1960s, where no competition with regards to price takes place.

²³ Hasegawa (1997), pp. 49-57.

²⁴ Doganis (1991), p. 297.

²⁵ Supersaver fares, introduced by American Airlines. For detailed story about the birth of the fare, refer to Cross (1997), pp. 110-130.

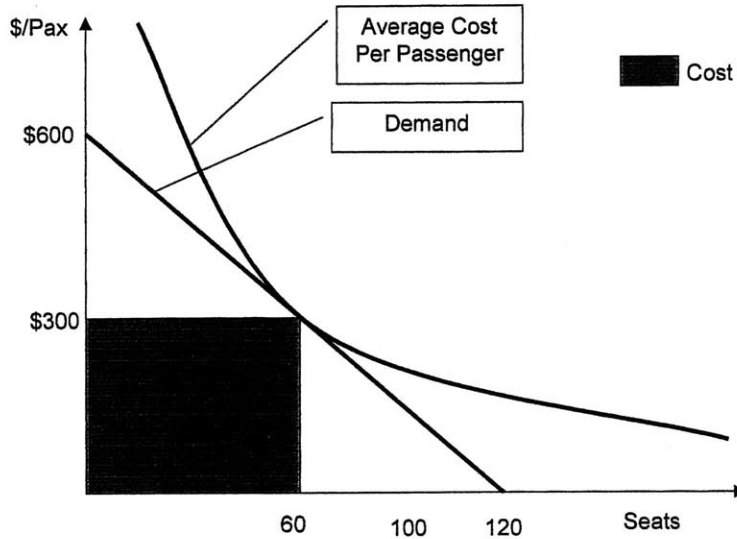


Figure 4-1 Base case

In this case, the cost curve meets the demand curve at 60, at cost of \$300; the total cost for this route is horizontally hatched area in Figure 4-1. The break-even point of this flight regarding the load factor is 60%. (Note that the airline cannot exceed its break-even point with a single fare, as the demand curve is always below the cost curve.)

However, after the deregulation, each airline can set fares freely. Figure 4-2 shows the relationship between cost and demand changes, but multiple fares are used.

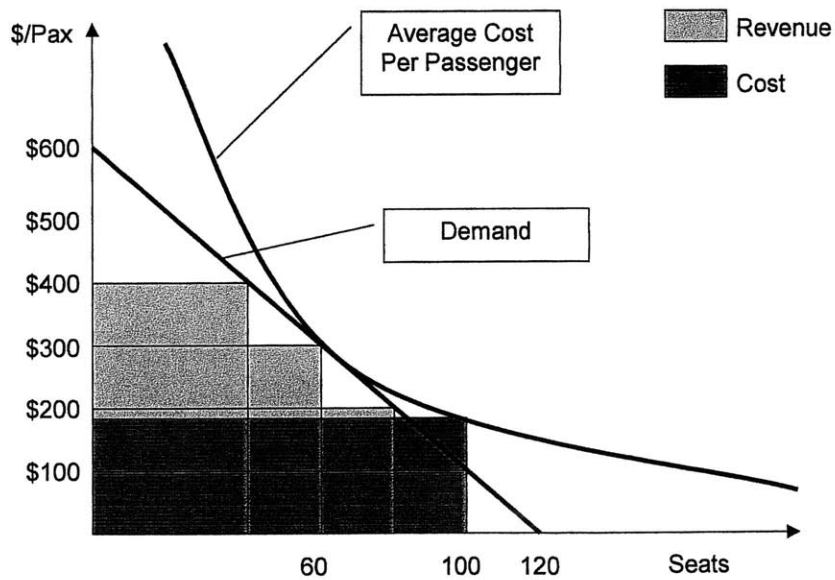


Figure 4-2 Differential pricing

In this case, revenue from a single price fare structure will not cover the total cost. Instead, adopting differential pricing, to set four types of fares varying from \$100 to \$400 in this case, the airline can cover total costs as well as make a profit if the total revenue (gray area in Figure 4-2) exceeds the total cost (vertically hatched area in Figure 4-2).

Differential pricing is admittedly the way to maximize the revenue with limited capacity, but most passengers try to purchase the tickets with the lowest price, regardless of their willingness-to-pay (WTP). Therefore, in order to prevent passengers for which WTP is high from using cheap tickets, airlines set fences between fares by adding restrictions to each fare. This practice is defined as product differentiation.

The most obvious example of this fare product differentiation is fares by compartment class: first class, business class, and economy class fares. In flight services, and additional ground services such as priority check-in and use of a lounge, are provided to higher fare classes to make a distinction between first, business and economy class. Such services can convince high WTP passengers to buy a more expensive ticket. However, product differentiation by in-flight service does not fit the case for differential pricing among the same compartment that we represented above. Instead, adding various penalties such as no refundability, cancellation, minimum stay conditions and so on, airlines are providing different products even within the same compartment class. Those attributes added are based upon the behavior of the two segments of passengers, business and leisure, mainly preventing business passengers from using lower fares. The WTP of business passengers is generally higher than that of leisure passengers, and they tend to book later than leisure passengers. Their trip plan is less flexible than that of others. Hence, in order to hamper business passengers from using cheaper tickets, airlines set advance purchase requirements, high cancellation charges and no refundability to those tickets.

As explained, differential pricing by product differentiation is one of the useful methods to increase revenue, but in order to maximize revenue, we need to properly allocate seat inventory to each fare class and try not having empty seats at the time of departure. To achieve this, we need to incorporate another important element of revenue management, yield management.

4.1.2 Yield Management

Background

Before Littlewood²⁶ presented his two-class seat allotment control model, almost all research for booking control focused on how to control overbooking. It is a reasonable way to increase revenue under a regulated market since airlines can do little to increase revenue when fares are controlled by government, but can increase load factor to gain more revenue.

In the 1970s, the introduction of multiple fare class, initially trying to increase load factors, changed the situation. The lower discount fares helped airlines to increase their load factor, but it did not link to the maximization of revenue. For example, revenue cannot be maximized where an airline sells every seat at lower fares and the load factor approaches 100%. The other example is where an airline sells every seat at higher fares, but the load factor drops and the revenue again cannot be maximized.

Hence, airlines turned their focus on not only increasing the load factor but also maximizing revenue by properly allocating seat inventory to each fare class. This practice, seat inventory control, interchangeably called yield management, is now widely used among many airlines in a deregulated environment. Table 4-1 shows how seat inventory control affects the revenue as a result.

²⁶ Littlewood (1972), Section 5.

Table 4-1 Seat inventory control approaches²⁷

Example: 2100 Mile flight leg

Capacity =200

Number of seats sold				
Fare Class	Average Revenue	Yield Emphasis	Load Factor Emphasis	Revenue Emphasis
Y	\$420	20	10	17
B	\$360	23	13	23
H	\$230	22	14	19
V	\$180	30	55	37
Q	\$120	15	68	40
Total Passengers		110	160	136
Load Factor		55%	80%	68%
Total Revenue		\$28,940	\$30,160	\$31,250
Average Fare		\$263	\$189	\$230
Yield (cents/RPM)		12.53	8.98	10.94

In this case, if we put too much emphasis on yield, then we will allocate as many seats as possible to the higher fare class, and limit the number of seats for lower fares. With this “Yield Emphasis” method, we could gain the highest yield, but achieve the lowest load factor and lowest total revenue. On the contrary, if we put too much emphasis on increasing load factor, the easiest way is to take as many requests for lower fares as possible and share the remaining inventory with the higher fare class. This “Load Factor Emphasis” method ended in the lowest yield, thus lower revenue, than when we put an emphasis on revenue. Hence, paying attention not only to yield but also load factor is the best way to achieve the highest revenue.

“Tools” for yield management

For an effective use of yield management, we use three tools listed below²⁸:

→ *Overbooking.* As explained, the research on overbooking has a history of more than 20 years, and this practice now has become a standard part of tools used in yield management. The

²⁷ Belobaba (1992a), p. 145.

²⁸ Belobaba and Weatherford (2001), p. 3.

objective is to minimize the sum of costs that are incurred by denied boarding, and lost revenue (spoilage cost) caused by restricting overbooking.

→ *Fare Class Mix.* The objective of Fare Class Mix, equivalent to Seat Control, is to set the booking limit for each fare class in order to optimize the revenue. Various methods are developed, but Expected Seat Marginal Revenue methods, widely known as ESMR methods, are widely used among airlines.

→ *Traffic Flow (O-D) Control.* It is common for international routes and the U.S. domestic market that passengers use connecting flights from their Origin to Destination (O-D), so that we now have to think about how we allocate seat inventory of a single leg flight to local passengers (using single leg only for their O-D) and connecting passengers (using such a leg as a part of their itinerary). Greedy Virtual Nesting (GVN), Displacement Adjusted Virtual Nesting (DAVN), Deterministic LP Network Bid Price (Netbid), Heuristic Bid Price (HBP), and Prorated Bid Price (ProBP) are proposed as methods for O-D control.

4.1.3 Seat Inventory Control

Classification of Seat Inventory Control Problem

Seat inventory control problem can be classified as a distinct (partitioned) and nested fare class problem, and a static and dynamic problem. Readers are directed to refer Belobaba²⁹ for further detail.

An easily understandable example of distinct fare class is a compartment fare class, in which the fare is categorized by compartment. The capacity of aircraft is physically separated into first, business and economy class, so that first class seats are sold to passengers who paid first class fares, or remain unsold and possibly be used for upgraded passengers as a result of overbooking of lower class seats or awards for FFP (Frequent Flyers Program).

²⁹ Belobaba (1987), Chapter 4.

However, it is not crystal clear which distinct fare class is applied to the same compartment class. The capacity of each distinct class, once visible by compartment fare class, can be identified only on CRS (Computer Reservation System) screen. The booking limit for each distinct class is fixed based on the forecast for each fare class, and once a seat is allocated to that class, it can be sold or remain unused. However, due to the stochastic nature of demand, it is difficult to make a precise forecast to decide the booking limit. Consequently, it is inevitable that an inaccurate forecast for each fare class can cause a loss of revenue.

Conversely, a nested fare class is structured such that a higher fare request is accepted unless all seats are booked. The booking limit for each class is also set by forecast, but inaccuracy of the forecast for higher fare class can be recovered by relaxing the limit for such a class by nesting.

The other categorization is the static and dynamic problem. The static problem is that once a booking limit for each fare class is applied at the beginning of booking process, it will not change during the booking period. Similar to the problem for the distinct fare class, an inaccurate forecast used to determine the booking limit leads to a revenue loss.

On the contrary, the dynamic problem is that the booking limit can be changed as actual bookings are accepted. In this case, adjusting the booking limit can reduce the revenue loss incurred by an inaccurate forecast. Solving distinct fare class problem as a dynamic problem, and reviewing booking limit per request, can reduce the revenue loss, thus eliminating the advantage of a nested fare class.

Past Research (before EMSR)

Past Research made before 1987 can be classified as mathematical programming approach and decision rule approach. A brief review of each method is represented.

The mathematical programming approach makes use of equating marginal revenues of the last seat allocated to each inventory in determining the revenue maximizing seat allotments. In a two-fare class model, the problem is formulated as follows.

$$\bar{R} = \bar{R}_1(S_1) + \bar{R}_2(S_2) = \bar{R}_1(S_1) + \bar{R}_2(C - S_1) \quad (4.1)$$

Where

- \bar{R} : Total expected value
- \bar{R}_1 : Total expected value from fare class 1 with S_1
- \bar{R}_2 : Total expected value from fare class 1 with S_2
- C : Capacity for the aircraft
- S_1 : Seat allotment for fare class 1
- S_2 : Seat allotment for fare class 2

To find the maximum total expected value for \bar{R} , we need to find S_1 that satisfies

$$\frac{\partial \bar{R}}{\partial S_1} = 0 \quad (4.2)$$

s.t.

$$S_1 = C - S_2$$

Equation (4.2) has two meanings: that the marginal total expected value is zero, and the total expected flight revenues cannot be increased by taking a seat from class 1 and allocating it to class 2. Also, the expected marginal revenue of the last seat allocated to each class will be equal across two classes, expressed as

$$\frac{\partial \bar{R}}{\partial S_1} = \frac{\partial \bar{R}}{\partial S_2} \quad (4.3)$$

And it can be extended to a multiple fare classes structure such that

$$\frac{\partial \bar{R}}{\partial S_i} = \frac{\partial \bar{R}}{\partial S_j} = \lambda \quad (i \neq j) \quad (4.4)$$

Where λ is a Lagrangian multiplier³⁰.

There are several examples of research using the mathematical program of airline's system-wide seat inventory control problem, such as Glover et al (1982), but their major shortcomings are summarized in two points:

- Because of the size of the problem, it took time to solve, not interactive.
- Based on deterministic demand estimates for each fare class that no consideration of probabilistic demand or spill was included.

Some optimization approach, which incorporates probabilistic behavior of demand by introducing binary decision variables, is used for some research such as Wollmer (1985). However, drawbacks for such research are as follows:

- They need to run the optimization problem per each request to decide whether to accept the request, which is infeasible to practical application.
- They only produce non-nested allocation.

Conversely, the decision rule approach, using the 'marginal seat' concept, incorporates probabilistic demand and can be applied to nested allocation. Littlewood (1972) stated that revenues could be maximized by 'closing down' the lower fare class to additional booking when the certain revenue from selling another (marginal) seat to low-fare class is exceeded by the expected revenue from saving that seat for a potential high-fare passenger. Therefore, a seat can be sold to low-fare class passengers as long as

³⁰ From (4.2), it can be zero, but because of the capacity constraint, it is not necessary.

$$f_2 \geq f_1 \cdot \bar{P}_1(S_1) \quad (4.5)$$

Where

f_1 : Higher fare level

f_2 : Lower fare level

$\bar{P}_1(S_1)$: The probability of selling all S_1 remaining seats to high fare passengers (i.e. the probability of all remaining seats being filled with high fare passengers)

And the right-hand side of the formulation does represent the expected marginal seat revenue for fare class 1, since it is dominated by the probabilistic demand so that revenue gained can be inevitably 'expected' value, and it is a marginal 'revenue' obtained by additional ('marginal') 'seat' for class1 request.

This simple decision rule is extended by several cases of research. Bhatia and Parekh (1973) described another expression of Littlewood's rule, as

$$f_2 \geq f_1 \cdot \int_{C-S_2}^{\infty} p_1(r_1) dr_1 \quad 0 \leq S_2^* \leq C \quad (4.6)$$

Where

$p_1(r_1)$: Probability density of reservation request for class 1

Richter (1982) proposed the differential revenue concept, which is the loss in total expected revenue when low-fare passengers ultimately deny space to higher-fare passengers. The differential revenue, denoted as DR, from allocating an additional seat to a low-fare passenger is a difference between additional (marginal) revenue from low-fare passenger and revenue lost from a prospective high fare passenger, defined as

$$DR = f_2 \cdot \bar{P}_2(S_2) - f_1 \cdot \bar{P}_1(C - S_2 + 1) \quad (4.7)$$

Expected marginal seat revenue for fare class 2 and fare class 1, represented in the first and second term of the right-hand side of the equation, respectively, are equal at DR=0, so that the optimal value of S_2 must satisfy

$$\frac{f_1}{f_2} = \frac{\overline{P}_2(S_2)}{\overline{P}_1(C - S_2 + 1)} \quad (4.8)$$

This model is actually a distinct fare classes optimal model to set the booking limit for each class independently, but Richter demonstrated that the optimal limit on the lower fare class in a dynamic application is a function of relative fare levels, total capacity, and the demand for the high-fare class only. Therefore, for dynamic application, (4.8) is revised as

$$\frac{f_2}{f_1} = \overline{P}_1(C - S_2 + 1) \quad (4.9)$$

which is equivalent to Littlewood's decision rule. The conclusion that the density of low-fare demand will not affect the optimal number of seats to be allocated to the higher fare class is important in the nested fare class.

To summarize, mathematical programming and the network solution model has been applied to multiple fare classes, flight legs, and passenger itineraries, but due to the lack of its ability to handle probabilistic demand and the need for long processing time makes it impractical to use. On the contrary, the marginal seat concept has succeeded in incorporating probabilistic demand explicitly into the seat inventory revenue management. However, since this concept applied to multiple fare classes has not addressed the nested fare classes problem, Belobaba (1987) formulated EMSR³¹ approach that can be applied to multiple fare classes on a single flight leg, in a nested reservation system, which is described in the next section.

Expected Marginal Seat Revenue –Two fare class case

³¹ For distinction, the EMSR method in 1987 is called EMSRa, and the modified EMSR by Belobaba (1992b) is called EMSRb.

In this approach, demand is treated as probabilistic, which is central to the airline seat inventory problem. And some assumptions are applied such as demand densities for different fare classes are not correlated, the number of requests received for the different classes are not correlated, and total demand is assumed to be a Gaussian.

The Probability Distribution Function (PDF) for the total demand for fare class i , is defined as $p_i(r_i)$, r_i as the number of requests for reservation by the close of booking process. This PDF is derived from historical data for the same or similar flights, and assumed to be valid during the booking period.

Using $p_i(r_i)$, the Cumulative Density Function (CDF), $P_i(S_i)$, that all requests will be accepted for a fare with the number of seats allocated to such fare class i , S_i , is defined as

$$P_i(S_i) = \int_0^{S_i} p_i(r_i) dr_i \quad (4.10)$$

The average of the expected number of total bookings in fare class i , $\bar{b}_i(S_i)$ is then described using complementary event of $P_i(S_i)$, $\bar{P}_i(S_i)$, as follows:

$$\bar{b}_i(S_i) = \int_0^{S_i} r_i \cdot p_i(r_i) dr_i + S_i \cdot \bar{P}_i(S_i) \quad (4.11)$$

Therefore, using $\bar{b}_i(S_i)$, the expected revenue obtained from each fare class, \bar{R}_i is defined as

$$\bar{R}_i = f_i \cdot \bar{b}_i(S_i) \quad (4.12)$$

Where f_i is the average fare for fare class i . Consequently, the aggregate of \bar{R}_i , \bar{R} , is described as follows:

$$\bar{R} = \sum_i \bar{R}_i = \sum_i f_i \cdot \bar{b}_i(S_i) \quad (4.13)$$

In order to maximize the expected total revenue \bar{R} , we need to find the integer value of S_i , subject to the capacity constraint of

$$\sum_i S_i = C \quad (4.14)$$

Where C is the total capacity allocated over the fare classes in the same compartment.

The equation (4.13) is applied to (4.1) as

$$\begin{aligned} \bar{R} &= \bar{R}_1(S_1) + \bar{R}_2(S_2) \\ &= f_1 \cdot \bar{b}_1(S_1) + f_2 \cdot \bar{b}_2(S_2) \end{aligned} \quad (4.15)$$

And at its optimal, equation (4.3) is again applied as

$$\frac{\partial \bar{R}}{\partial S_1} = \frac{\partial \bar{R}}{\partial S_2} \quad (4.16)$$

The left-hand side of (4.16) represents the expected marginal seat revenue of the S_1 th seat in fare class 1, and the right-hand side of the above represents the expected marginal seat revenue of S_2 th seat in fare class 2, and they are denoted as $EMSR_1(S_1)$, and $EMSR_2(S_2)$, respectively. Such EMSR value for fare class i of the S_i th seat is described as

$$EMSR_i(S_i) = f_i \cdot \bar{P}_i(S_i) \quad (4.17)$$

Hence, (4.16) is revised as

$$\begin{aligned}
 EMSR_1(S_1^*) &= EMSR_2(S_2^*) \\
 f_1 \cdot \bar{P}_1(S_1^*) &= f_2 \cdot \bar{P}_2(S_2^*)
 \end{aligned}
 \tag{4.18}$$

$$st. S_1^* + S_2^* = C$$

For generalized expression, the optimal condition is

$$\begin{aligned}
 f_i \cdot \bar{P}_i(S_i^*) &= f_j \cdot \bar{P}_j(S_j^*) \quad \text{for all } i \neq j \\
 st. \sum_i S_i^* &= C
 \end{aligned}
 \tag{4.19}$$

And each S_i^* defines the booking limit for respective fare class. However, the optimal condition is valid for distinct fare class problem, not for nested. For better understanding, Figure 4-3 illustrates the two-fare distinct fare class problem.

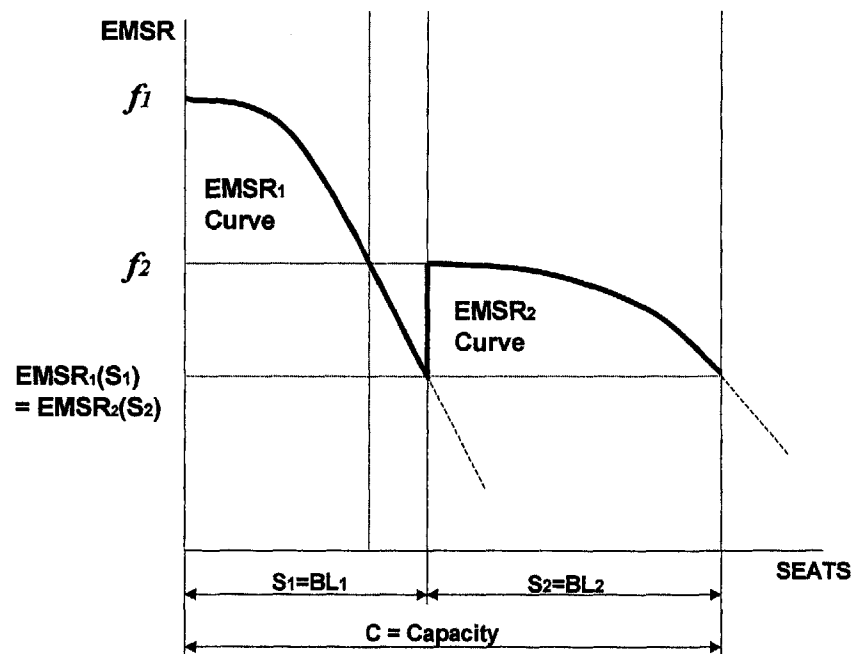


Figure 4-3 Solution for distinct fare class inventories³²

In this case, class 1 and class 2 represents higher and lower class with fare level f_1 and f_2 , respectively. As shown in Figure 4-3, some of the requests in class 1 have lower EMSR value

³² Belobaba (1987), p. 111.

than f_2 , so that we could have more revenue if such a higher fare class request with less EMSR value can be replaced by lower fare class requests with EMSR value equal to f_2 . And Belobaba (1987) demonstrated that a distinct fare class could result in lower total expected revenue than that of nested fare class.

Finally, EMSR with nested multiple fare class structure is described. Again, consider two-fare class structure for example. Class 1 and class 2 represent a higher and lower class with fare level f_1 and f_2 , respectively. Higher fare class request shall be accepted in which any available seat exists in the inventory. As a result, the booking limit for class 1, denoted as BL_1 , is equal to the capacity, C . And the seat protection level S_2^1 , which is an integer value and defines the number of seats exclusively used for class 1 and request for class 2 is rejected, shall satisfy the following:

$$EMSR_1(S_2^1) = f_1 \cdot \bar{P}_1(S_2^1) = f_2 \tag{4.20}$$

Booking limit for fare class 2, BL_2 , is then calculated as $C - S_2^1$. Figure 4-4 illustrates the EMSR curve for each fare class, together with the booking limits and seat protection level.

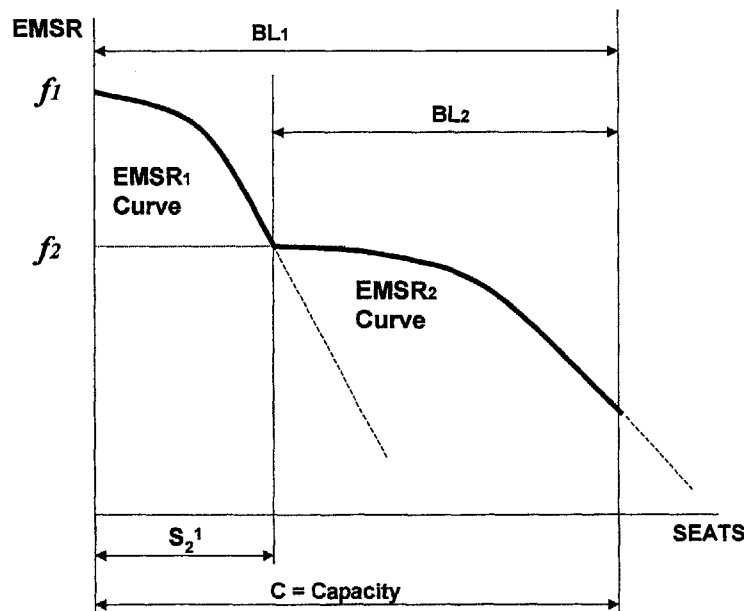


Figure 4-4 Solution for nested fare class inventories³³

³³ Belobaba (1987), p. 111.

EMSRa application for more than two fare class structure

In the previous section, EMSR application for two-fare class has been reviewed. In this section, application for more than two fare classes with nested structure is reviewed. In this case, we consider three fare classes, with highest classified as class 1, middle as class 2, and lowest as class 3. Fare level for class 1 through 3 is denoted as f_1 through f_3 , respectively.

Similar to two-fare class case, seat protection level for each fare class is defined as follows:

- S_2^1 : Seat protection level from fare class 2 and available for fare class 1 requests only
- S_3^1 : Seat protection level from fare class 3 for fare class 1 demand
- S_3^2 : Seat protection level from fare class 3 for fare class 2 demand

And optimal protection level must comply with the following equations.

$$EMSR_1(S_2^1) = f_2 \quad (4.21)$$

$$EMSR_1(S_3^1) = f_3 \quad (4.22)$$

$$EMSR_1(S_3^2) = f_3 \quad (4.23)$$

BL_1 , the booking limit for class 1 is equal to the capacity, C . Booking limit for subsequent classes are defined as follows:

$$BL_2 = C - S_2^1 \quad (4.24)$$

$$BL_3 = C - S_3^1 - S_3^2 \quad (4.25)$$

Figure 4-5 illustrates the EMSR curve for each fare class, as well as seat protection level and booking limit.

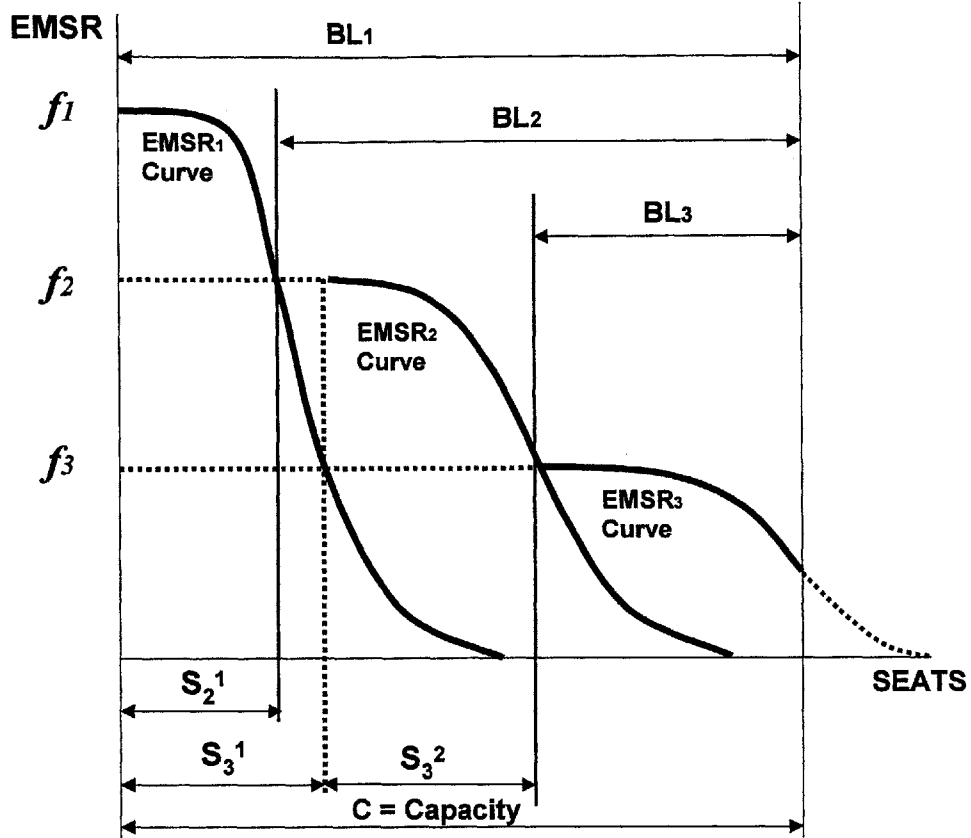


Figure 4-5 EMSR solution for nested three class³⁴

From the Figure 4-5, seat protection level for fare class 1 shall be S_2^1 , not S_3^1 since the $EMSR_1$ value for the seats between S_2^1 and S_3^1 can take lower value than some value of $EMSR_2$. Therefore, 'nested' protection level for fare class 2 is a sum of the gap between S_2^1 and S_3^1 , and S_3^2 . This Nested Protection Level for fare class i , denoted as NPL_i , is given by

$$NPL_j = BL_j - BL_{j+1} = \sum_{i \leq j} S_{j+1}^i - \sum_{i < j} S_j^i \quad (4.26)$$

$$s.t. \quad C = \sum_{j < k} NP_j + BL_k$$

³⁴ Belobaba (1987), p. 117.

Thus, the concept of *NPL* is central to the nested multiple fare class EMSRa approach, and it can be applied to more than three fare classes with ease.

EMSRb application for more than two fare class structure

In 1992, Belobaba presented modified EMSRa approach, later called as EMSRb³⁵. The essence of this new approach is the introduction of ‘joint’ protection instead of NPL in EMSRa, to set the seat protection level for each fare class.

Joint protection approach is to find a total (joint) protection level for the aggregate of all classes $i < j$, based on combined demand and weighted price level for all classes above the one for which a booking limit is being calculated.

Consider nested four-fare class, Y, B, M, and Q, for example. Let f_Y, f_B, f_M and f_Q as the fare level for Y, B, M and Q, respectively. For the highest Y class, the same method used in EMSRa is applied, and the seat protection level for Y, π_Y , is calculated below:

$$EMSR_Y(\pi_Y) = f_Y \cdot \overline{P}_Y(\pi_Y) = f_B \tag{4.27}$$

To calculate joint protection for multiple classes, we need to consider the joint probability density of joint demands. Due to the reproductive character of normal distribution used to represent the demand, the joint demand is represented by normal distribution³⁶. And using the mean and standard deviation of probability density of demand for each fare class, mean and standard deviation of the probability density for joint demand P_{YB} and P_{YBM} is described in (4.28) and (4.29), respectively.

³⁵ Belobaba (1992).

³⁶ For the reproductive property of normal distribution and convolution used to calculate the joint mean and demand, refer to Meyer (1975), pp. 150-151 and pp. 234-235.

$$\begin{aligned}\overline{X}_{YB} &= \overline{X}_Y + \overline{X}_B \\ \hat{\sigma}_{YB} &= \sqrt{\hat{\sigma}_Y^2 + \hat{\sigma}_B^2}\end{aligned}\tag{4.28}$$

$$\begin{aligned}\overline{X}_{YBM} &= \overline{X}_Y + \overline{X}_B + \overline{X}_M \\ \hat{\sigma}_{YBM} &= \sqrt{\hat{\sigma}_Y^2 + \hat{\sigma}_B^2 + \hat{\sigma}_M^2}\end{aligned}\tag{4.29}$$

Price level for such joint demand is calculated as a weighted average of fare involved as follows:

$$f_{YB} = \frac{f_Y \cdot \overline{X}_Y + f_B \cdot \overline{X}_B}{\overline{X}_Y + \overline{X}_B}\tag{4.30}$$

$$f_{YBM} = \frac{f_Y \cdot \overline{X}_Y + f_B \cdot \overline{X}_B + f_M \cdot \overline{X}_M}{\overline{X}_Y + \overline{X}_B + \overline{X}_M}\tag{4.31}$$

Using joint probability and weighted fare level, joint seat protection level for Y and B, π_{YB} , as well as joint seat protection level for Y, B, and M, π_{YBM} , satisfy

$$f_{YB} \cdot \overline{P}_{YB}(\pi_{YB}) = f_M\tag{4.32}$$

$$f_{YBM} \cdot \overline{P}_{YBM}(\pi_{YBM}) = f_Q\tag{4.33}$$

Booking limit for each fare class, BL_Y , BL_B , BL_M , is then calculated as

$$BL_Y = C\tag{4.34}$$

$$BL_B = C - \pi_Y\tag{4.35}$$

$$BL_M = C - \pi_{YB}\tag{4.36}$$

$$BL_M = C - \pi_{YBM}\tag{4.37}$$

The relationship between booking limit and seat protection level is illustrated as Figure 4-6. For further detail of EMSRb calculation, refer to Wei (1997).

General case for class n , above equations are generalized as follows:

$$\overline{X}_{1,n} = \sum_{i=1}^n \overline{X}_i \quad (4.38)$$

$$\hat{\sigma}_{1,n} = \sqrt{\sum_{i=1}^n \hat{\sigma}_i^2} \quad (4.39)$$

$$f_{1,n} = \frac{\sum_{i=1}^n (f_i \cdot \overline{X}_i)}{\sum_{i=1}^n \overline{X}_i} \quad (4.40)$$

We then find the value of $\pi_{1,n}$ that satisfies

$$EMSR_{1,n}(\pi_{1,n}) = f_{1,n} \cdot P_{1,n}(\pi_{1,n}) = f_{n+1} \quad (4.41)$$

And once $\pi_{1,n}$ is found, set

$$BL_{n+1} = Capacity - \pi_{1,n} \quad (4.42)$$

EMSRb is applied to a single leg, static problem, but it can be used for dynamic problem solution by applying this method periodically during the booking process.

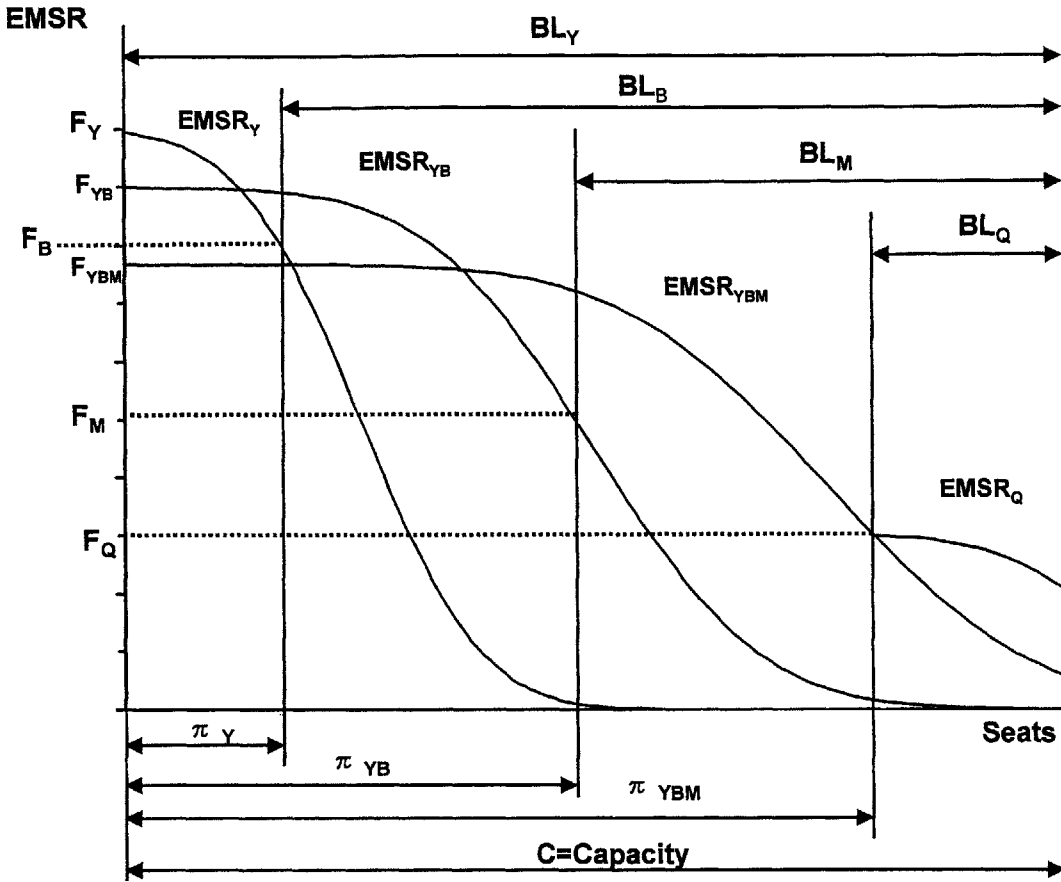


Figure 4-6 EMSRb applied to four-fare class³⁷

4.1.4 Traffic Flow (O-D) Control

From the point of maximizing total revenue over the entire network, leg based seat inventory control explained in the previous section has some drawbacks. As an introduction to the O-D control, we explain such drawbacks using simple example illustrated as Figure 4-7.

The network consists of 2 flight legs, BOS-YVR and YVR-HKG, with the fare class and level shown as below.

³⁷ Adapted from Williamson (1992), p. 54.

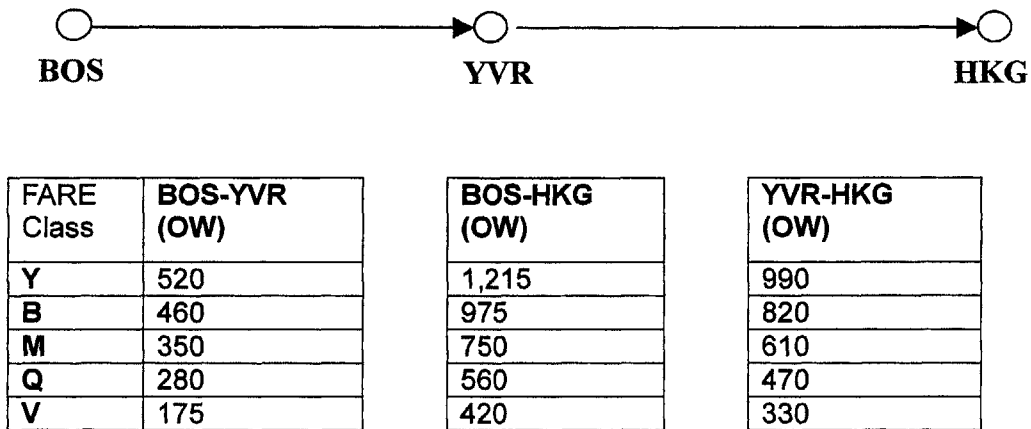


Figure 4-7 Example of network (BOS-YVR-HKG)

Assume that only Y and B class seats are available for BOS-YVR, for example. In this case, passengers flown from BOS to HKG can only book Y and B class, even if there are plenty of seats available for next YVR-HKG flight. Consequently, the system refuses to accept BOS-HKG M-class booking (\$750), and chooses to take BOS-YVR B-class (\$460) instead.

Furthermore, as leg-based system can't distinguish between local and connecting passengers, it might choose a BOS-HKG B-class (\$975) booking and deduct one seat from each leg, but it can be used by BOS-YVR B-class and YVR-HKG B-class booking separately, resulting the total revenue of $\$460 + \$820 = \$1,280$.

Greedy Virtual Nesting (GVN)

One method to avoid such discrepancies is the introduction of revenue bucket concept. The two types of bucket concepts are stratified buckets which utilize a current bucket structure, and a virtual revenue bucket, but I would explain the virtual revenue bucket, as a stratified bucket is confusing to travel agents and consumers, even for airline employees, and the methodology is

almost the same. The latter concept, virtual bucket, is called the Greedy Virtual Nesting (GVN) or VEMSRb. The reason why it is ‘greedy’ is explained later.

Table 4-2 shows the virtual revenue buckets for the network described in Figure 4-7. By using virtual nested buckets, bookings for BOS-HKG with higher fares have a high priority so that the first shortcoming that local B-class is chosen first shall be avoided.

Table 4-2 Mapping of ODFs to Virtual Value Classes

Virtual Class	Revenue Range	Mapping of O-D markets/Classes
1	1000+	$Y_{BOS-HKG}$
2	900-999	$B_{BOS-HKG}$ $Y_{YVR-HKG}$
3	800-899	$B_{YVR-HKG}$
4	700-799	$M_{BOS-HKG}$
5	600-699	$M_{YVR-HKG}$
6	500-599	$Y_{BOS-YVR}$ $Q_{BOS-HKG}$
7	450-499	$B_{BOS-YVR}$ $Q_{YVR-HKG}$
8	350-449	$M_{BOS-YVR}$ $V_{BOS-HKG}$
9	200-349	$Q_{BOS-YVR}$ $V_{YVR-HKG}$
10	0-199	$V_{BOS-YVR}$

However, this methodology can’t overcome the second shortcoming that a leg based system has: the connecting bookings have a higher priority than the aggregated B-class local bookings, so that it will not lead to maximum system revenue from this point. (It is why this model is called ‘greedy’.)

Heuristic Bid Price (HBP)

As pointed out in GVN, we need to consider the impact of giving a seat to a connecting passenger, not to a local passenger. In order to implement such an impact into decision making, as to accepting connecting passengers, EMSR Heuristic Bid Price Control method was developed by Belobaba (1995). This model applies ‘bid price’ to incorporate the impact of displacement; connecting passengers are accepted unless the fare for such passengers are higher than the bid price, otherwise rejected. And in this case, bookings for 1-leg is controlled by each leg-based system.

In HBP model, the virtual class structure for each leg is shown in Table 4-3.

Table 4-3 Virtual classes for BOS-YVR and YVR-HKG

Virtual Class	BOS-YVR		YVR-HKG	
	Fare Class	Fare	Fare Class	Fare
Y1	Y _{BOSHKG}	1,215	Y _{BOSHKG}	1,215
Y2	B _{BOSHKG}	975	Y _{YVRHKG}	990
Y3	M _{BOSHKG}	750	B _{BOSHKG}	975
Y4	Q _{BOSHKG}	560	B _{YVRHKG}	820
Y5	Y _{BOSYVR}	520	M _{BOSHKG}	750
Y6	B _{BOSYVR}	460	M _{YVRHKG}	610
Y7	V _{BOSHKG}	420	Q _{BOSHKG}	560
Y8	M _{BOSYVR}	350	Q _{YVRHKG}	470
Y9	Q _{BOSYVR}	280	V _{BOSHKG}	420
Y10	V _{BOSYVR}	175	V _{YVRHKG}	330

The bid price is then calculated as

$$\text{Max}[EMSR_{BOSYVR}, EMSR_{YVRHKG}] + d \cdot \text{Min}[EMSR_{BOSYVR}, EMSR_{YVRHKG}] \quad (4.43)$$

Here, d is a product of the proportion of local/connecting passenger mix for each leg, and the proportion is calculated using the mean demand for each type of passengers. And the EMSR value used to calculate bid price is described as

$$EMSR_i(S_i) = f_i \cdot \bar{P}_i(S_i) \quad \text{for all leg } i \quad (4.44)$$

Where f_i is a weighted fare level for all available fare classes involved in the leg at the time of calculating EMSR value, and $\bar{P}_i(S_i)$ is a joint probability for the last S_i th seat that is available at the time of calculating EMSR value.

Increasing the number of recalculations for EMSR value can increase the revenue obtained from HBP, but we also need to revise d -factor, empirically obtained. Also, since virtual fare class that includes total fare for connecting itinerary is used for calculating EMSR value, it is still ‘greedy’.

Displacement Adjusted Virtual Nesting (DAVN)

This method is using shadow price, obtained from solving network LP optimization. The shadow price of each leg, which is the revenue gain by relaxing the capacity constraint for each leg, is used to calculate Pseudo-fare (PSF) for connecting fare as

$$PSF_{BOSYVR} = f_{BOSHKG} - SP_{YVRHKG} \quad (4.45)$$

$$PSF_{YVRHKG} = f_{YVRHKG} - SP_{BOSYVR} \quad (4.46)$$

Where f is a fare for a connecting flight (BOS-HKG), and SP is a shadow price for the other leg traversed. The virtual class structure represented in Table 4-3 is revised with this PSF for connecting fares, and seat allocation for each virtual class is decided by EMSRb method.

Deterministic LP Network Bid Price (Netbid)

Unlike DAVN, this method uses shadow price itself to determine whether to accept or reject the request. For the request of local passenger, shadow price for the target leg is used, and the sum of shadow price is used for the request of a connecting passenger. In each case, a request is accepted if the fare for such a request is higher than the shadow price, and rejected otherwise.

There are a couple of shortcomings in this method. Since all requests in which the fare level is higher than bid price are accepted, seat inventory might be filled with lower fare passengers and higher fare passengers are spilled due to the different booking pattern. And this method is deterministic as the shadow price calculated is based upon the mean demand of each fare class, so that no stochastic nature of demand is taken into account, and frequent re-optimization is required for better result, which can be infeasible for airlines with a large network.

Prorated Bid Price (ProBP)

Prorated Bid Price is using critical EMSR value (EMSRc) that is used to calculate the bid price for HBP. The fares for connecting fares are prorated using the EMSRc value for each leg, and recalculated until such a prorated fare is 'converged'. For further detail, refer to Wei (1997) and Bratu (1998).

4.2 Group Bookings in Japanese Market

4.2.1 Background

The major characteristics of group passengers who made group bookings are as follows:

- More than five passengers are involved in the group
- Mostly bookings are made through travel agents
- Group travel packages include accommodation, ground transportation and so on

The first point that specifies the lower limit of the size of group depends on how an airline defines 'group'. In terms of group passengers, more than two passengers who travel together can be treated as 'group', but groups that have less than 5 passengers are treated as individual demand.

As stated in the second point, the majority of group passengers book their flights through travel agents. In fact, group passengers in Japan do not buy their tickets; they buy tour packages instead, as is explained in the third point, which incorporates other travel elements, such as accommodation, meals, ground transportation, and so on. Therefore, understanding the stakeholders for such a travel package helps to understand the complex nature of group bookings.

Stakeholder analysis

There are many stakeholders involved in formulating travel packages. Figure 4-8 shows an overview of the travel package process.

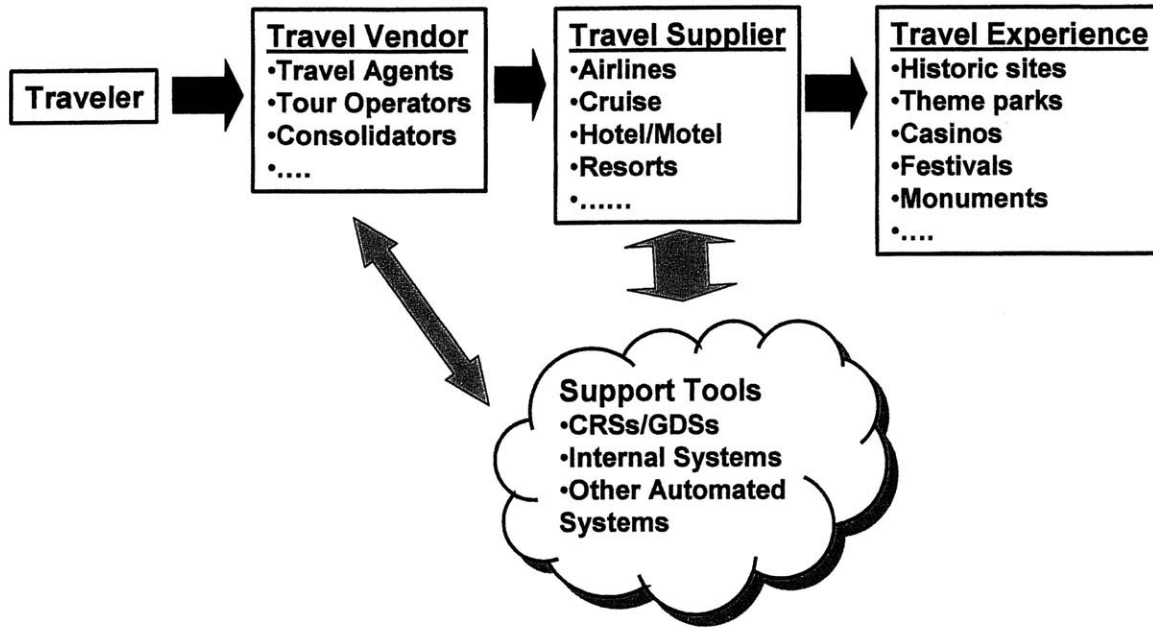


Figure 4-8 Overview of stakeholders for travel package³⁸

The explanation for each segment of the figure is as follows.

→ **Traveler.** Travelers who want to go on a trip for leisure or vacation contact travel vendors and look for travel packages that meet the traveler’s demand.

→ **Travel Vendor.** The travel vendor acts as an agent for the traveler, and makes necessary arrangements by using support tools. There are various stakeholders involved in this segment. The travel agent is a direct interface to the customer, and a tour operator makes packages and wholesales them to travel agents. Consolidators are another type of wholesaler, but they make contracts with airlines and buy a bulk of seats at a discounted price and wholesale tickets to travel agents and customers.

³⁸ Adapted from IATA (2000).

→ **Travel Supplier.** A travel supplier provides what is necessary to ‘assemble’ a travel package, such as transportation, accommodation, and so on. Various stakeholders from airlines to resorts are included in this segment.

→ **Travel Experience.** Stakeholders in this segment create the purpose of the trip, such as seeing beautiful landscapes, historic sites, or festivals.

→ **Support Tools.** These tools, including CRS (Computer or Central Reservation System) and GDS (Global Distribution System) are computer systems used to communicate between travel vendors and travel suppliers.

As shown, there are multiple stakeholders associated with travel packages, making the group trip process more complex. Since travel vendors dominate this area in the Japanese domestic market, airlines have less ability to alter the business process into one that would benefit them more. Hence, the first step airlines need to take is to change their internal process and squeeze more profit from travel vendors.

4.2.2 Past Research

Past research that considers the group booking/sales process is difficult to find. For example, there are only four presentations made in past AGIFORS symposia that focus on dealing with the group booking handling process.

Descroix (1989) of Air France presented an expert system for group reservation, to incorporate the knowledge of expert handling of group bookings. After that, Smith (1990) of American Airlines proposed a group decision support model, and Busuttill (1995) of Cathay Pacific described the process to improve the management of the group sales process by improving an airline’s internal process.

Later on, Kaduwela (1996) of United Airlines presented an overbooking model for group passenger cancellations, dealing with the overbooking for blocks allocated to group passengers.

Apart from those presentations made from airline side, Svrcek (1991) undertook comprehensive research on modeling airline group passenger demand for revenue optimization. Svrcek first clarified the difference between individual and group passengers, and then went on to the need to handle group passengers demand separately. Then, Svrcek modeled the group demand according to three variables, group size, the number of groups on a flight, and utilization rate, to indicate what portion of the group request are verified and ascertain group demand, taking the stochastic nature of demand into consideration. Detailed explanation of modeling group demand is described in a later chapter.

Svrcek also described the group seat inventory control model using a planning model approach that uses mathematical programming, and a decision making model that uses displacement cost. In the next section, a brief review of group seat inventory control is presented. For further detail, readers are directed to Chapter 5 of Svrcek (1991).

4.2.3 Group Seat Inventory Control

Mathematical Programming Approaches³⁹

Mathematical programming approaches are used for a planning model approach to decide how many seats shall be allocated to group bookings.

First, mathematical programming using deterministic demand is used for calculation. The assumption used in this case is that the group demand for the flight comes from a single request with the size of μ_g , and the average fare of F_g . Together with S_i , the number of seats allocated to fare class i applicable to individual passengers with average fare F_i , the objective function can be described as follows:

³⁹ Svrcek (1991), pp. 71-82.

$$\text{Max } \sum_{i=1}^k F_i \cdot S_i + F_g \cdot \mu_g \cdot x_g$$

Subject to

$$0 \leq S_i \leq D_i \quad \text{for all } i$$

(4.47)

$$\sum_{i=1}^k S_i + \mu_g \cdot x_g \leq C$$

$$x_g = 0 \text{ or } 1$$

Where

- D_i : Mean demand for each fare class i
- k : Total number of fare class for individual passengers
- x_g : Decision variable as to decide whether to accept group demand
- C : Capacity

Similar to the mathematical program for individual passengers presented in this chapter, the shortcomings of this model are its unrealistic assumption that the demand is 'deterministic', and the optimal condition is valid for distinct fare class structure that also leads to a revenue loss in which the demand is probabilistic.

In order to implement the stochastic nature of demand, the notion of expected marginal revenue is introduced. $EMR_{i,j}$, the expected marginal revenue for j th seat in which it is allocated for fare class i , is used to calculate the revenue obtained from both individual and group passengers as follows:

$$\text{Max} \sum_{i=1}^{k,g} \sum_{j=1}^C \text{EMR}_{i,j} \cdot x_{i,j}$$

Subject to

(4.48)

$$\sum_{j=1}^C \sum_{i=1}^{k,g} x_{i,j} \leq C$$

$$x_{i,j} = 0 \text{ or } 1$$

Where $x_{i,j}$ is a decision variable whether the j th seat is allocated to fare class i , and C is a capacity. Using EMR, the probabilistic nature of demand is incorporated, but this approach is still applicable only for distinct fare class structure, so that the solution might be sub-optimal.

Displacement Cost Model⁴⁰

The second model is using displacement cost to decide whether group bookings shall be accepted or not. In accepting a group request, such a group request displaces up to S_g (= the size of group request) individual passengers. From this standpoint, revenue coming from a group request must be higher than the revenue potentially obtained from displaced individual passengers.

In order to calculate the displacement cost, Svrcek used EMSR value for individual passengers that are displaced by group bookings. The decision model can be described as follows:

$$\text{Accepted if } \sum_{i=C-S_g+1}^C \text{EMSR}(S_i) \leq f_g \cdot S_g \quad (4.49)$$

Rejected *otherwise*

Where f_g is a fare for a group passenger, and C is the number of seats available at the time of comparison. This model uses an assumption that f_g is less than any fare for individual

⁴⁰ Svrcek (1991), pp. 83-85.

passengers, so that EMSR value for the $(C - S_g + 1)$ th to C th seat are summed for comparison. This model can be applied for nested fare class structure and incorporate stochastic nature of demand so that it is the most practical model to use among the approach we reviewed for group booking seat inventory control.

Chapter 5

Analysis of Group Passengers Demand

As explained in the previous chapter, passengers are categorized into three segments – individual business, individual leisure, and group. In this chapter, group passengers are classified as two types, ad hoc and series, and analysis of each type is made using data obtained from an airline. And based upon the result of analysis, group passengers demand is modeled in later chapter by using characteristics of the demand, the number of group requests, the size of each individual group request, and the utilization rates associated with a group request.

5.1 Types of group passengers

At the airport, we can see many types of group passengers. The most common type of group is a *package tour group*, led by the tour conductor holding a small flag with the name of the travel package on it, and each passenger in this group wears a small tag for identification. Travel agents organize this package tour, and meals, accommodation, as well as air and ground transportation for the tour are included in the package. Passengers interested in the contents of the package join the tour individually, so that each passenger does not know the others at the beginning of their trip. The second type of group is an *assisted tour group*. This type of group includes an excursion trip for high and junior high school students, and more than 200 students are included in the tour. Indeed, it is common for students to use airplane for their excursion trip, and some high schools choose to go abroad for their excursion. This type of group makes bookings fairly early, about a year before the day of departure, and the cancellation rate is significantly low, so that airlines can expect some “fixed” revenue from such a group. However, this type of group is much less common than a package tour group and it has high seasonality, so we will focus on the first type of group, package tour group.

The package tour group is categorized into two types, *ad hoc* and *series*. Ad hoc is a type of package specially designed for specific purpose. Package tours to see festivals, and partake in

outdoor activities, such as skiing, are typical examples for this type. Package tours to go to theme parks, such as Tokyo Disney Land, are other good examples of this type. On the contrary, a series is a type of package that travel agents set throughout the year to visit popular cities for sightseeing. The contents of this package are more general compared to the ad hoc type, and are suitable for most passengers who want to visit and experience the sightseeing highlights of one place at a time. The characteristics of each type is described later, but here we display the booking curve for each type so that readers can have some image as to the motivation for categorizing group demand.

Figure 5-1 shows the cumulative booking curves for ad hoc and series requests. A tour package for a series is a general, fundamental package for a travel agent, and travel agents book a certain amount of seats at 6 months and 3 months before departure, for which the curve for series passengers shows a steep rise. On the contrary, the booking profile for ad hoc requests is similar to that of individual leisure passengers and increases gradually. In each case, travel agents make bookings even if they have no actual passengers on hand, referred to here as ‘pseudo’ bookings, to give more flexibility to their customers. For example, a travel agent makes 100 bookings for a package 6 months before departure, even if they have only 20 actual customers on hand.

As it is shown, both types of cumulative bookings go up to 100% at 14 days before departure in Japan. This is one of the major characteristics of group passenger booking behavior, since airlines close their buckets for group passengers at 14 days before departure, and ask travel agents to input actual name for each passenger included in the group. Hence, ‘pseudo’ bookings have to be realized within this time frame, and the size of the group shrinks significantly at this time. We are going to introduce the notion of utilization rate to model such behavior; it is described in the later section.

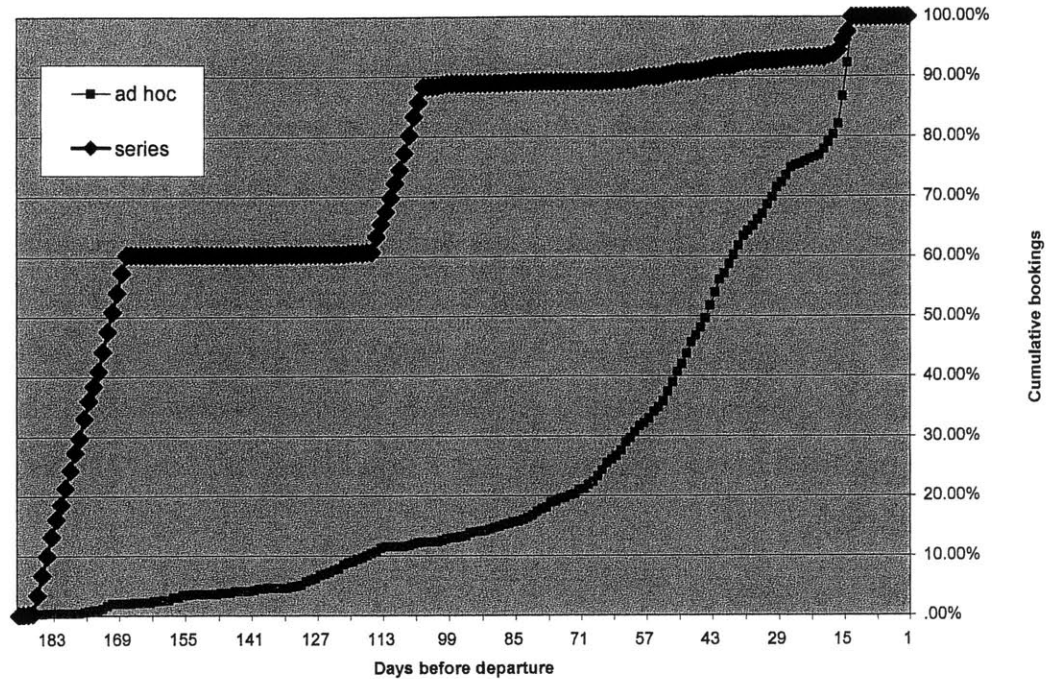


Figure 5-1 Cumulative booking curves for ad hoc and series group request⁴¹

5.2 Characteristics of Group Demand

In his thesis, Svrcek (1991) showed how to quantify the parameters associated with the group booking process in order to accurately model group passenger demand. And Svrcek introduced three major sources of variation associated with group demand: the number of group requests received, the size of each individual group request, and the utilization rate, a measure of what fraction of the original group passenger bookings will ultimately be used. A brief review of each component is described below.

The number of group requests

The number of group requests, the first dimension of variability, is the actual number of requests an airline receives for a given flight leg. Note that not all requests are realized since some are

⁴¹ Data is obtained from a typical Japanese airline.

based on travel agent speculation of anticipated demand. The data we obtained from airline indicate the fact that a significant amount of requests remain unused, and it results in a low utilization rate. Consequently, the number of group requests is higher than the number of groups on board. This number of group requests, defined by n , is a discrete random variable, and takes a non-negative integer value. The probability distribution function for n , $p_n(n_0)$, can be expressed as a probability mass function, with impulses of probability with the value of n_0 , a discrete value that n can take. Svrcek made an intuitive insight that the number of group requests for a given flight leg will have some reasonable upper bound, which is likely to be rather small in most instances. The actual distribution observed confirmed his insight, however the upper bound for n is higher than he predicted in our case, mainly due to the absence of a cancellation penalty in Japan's domestic market.

The size of the group request

The size of the group request, the second dimension of variability, is the actual size of each group request received, defined by s . Svrcek again had a good insight that the upper bound of s can be in the order of 400 seats, and it may be reasonable to assume that the number of seats travel agents use for an inclusive tour is in multiples of five or ten, rather than some prime number. In fact, observation shows that a large portion of the data concentrate on multiples of five or ten. And since s can be treated as a random discrete variable, the probability distribution function for s , $p_s(s_0)$, can be expressed as a probability mass function, with impulses of probability, with the value of S_0 being a multiple of five or ten.

The utilization rate

Svrcek defined the utilization rate as the fraction of seats in the original group request that will ultimately be used by that group⁴². From this context, the idea of the utilization rate is the complement of cancellation rate. There is no "fraction" for each individual passenger, but utilization rate can be applied to the aggregate of individual passengers, dividing the number of passengers on board by the number of passengers booked.

⁴² Svrcek (1991), p. 57.

The utilization rate, u can be a continuous number that varies between zero and one. It is plausible to say that u is more than one if we assume the case that the number of passengers willing to travel with the tour package is more than anticipated, but based on the observation, such case is rare. Indeed, many of the requests remain unused, forcing the total utilization lower. On the contrary, the remainder of the requests is nearly fully utilized, indicating the fact that some requests are made after a certain amount of actual requests have been received from customers so that travel agents makes little 'pseudo' requests in such cases. As a result, the probability distribution function for u , $p_u(u_0)$ is again a probability mass function, with the impulses of probability with the value of zero and one, or we may just use average utilization rate to calculate the demand.

In summary, all three sources of variation take a non-negative, random discrete value, and the probability distribution function is a probability mass function. The distributions of sources, which are obtained from airline data for each group type, are shown later. Before entering the detailed analysis, we describe the data we had. The actual booking data are obtained from an airline, which include the type of tour package, day of departure, day of booking, number of bookings involved and actual number of passengers boarded. Utilization rate for each group is then calculated as the passengers boarded divided by the number of bookings per each tour package. As is always the case for data collection, there are some garbage data included, such as a tour package with zero bookings and zero on board passengers⁴³. We might have a small sample bias since the data is collected from an airline and it is one-month data, but as we have no data other than the data we have, it is inevitable to use the result of analysis to decide the characteristics of the variables that are used to model the group demand. Some data are used to make histogram to estimate the distribution.

⁴³ This might be because commission from airlines to travel agents is paid, based upon number of bookings they made, so that sometimes travel agents might make "fake" bookings to increase the number of bookings.

5.3 Ad Hoc Group Analysis

The number of group requests

Figure 5-2 shows the distribution of group requests per flight. Readers shall keep it in mind that not all group requests are actually on board.

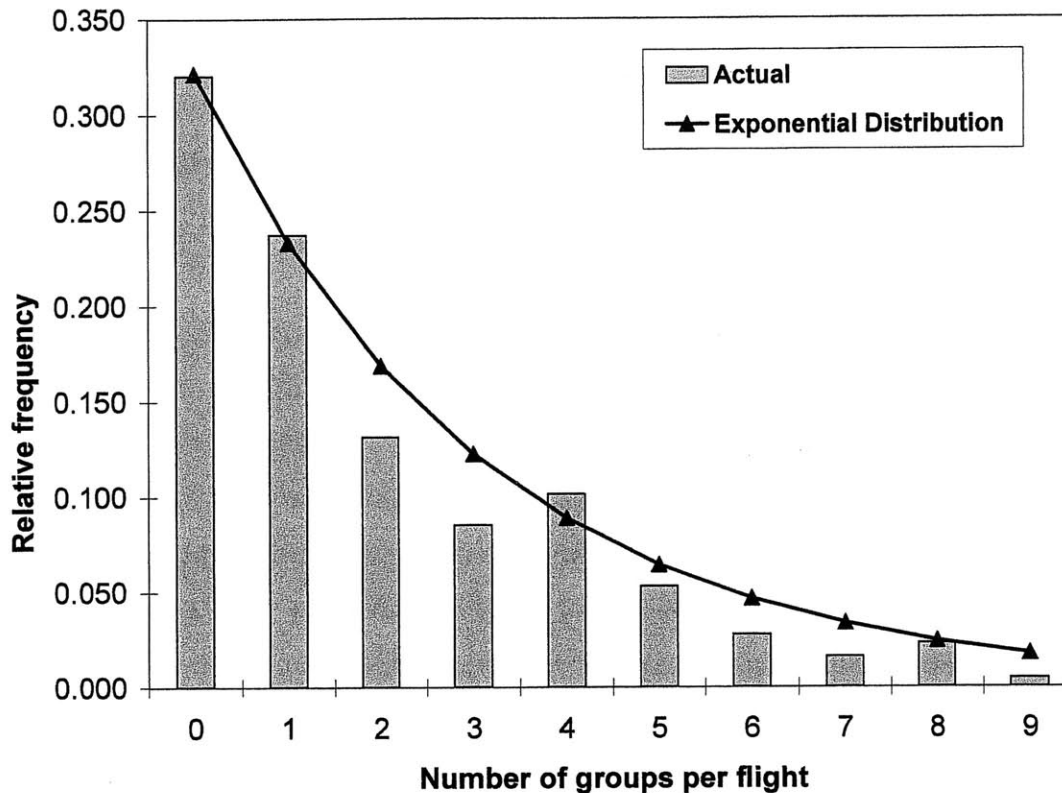


Figure 5-2 Distribution of number of group requests per flight⁴⁴

As shown, the number of ad hoc groups per flight is distributed between one and nine, and the distribution pattern is close to the exponential distribution, with $\lambda=0.321$. And the R^2 for the regression analysis between observed data and calculated data is 0.975, indicating that the exponential distribution provided can be used to represent the probability distribution of the number of groups per flight. Hence, $p_n(n_0)$ for an ad hoc group, distinguished as $p_{nadhoc}(n_0)$ can be described as below:

⁴⁴ Data is obtained from a typical Japanese airline.

$$p_{\text{ad hoc}}(n_0) = 0.321 \exp(-0.321 \times n_0) \quad (5.1)$$

The size of group requests

The distribution of the size of group shows the fact that the 83% of the data falls within the range of [multiple of 5 ±1], it is plausible to assume that a travel agent set the size of group using multiples of five. And for simplicity, we assume that a travel agent use multiples of ten for an ad-hoc group.

Figure 5-3 shows the histogram of the size of groups with intervals of ten. Since we will take a limited number of discrete integers, multiples of ten as random variables, the probability distribution function for the size can be represented as follows:

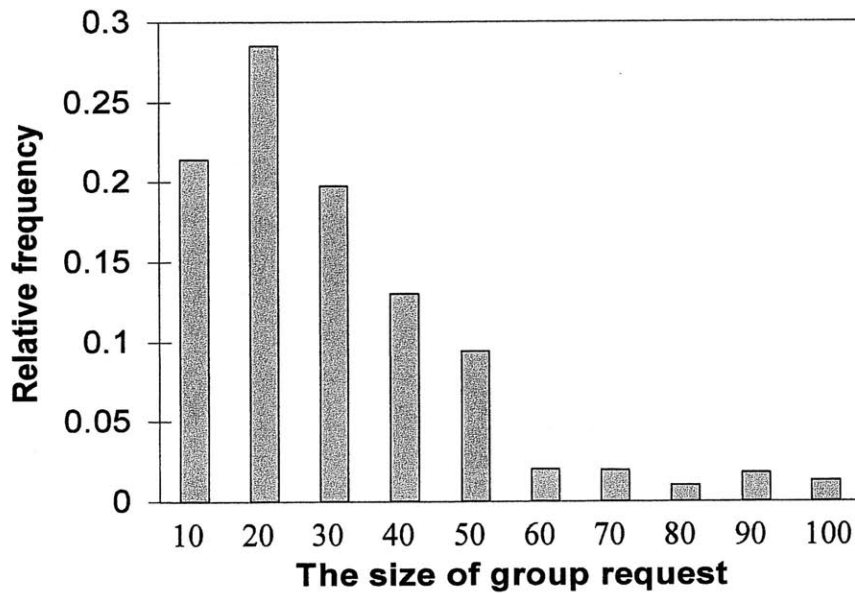


Figure 5-3 Histogram of the size of ad hoc group⁴⁵

⁴⁵ Data is obtained from a typical Japanese airline.

$$p_{\text{sadhoc}}(s_0) = \begin{cases} 0.21 & s_0 = 10 \\ 0.29 & s_0 = 20 \\ 0.20 & s_0 = 30 \\ 0.13 & s_0 = 40 \\ 0.09 & s_0 = 50 \\ 0.02 & s_0 = 60 \\ 0.02 & s_0 = 70 \\ 0.01 & s_0 = 80 \\ 0.02 & s_0 = 90 \\ 0.01 & s_0 = 100 \\ 0 & \text{otherwise} \end{cases} \quad (5.2)$$

The utilization rate

Figure 5-4 shows the distribution of utilization rate.

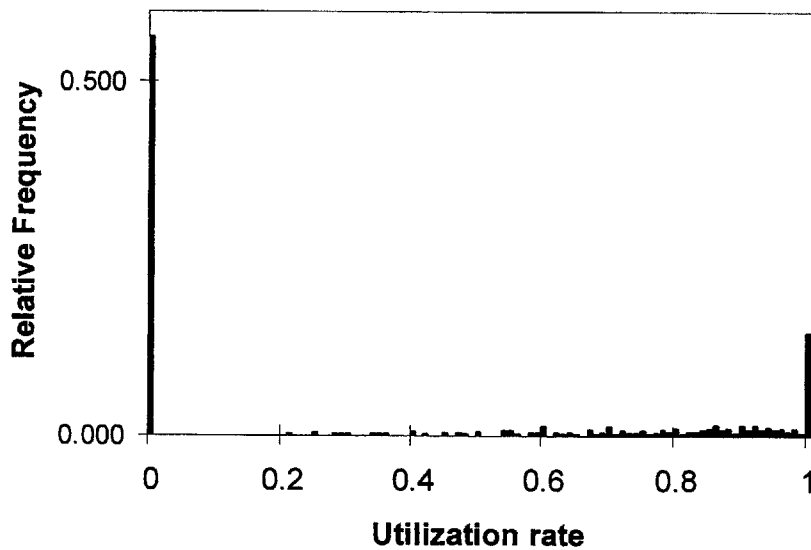


Figure 5-4 Relative frequency distribution of utilization rate⁴⁶

⁴⁶ Data is obtained from a typical Japanese airline.

As is shown in the figure, more than half of the data holds the utilization rate of 0, and around 20% of the data holds the utilization rate of 1, and the rest of the data holds the various utilization rates. The reason for such bipolarized utilization rate can be explained as follows:

→ Since there is no deposit or cancellation penalty until 14 days before departure, there is no incentive for travel agents to make accurate bookings. As a result, travel agents tend to book as many seats as possible to have a free hand to choose the most convenient flight for their customers to achieve their need.

→ On the contrary, once the contents of the package provoke demand among a particular type of passengers, the tour fills up, resulting in the utilization rate equal to 100%. Also, travel agents make some requests after they have a certain number of actual requests on hand. Hence, it is not too far from reality to assume that probability distribution function for utilization rate is the probability mass function described as follows:

$$p_{\text{uadhoc}}(u_0) = \begin{cases} 0.56 & u_0 = 0 \\ 0.44 & u_0 = 1 \\ 0 & \text{otherwise} \end{cases} \quad (5.3)$$

5.4 Series Group Analysis

The number of group requests

Figure 5-5 shows the distribution of group requests per flight. Again, readers shall keep it in mind that not all group requests are actually on board.

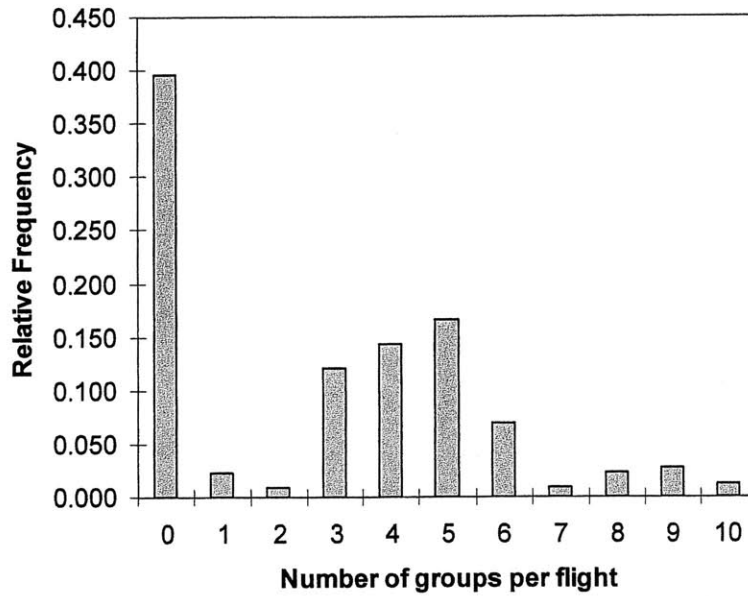


Figure 5-5 Distribution of number of group requests per flight⁴⁷

Unlike the case of ad hoc, the distribution shows little possibility that it will fit any known distribution. Therefore, the probability mass function for the number of series groups per flight can be described as follows:

$$p_{\text{series}}(n_0) = \begin{cases} 0.40 & n_0 = 0 \\ 0.02 & n_0 = 1 \\ 0.01 & n_0 = 2 \\ 0.12 & n_0 = 3 \\ 0.14 & n_0 = 4 \\ 0.17 & n_0 = 5 \\ 0.07 & n_0 = 6 \\ 0.01 & n_0 = 7 \\ 0.02 & n_0 = 8 \\ 0.03 & n_0 = 9 \\ 0.01 & n_0 = 10 \\ 0 & \text{otherwise} \end{cases} \quad (5.4)$$

⁴⁷ Data is obtained from a typical Japanese airline.

The size of group requests

Similar to ad hoc group, the observed data shows the fact that 85% of the total data lies in [multiple of 15 ±1], so that it is plausible to assume that the size of series group passengers takes only multiples of 15.

Figure 5-6 shows the histogram of the size of series group request, using intervals of width 15.

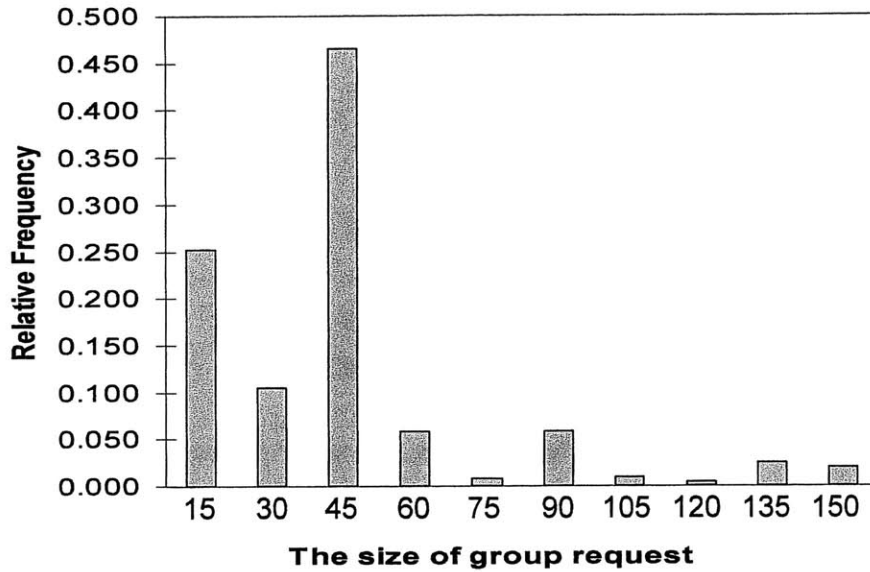


Figure 5-6 Histogram of the size of series group request⁴⁸

Using the relative frequency, the probability mass function for the size of series group request is described as follows:

$$p_{\text{series}}(s_0) = \begin{cases} 0.25 & s_0 = 15 \\ 0.10 & s_0 = 30 \\ 0.47 & s_0 = 45 \\ 0.06 & s_0 = 60 \\ 0.01 & s_0 = 75 \\ 0.06 & s_0 = 90 \\ 0.01 & s_0 = 105 \\ 0.02 & s_0 = 135 \\ 0.02 & s_0 = 150 \\ 0 & \text{otherwise} \end{cases} \quad (5.5)$$

⁴⁸ Data is obtained from a typical Japanese airline.

The utilization rate

Figure 5-7 shows the distribution of utilization rate for series group request.

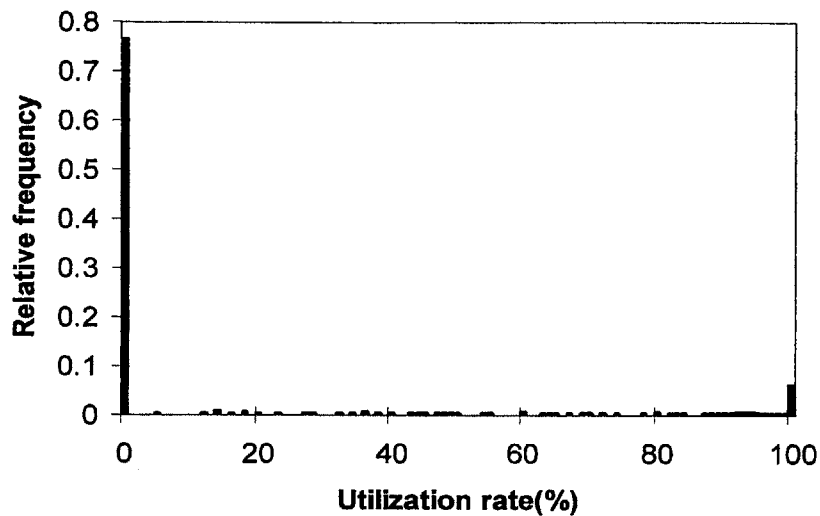


Figure 5-7 Distribution of utilization rate for series group request⁴⁹

The relative frequency at utilization rate of 0% is close to 0.8, meaning that almost 80% of the data holds a utilization rate of 0%. Compared to the ad hoc group request, the relative frequency at a utilization rate of 0% is significantly high, but it can be explained by the nature of series group requests, that series type package tour is designed to fit a generic type of passengers. Because of that, it is hard for travel agents to predict prompt demand distribution over the day of week and time of day, resulting in travel agents making more bookings to more flights than they do for an ad hoc package.

Similar to the ad hoc case, based on the observation described above, we assume that probability distribution function for utilization rate is probability mass function described as follows:

$$p_{\text{useries}}(u_0) = \begin{cases} 0.76 & u_0 = 0 \\ 0.24 & u_0 = 1 \\ 0 & \text{otherwise} \end{cases} \quad (5.6)$$

⁴⁹ Data is obtained from a typical Japanese airline.

Chapter 6

Modeling Booking Process for Group Passengers

In this chapter, we first give a brief overview of PODS, and then create a booking process for group passengers to model and incorporate such a function into PODS. For a detailed explanation as to the basic setup of PODS, refer to Wilson (1995) for setting the competitive environment and Skwarek (1997) for forecasting and det truncation methods. And for further information for the current function of PODS, readers are directed to recent theses such as Gorin (2000), Lee (2000), and Darot (2001).

6.1 Overview of PODS

6.1.1 Background

The PODS (Passenger Origin Destination Simulator) is a simulator that was originally developed by Boeing, later integrated to incorporate yield management simulation capabilities developed at the MIT Flight Transportation Laboratory. Before PODS, MITSIM was developed by MIT and used by Williamson (1992) and Mak (1992) to evaluate the revenue impacts of revenue management, but not reflecting a competitive environment made MITSIM less realistic. The Boeing Decision Window Model (DWM)⁵⁰, on the other hand, incorporated the passenger behavior as to how they choose one specific airline by introducing the concept of time windows and other attributes associated with competitors in the market. However, the lack of critical attributes for passenger choice, such as fares, made DWM insufficient to use as a practical tool to simulate the real world.

In order to overcome its forerunner's flaw, PODS uses historical booking data from previous iterations of the simulation for demand forecasts, just as contemporary RM systems do, and

⁵⁰ Boeing (1994).

enables us to simulate a competitive environment by allowing passengers in the simulation to choose airlines by their schedules and fares.

6.1.2 Architecture

Before entering into a brief explanation of PODS architecture, we should give a description of some assumptions used in PODS. It assumes a stationary process in terms of overall mean demand level. Therefore, PODS simulates a single day of the week, without taking into account any exogenous factors such as seasonal demand change. Another assumption to mention is that PODS incorporates two primary processes, passenger choice and RM availability, at the same time⁵¹.

Figure 6-1 shows the architecture of PODS.

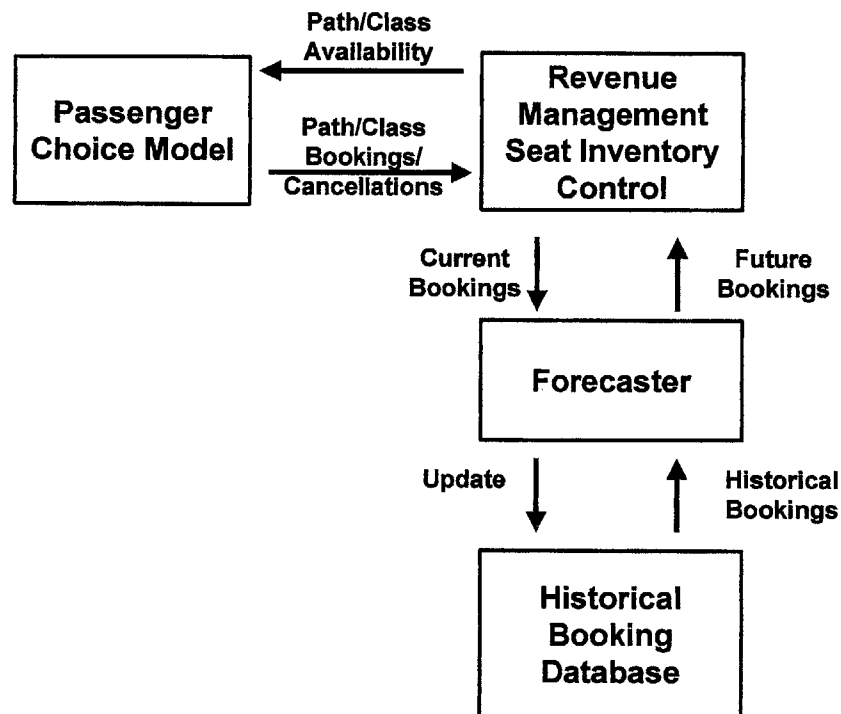


Figure 6-1 Architecture of PODS⁵²

A brief explanation for each module is described below.

⁵¹ Wilson (1995), p. 40-44.

⁵² Courtesy of Hopperstad as reproduced in Zickus (1998), p. 52.

Passenger Choice Model (PCM) module

PCM module creates the demand to be used in the simulation, and sends booking requests to the Revenue Management Seat Inventory Control (RMSIC) module, based on the availability of the path/fare class information sent from RMSIC module.

The total mean demand for the market is given as an input parameter, and allocated to each leisure and business passenger type demand. Then, time frame demand as to the level of demand within booking period, such as 14 days or 21 days before departure and so on, is decided based on the booking curve for each passenger type. For each passenger in the time frame demand, passenger behavioral attributes, such as disutility cost and decision window, are generated, and the passenger is assigned to the path/fare class that satisfies the passenger's criteria, based on the availability of such path/fare class sent from RMSIC module⁵³.

Revenue Management Seat Inventory Control (RMSIC) module

RMSIC module, the Revenue Optimizer module executes a decision making process with regards to whether it accepts or rejects the booking request that the PCM sends to the module until there is no booking request remaining in the time frame. Future booking forecasts, used to calculate the booking limit for each fare class, is sent from the Forecaster module prior to start the whole process. Conversely, current bookings information is sent to Forecaster module to update the booking for each class. Airlines in the market can choose one of the seat inventory control methods introduced in Chapter 4, and multiple scenarios with regards to the selection of seat inventory control methods can be tested.

Forecaster module

This module feeds the number of bookings of each path/fare class to the RMSIC module, based on the historical bookings stored in the database. Also, it updates the forecast by using the current booking information sent from RMSIC.

⁵³ For a detailed explanation about attributes, readers are directed to Lee (1998).

Historical Booking Database (HBD) module

HBD module is a database module that feeds historical booking information to Forecaster module for forecasting future bookings, and updates the database with current booking information.

For better understanding, Figure 6-2 shows the whole flow for a single trial (sequence of flight departures for each leg flown). Simulations in PODS are run by cases, in which the same combination of forecasting, detruncation to obtain unconstrained demand, and seat optimization method is applied to the trials involved in a case⁵⁴.

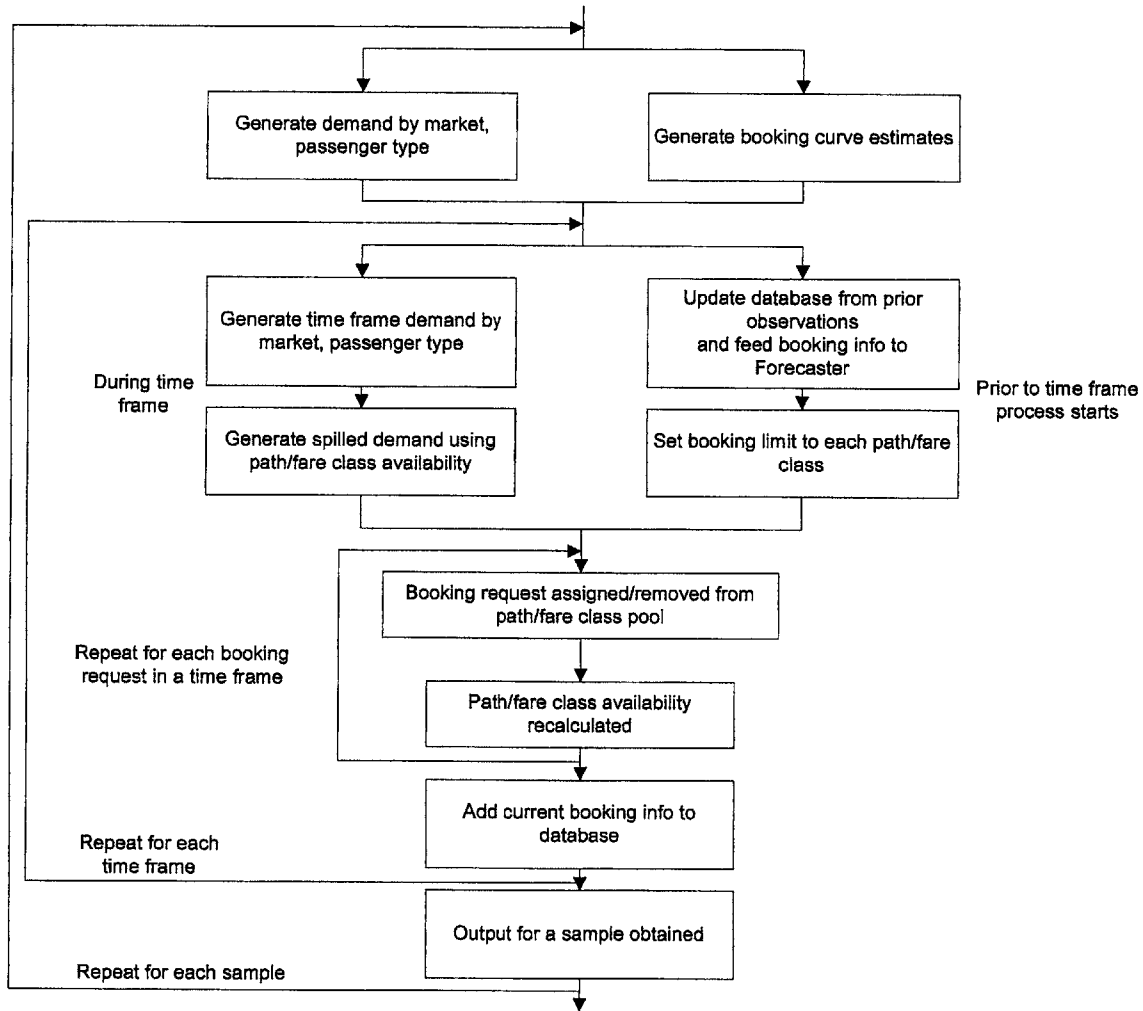


Figure 6-2 PODS flow chart for a single trial (revised from Zickus (1998))

⁵⁴ Readers are directed to Zickus (1998), pp. 51-56, for detailed explanation for PODS process.

6.1.3 Simulation Inputs

There are three types of inputs required for PODS. The first type of input is system-level input that defines the fundamental setup of simulation, such as the number of airlines, number of markets, number of passenger types, and so on. The second type of input is airline input parameters, assigned to each airline to specify which methods the airline uses for revenue optimization, as well as forecasting and detrunctation. The last type of input is market level parameters, which decides the characteristics of each market, such as capacity on each leg, distance, time of day and so on. For a detailed explanation, readers are directed to Zickus (1998).

6.1.4 Simulation Outputs

There are four types of outputs obtained from PODS. The first type of output is overall network revenue, the average network revenue over 20 trials, with network revenue for each trial being described as follows:

$$\sum_i \left(\sum_j ODPAX_{i,j} \cdot f_{i,j} \right) \quad \text{for all } i, j \quad (6.1)$$

Where

- $ODPAX_{i,j}$: Number of passengers onboard in fare class i in market j
 $f_{i,j}$: Fare level for fare class i in market j

This output gives the overall result of the performance of airlines. The second type of output is the passenger leg load, used to analyze the reason for the increase or decrease of revenue output. This output is important since we can analyze the passenger mix between local and connection passengers, as well as the load distribution among fare classes, which are controlled by methods we assigned to each airline by selecting specific method for it.

The third type of output is fare class closures, which indicates the time frame of the booking period in which the fare class is closed. And the last type of output is forecasted remaining demands, how many potential booking requests are expected during each time frame.

6.2 Modeling booking process for group passengers

6.2.1 Overview of Group booking process

Figure 6-3 displays the overview of the group booking process developed in this thesis. The first component, Group Request Generation Model, is to generate the total group requests per day and feed requests to a second component. The second component, Group Request Allocation Model, is to allocate requests to flights by their schedule attributes, and make an inventory of group requests for each flight. This inventory is kept until 14 days before departure, when it is handed to the third component.

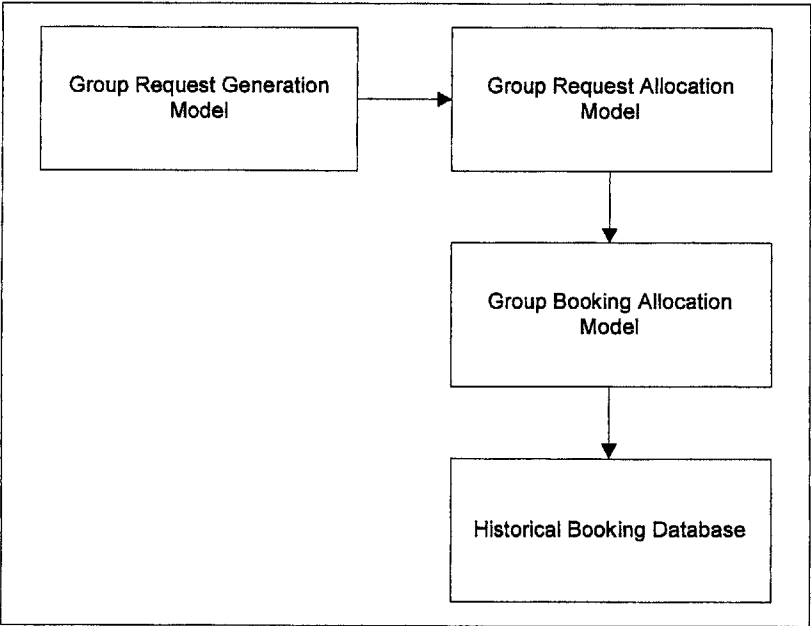


Figure 6-3 Overview of group booking process

In the third component, Group Booking Allocation Model, actual group bookings per flight is calculated by using utilization rate, and the spilled group is reallocated to flights which still have unused capacity for group bookings. The result of group bookings for the flights is then stored into the Historical Booking Database, and this result becomes one “sample”.

As for the amount of data, similar to PODS, 8,000 samples are obtained, which consist of 20 trials with 600 samples and 200 burns in each trial.

Before going into detail, some important assumptions are described. The first explicit assumption is that there is only one fare class available for group passengers, which is significantly different from individual passengers. And the second assumption is that the travel agent does not make multiple requests over multiple flights in the same day, and over multiple airlines. This might not be a realistic assumption, but since we have no empirical data to verify this, it is useful to apply this assumption for simplicity.

6.2.2 Group Request Generation

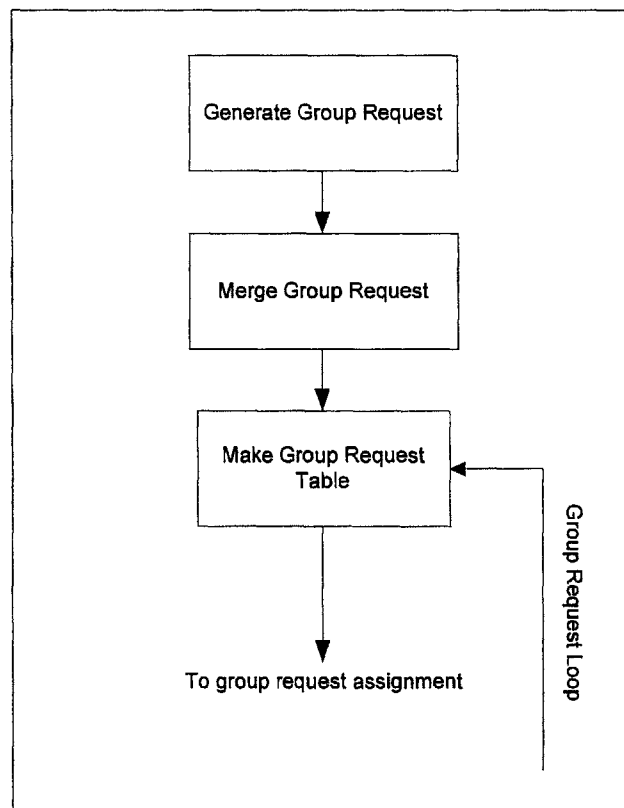


Figure 6-4 Request Generation Flow

As shown in Figure 6-4, the first component of the Figure 6-3 is described as three steps, which are explained as follows.

- (1) Generate group request
- (2) Merge group request
- (3) Make group request table

Step 1. Generate Group request

In this step, three parameters explained in Chapter 5 are used. Those parameters are:

- The number of group requests per flight, n , with the probability mass function of $P_n(n_o)$
- The size of the group requests, s , with the probability mass function of $P_n(s_o)$
- Utilization rate, u , with the probability mass function of $P_u(u_o)$

In order to create the group requests per flight, we first generate the number of group requests per flight, and then attach the size of group to each request. And the last parameter, utilization rate, is also attached, but it is used in the Group Booking Allocation Model.

Since there are two group types defined in the previous chapter, *ad hoc* and *series*, the above parameters are calculated separately.

Ad hoc group

For ad hoc groups, the number of group requests per flight, n_{adhoc} , follows the probability mass function shown as (5.1), that is

$$p_{nadhoc}(n_0) = 0.321 \exp(-0.321 \times n_0) \quad (6.2)$$

Where

n_0 : discrete integer value between 0 and 9

Using this function, the number of group requests per flight is generated. In order to obtain the total number of group requests per day, n_{adhoc} is generated until the number of n_{adhoc} reaches the total number of flights per day in the market. For example, 14 number of group request shall be generated in which there are 14 flights per day in the market.

As for the size of group, s_{adhoc} , the PMF for this parameter is shown in (5.2) as

$$p_{s_{adhoc}}(s_0) = \begin{cases} 0.21 & s_0 = 10 \\ 0.29 & s_0 = 20 \\ 0.20 & s_0 = 30 \\ 0.13 & s_0 = 40 \\ 0.09 & s_0 = 50 \\ 0.02 & s_0 = 60 \\ 0.02 & s_0 = 70 \\ 0.01 & s_0 = 80 \\ 0.02 & s_0 = 90 \\ 0.01 & s_0 = 100 \\ 0 & \text{otherwise} \end{cases} \quad (6.3)$$

Where

s_0 : discrete integer value

s_{adhoc} is generated until all group requests in the market have their size. For example, if a market has three flights per day and the number of group requests for each flight are given as 3, 5, 9, then 17 s_{adhoc} shall be generated to match all group requests in the market.

Finally, utilization rate, u_{adhoc} , is generated, following the PMF shown in (5.3) as

$$p_{u_{adhoc}}(u_0) = \begin{cases} 0.56 & u_0 = 0 \\ 0.44 & u_0 = 1 \\ 0 & \text{otherwise} \end{cases} \quad (6.4)$$

Where

u_0 : discrete integer value

Again, u_{adhoc} is generated until the total number of u_{adhoc} reaches the number of group requests in the market.

To summarize, an example of the parameters generated are shown in Table 6-1.

Table 6-1 Example of group request (number of flights per day in the market = 14)

Group type	Flight	No. of group request, n	Group request No.	Size of group, s	Utilization Rate, u
Ad hoc	1	2	1	10	1
			2	40	1
	2	3	1	20	0
			2	100	0
			3	80	0

	14	1	1	20	1

Series Group

For a series group, the number of group requests per flight, n_{series} , follows the probability mass function shown as (5.4), that is

$$p_{nseries}(n_0) = \begin{cases} 0.40 & n_0 = 0 \\ 0.02 & n_0 = 1 \\ 0.01 & n_0 = 2 \\ 0.12 & n_0 = 3 \\ 0.14 & n_0 = 4 \\ 0.17 & n_0 = 5 \\ 0.07 & n_0 = 6 \\ 0.01 & n_0 = 7 \\ 0.02 & n_0 = 8 \\ 0.03 & n_0 = 9 \\ 0.01 & n_0 = 10 \\ 0 & \text{otherwise} \end{cases} \quad (6.5)$$

Where n_{oadhoc} is a discrete integer value between 0 and 10.

As for the size of group, s_{series} , the PMF for this parameter is

$$P_{s_{series}}(s_0) = \begin{cases} 0.25 & s_0 = 15 \\ 0.10 & s_0 = 30 \\ 0.47 & s_0 = 45 \\ 0.06 & s_0 = 60 \\ 0.01 & s_0 = 75 \\ 0.06 & s_0 = 90 \\ 0.01 & s_0 = 105 \\ 0.02 & s_0 = 135 \\ 0.02 & s_0 = 150 \\ 0 & \text{otherwise} \end{cases} \quad (6.6)$$

Where

s_0 : Discrete Integer Value

Finally, utilization rate, u_{series} , is generated, following the PMF shown in (5.6) as

$$P_{u_{series}}(u_0) = \begin{cases} 0.76 & u_0 = 0 \\ 0.24 & u_0 = 1 \\ 0 & \text{otherwise} \end{cases} \quad (6.7)$$

Where

u_0 : discrete integer value

An example of the parameters generated is shown in Table 6-2.

Table 6-2 Example of group request (number of flights per day in the market = 14)

Group type	Flight Number	No. of group request, n	Group request No.	Size of group, s	Utilization Rate, u
Series	1	2	1	15	0
			2	75	1
	2	3	1	60	0
			2	45	0
			3	45	0

	14	1	1	135	1

Step 2. Merge group request

In the second step, group requests per day for each group type are aggregated to create the total group requests per day.

Step 3. Make group request table

The group requests are then stored to feed the group request to the second component. Table 6-3 shows an example of aggregated group requests.

Table 6-3 Example of aggregated group request

Group ID	Group size	Utilization Rate
1	10	1
2	40	0
...
50	15	1
51	75	0
...
100	45	1

6.2.3 Group Request Allocation

Figure 6-5 shows the process to allocate group requests to each flight. The process is much simpler than the same process for individual passengers, since a single fare is applied. Moreover, there is only one leg available so that we don't need to choose multiple paths. In this component, the following steps are applied:

- (1) Determine capacity for each flight
- (2) Determine decision window for each request
- (3) Allocate requests to each flight

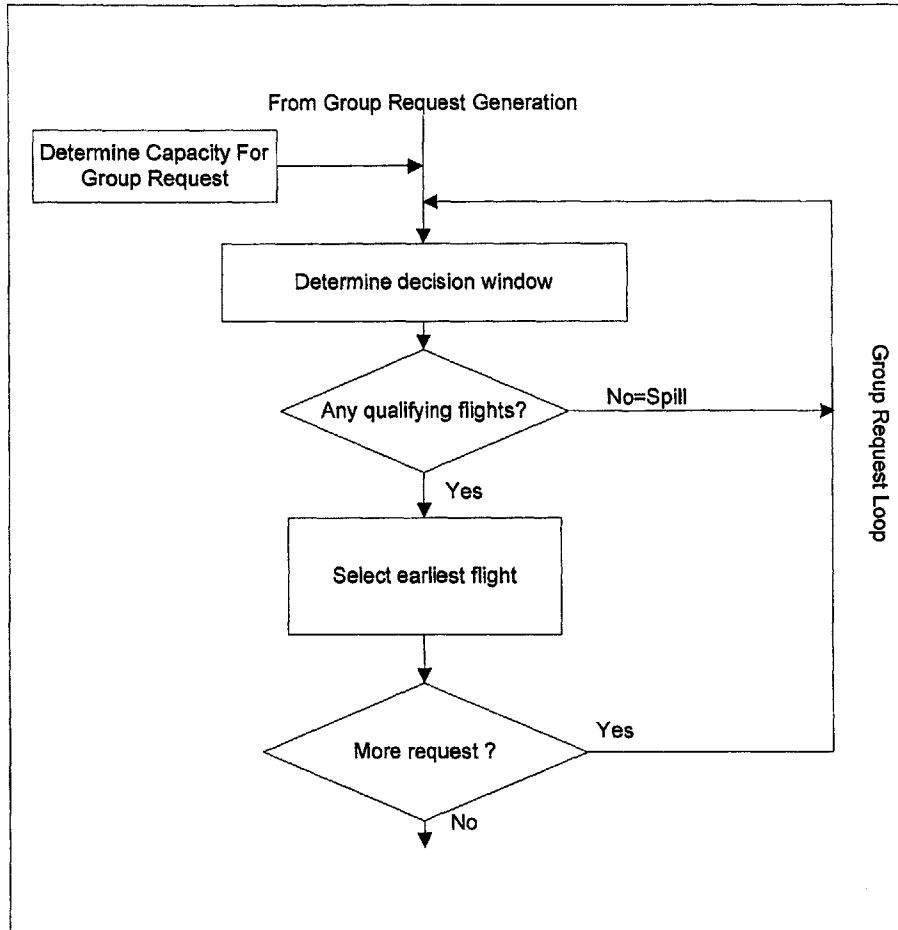


Figure 6-5 Allocate requests to flight

Step 1. Determine capacity for group request per flight

In the second step, we calculate the capacity for each flight to decide how many group requests we can accommodate on each flight. This is calculated as

$$\frac{(Cap - bi)}{u} = \frac{(Cap - bi)}{\frac{\sum_k b_k}{\sum_k S_k}} \quad (6.8)$$

Where

- Cap : Capacity of each aircraft
- bi : Final bookings for individual passengers, obtained from the most recent flights in the historical database
- u : Utilization rate for the flight
- b_k : Actual number of bookings for group request k that used the flight, obtained from the most recent flight in the historical database
- s_k : Size of group request k that booked the flight, obtained from historical database

As described in the previous chapter, not all passengers in the group request convert into actual passengers onboard. As a result, we need to increase the capacity allocated to group request by multiplying the inverse of utilization rate for the entire flight, which is calculated as (6.8).

Step 2. Determine decision window for each request

Similar to the individual demand in PODS, a time window is assigned to each group request generated in the request generation component explained in the previous section. The position of the time window is defined by the time of day demand curve, and the width of time window is calculated as a sum of delta-t defined by each market, and the schedule tolerance⁵⁵. Since time of day demand curve for group requests is hard to obtain and the objective of the trip can be treated similarly to the individual leisure passenger, the same time of day demand curve for individual leisure passengers is used for group request.

As for schedule tolerance, the value for individual leisure passenger is also used, assuming the behavior of group requests is likely to be the same as for individual leisure passenger. It can be said that the schedule tolerance for group requests is broader than for individual leisure passengers since travel agents don't set specific departure times for travel packages but set an approximate time (ex. around 2 to 5 pm)⁵⁶. However, with no empirical evidence to show a

⁵⁵ For further detail of delta-t and schedule tolerance, refer to Wilson (1995), pp. 51-52.

⁵⁶ However, since travel agents set no optional tour or sightseeing on the day of departure but send travelers to their hotel directly, there is no explicit difference in terms of tour package content whether passengers depart at 2 pm or 5pm.

significant difference between group requests and individual leisure in terms of schedule tolerance and demand of the day curve, and since the objective of both demands is the same, we think our assumption is plausible. The decision window attribute is kept and again used at 13 days before departure in which the group request is spilled and reallocation for such request is required.

Step 3. Allocate requests to each flight

In step 3, a group request is picked up from the aggregated group requests generated in the previous section and put into the allocating procedure shown in Figure 6-5. In this procedure, the group request is allocated to the “qualified” flight that both fits the decision window of the request, and has enough empty capacity to accept such a request. If there are multiple flights available to accommodate the group request, the earliest available flight is used for accommodation. If there is no flight available for the group request, then the request is spilled. This procedure is repeated until there is no group request awaiting allocation.

6.2.4 Calculate Actual Bookings and Reallocation

At 13 days before departure, all group requests are realized, and all group requests become actual bookings. Based on study of the sample data, and since travel agents need to pay a cancellation fee after 13 days before departure, we assume that no cancellation is made after this time, so that all realized bookings become actual passengers onboard.

Figure 6-6 shows the process for calculating actual bookings and reallocation. We have three steps to process this module, which are as follows:

- (1) Calculate Actual Booking per each group request
- (2) Create Unused Capacity Table and Spilled Group Table
- (3) Reallocation

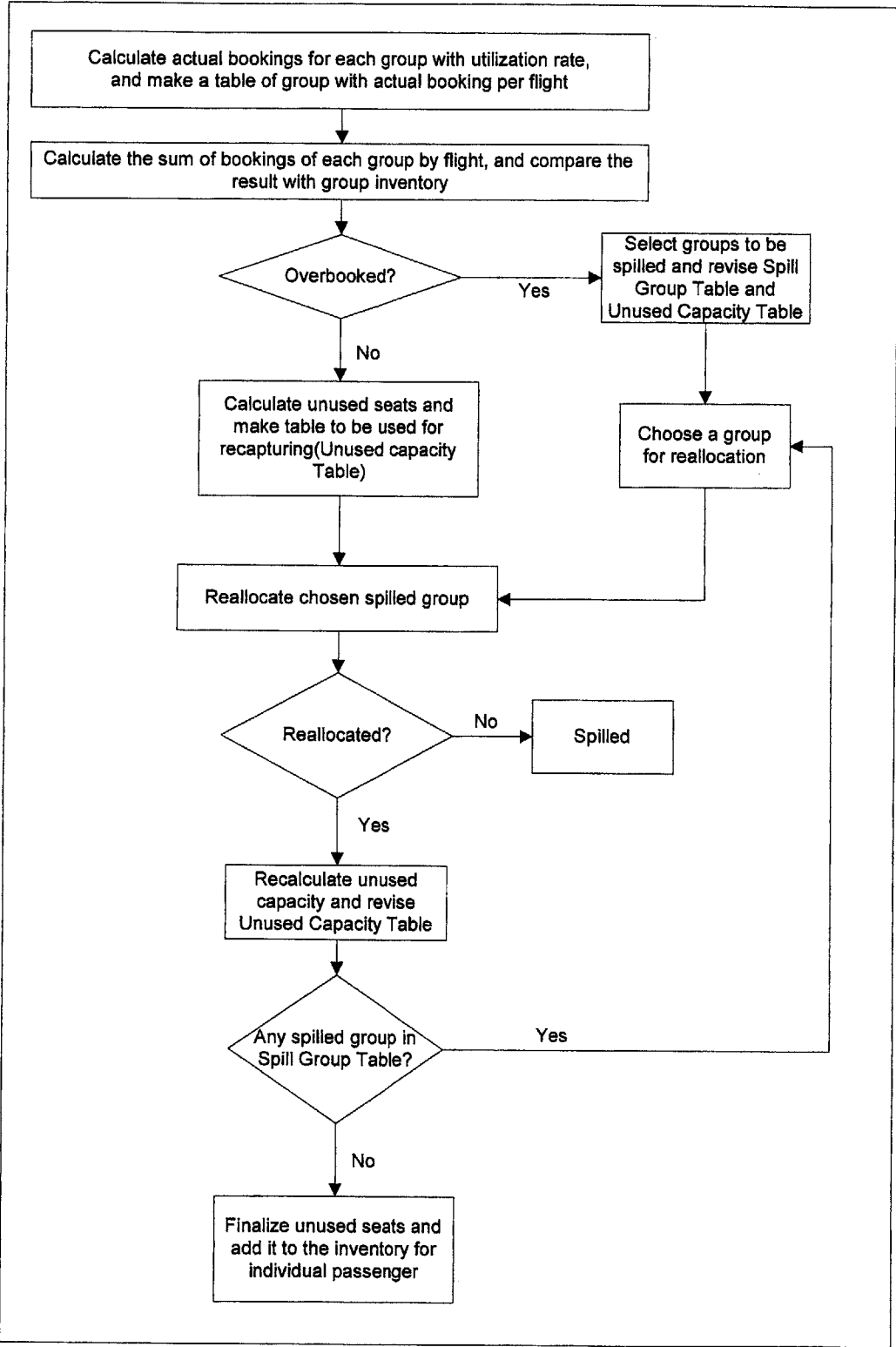


Figure 6-6 Booking Allocation

Step 1. Calculate Actual Booking per each group request

Using the utilization rate attributed to each group request, actual bookings are calculated as follows:

$$s_k \times u_k = b_k \quad \text{for all group request } k \quad (6.9)$$

Step 2. Create Unused Capacity Table and Spilled Group Table

The sum of actual bookings per flight is then compared to the actual capacity allocated for group passengers as,

$$(Cap - bi) - \sum_k b_k = r_f \quad (6.10)$$

Where

Cap : Capacity of flight f , same as the one used in (6.8)

bi : Final bookings for individual passengers, same as the one used in (6.8)

b_k : Actual bookings per request k in flight f

r_f : Residual of the first and second term

If r_f is between zero and four, then the group inventory for flight f is closed since this flight cannot accept a group for which the booking per group is greater than five.

If r_f is more than five, the value of r_f is recognized as unused capacity, and it will be used for spilled group bookings. Such unused capacity is stored in the Unused Capacity Table for reallocation process.

And if r_f takes a negative value, it means that this flight is overbooked. As a result, small group shall be spilled first, and the size will increment until enough groups are spilled and the sum of

remaining actual bookings is less than capacity with the difference smaller than five⁵⁷. New table, Spill Group Table, is made to list spilled groups for reallocation.

Some examples described as to how r_f works.

[Example 1. $0 < r_f < 4$]

Assume we have Flight 101 with the $Cap = 200$ seats and bi as 153. In this case, $(200-153)=47$ seats are allocated to accommodate group bookings in this flight. For this flight, we have three group requests that have 15, 20, 10 bookings, respectively. In this case, (6.10) is calculated as

$$(200-153) - (15+20+10) = 2$$

And $r_f=2$. In this case, since the minimum size of group bookings is 5, this flight cannot accommodate any more group bookings.

[Example 2. $r_f > 5$]

Assume we have Flight 102 with the $Cap = 200$ seats and bi as 143. In this case, $(200-143)=57$ seats are allocated to accommodate group bookings in this flight. For this flight, we have three group requests that have 15, 20, 10 bookings, respectively. In this case, (6.10) is calculated as

$$(200-133) - (15+20+10) = 12$$

And $r_f=12$. In this case, this flight can still accommodate some group requests such as (1) a group with 10 bookings, or (2) two groups with 5 bookings each, so that the r_f value is stored in the Unused Capacity Table for reallocation.

[Example 3. $r_f < 0$]

⁵⁷ It is intuitively understandable since a large size group is hard to accommodate again, and it might be spilled to other airlines.

Assume we have Flight 103 with the $Cap = 200$ seats and bi as 163. In this case, $(200-163)=37$ seats are allocated to accommodate group bookings on this flight. For this flight, we have three group requests that have 15, 20, 10 bookings, respectively. In this case, (6.10) is calculated as

$$(200-163)-(15+20+10) = -8$$

And $r_f = -8$. In this case, this flight is overbooked, so that the smallest group that has 10 bookings has to be spilled, and stored into Spill Group Table for reallocation. And with two bookings, 15 and 20 bookings, r_f is recalculated as

$$(200-163)-(15+20) = 2$$

So this flight closes its inventory for group bookings. Note that we will need to add value of recalculated r_f to Unused Capacity Table if r_f exceeds 5. For example, we have Flight 104 with the $Cap = 200$ seats and bi as 173. In this case, $(200-173)=27$ seats are allocated to accommodate group bookings in this flight. For this flight, we have three group requests that have 15, 20, 10 bookings, respectively. In this case, (6.10) is calculated as

$$(200-173)-(15+20+10) = -18$$

In this case, we need to displace two group requests with 10 bookings and 15 bookings, so that the recalculated r_f is

$$(200-173)-(20) = 7$$

Since this flight can accommodate a group with 5 bookings, the value of r_f is stored into the Unused Capacity Table.

Step 3. Reallocation

In a reallocation process, large spilled groups are given priority to be accommodated first. A spilled group is selected from Spill Group Table with its original decision window to search for the candidate, and search flights within the window. If there are any flights available, then one of the flights with the same airline is selected and the spilled group is accommodated. For example, if there is a group spilled from airline 1 in the market, and two flights, F101 that airline 1 operates and F102 that airline 2 operates, are available, then the group first selects F101. If there is no available flight with the same airline, then such a group is accommodated by another airline. And if there is no flight available in the market for a spilled group, the spilled group cancels the trip itself, and such group is deducted from the Spill Group Table.

Reallocation process continues until no spilled group is in Spill Group Table, and the rest of unused capacity is brought back to the inventory for individual passengers to increase capacity for such passengers.

6.3 Summary

A brief review of PODS was presented in the first section of this chapter, then group booking process model was developed. This model will be incorporated to use in PODS, and it will be explained in the next chapter.

Chapter 7

Analysis of Impacts of Revenue Management

In this chapter, the PODS9DJ, modified to simulate Japan's domestic market, is explained first. Then, impacts in the current market, in which three airlines are competing, are tested using PODS9DJ by changing revenue management methods of the airlines. Finally, in order to evaluate the impacts of the integration of Japan Airlines and Japan Air System in 2004, scenarios that simulate the market after the integration of airlines are tested.

7.1 PODS9DJ

7.1.1 Major modification to PODS9DJ

The PODS9DJ is developed to incorporate the booking process for group passengers, based on the group booking model in Chapter 6. Since PODS was originally designed to simulate for individual passengers, and it is cumbersome to incorporate every feature of the model in the previous chapter, we decided to modify PODS to include the fundamental concepts of the model. Major changes are described below.

Group Request Generation

In 6.2.2, we defined the PMF of group size and number of group per flight to generate group requests. However, to make our model easy to implement, we impose an assumption that the group size follows the normal distribution, and the mean of the size is equal to 10. Passenger behavioral attributes, such as disutility costs to unfavorable airlines and replanning, are set as equal to individual leisure passengers.

Group Booking Process

The group booking process we modeled consists of two steps, group request allocation and group booking allocation, as defined in Figure 6-3. The first step is to allocate group requests to each flight, and such group requests are realized as group bookings in 14 days before departure. In order to simulate this step, we first create an additional time frame, which is 70 days before departure. Since the previous time frame starts 63 days before departure, the new time frame

comes at the beginning of the series of time frames, thus the number of time frames increases from 16 to 17. This new time frame is used exclusively for group bookings, and individual passengers start their bookings at 63 days before departure, same as the previous version of PODS.

As defined in 6.2.2, the group request has a utilization rate that is 0 or 1. The PMF for the utilization rate is defined in (6.4), and it indicates that 56% of total group requests are cancelled. In order to simulate this behavior, a cancellation rate, used to simulate the rate of cancellation during each time frame for individual passengers, is also applied to group passengers as a substitute of utilization rate. A cancellation rate of 0.6 is set for time frame 11, which ends 14 days before departure, and it means that only 60% of total requests are cancelled before 14 days prior to departure.

Fare Class

There are four fare classes for individual passengers in current PODS setting, but they cannot be used for group passengers. Also, unlike individual passengers, group passengers can use only one fare class as defined in chapter 6. Therefore, a fifth fare class is added and used only for group passengers, by closing its booking limit at the first time frame, 70 days before departure. No restriction is applied to the fifth fare class, as all group passengers make bookings with the fifth fare class. Table 7-1 summarizes the major changes of settings for PODS9DJ.

Table 7-1 Major changes of settings for PODS9DJ

Parameter	Previous PODS version	PODS9DJ
Number of passenger type	2 (Business, Leisure)	3 (Business, Leisure, Group)
Number of time frame	16	17 (70 days before departure added)
Booking demand	Individual passenger bookings start 63 days before departure	Group passenger booking demand exists only in the first time frame (70 days before departure) Individual passenger demand is the same as previous setting, and no booking demand in the first time frame
Cancellation rate	No cancellation in each time frame	Set cancellation rate as 0.6 in time frame 11 for group passenger No cancellation for individual passengers
Number of fare classes	4	5 (fifth exclusively for group)

7.1.2 Input parameters

In the past research such as Lee (1998), a network-based market has been used to simulate the market in which connecting passengers take a significant role. However, such a market setting is not appropriate for Japan's domestic market that has three major characteristics, as explained in Chapter 2:

- Short range, short flight time
- High concentration on specific (major) routes
- Non hub and spoke structure

Based on characteristics shown above, we can assume that there is a negligible percentage of connecting passengers in this market, as most passengers are on single leg trips. Also, since this market can be considered as the aggregate of single-leg routes, and no interaction among routes in terms of passenger flow can be expected, choosing one single but major route and using it for simulation is an adequate way to obtain base case results for this market. We can extend the same approach used for a single leg to all other routes in which we need to obtain the results for the entire market, but it is beyond our scope.

Market used in simulation

A single, non-stop route that connects Tokyo and a major local city is selected for simulation. Current market conditions, such as the number of flights per day, capacity of each leg (flight), are used as input parameters. We obtained a certain amount of data from published material, such as air traffic statistics by the government, and the timetable of each airline and so on. However, due to confidentiality issues, some airline-specific data, such as passenger distribution over fare class, unpublished group fares and so on, were not obtained. Therefore, we used the specific data received from one airline and applied it to others if the same type of the data could not be obtained.

Table 7-2 shows the summary of major market conditions. Three airlines are operating a total of 38 flights per day. Of all 38 flights, Airline 1 operates 14 flights per day, and Airline 2 and 3 operates 11 and 13 flights, respectively. The capacity of each airline is also presented in the table, and Airline 1 has the largest capacity due to its large flight frequency and aircraft size. The capacity of Airline 2 is 54% of the capacity of Airline 1, although the ratio is 79% for the number of flights. It means that Airline 2 operates smaller aircraft than Airline 1. Airline 1 also has the highest load factor in this market while Airline 2 has the lowest, indicating that Airline 2 has the smallest market share. In fact, the market share of Airline 2 is 20%, almost the half of the others.

The parameters we explained above are explicit and can be obtained from market statistics, but the last parameter, airline preference, is quite different. This parameter defines how passengers select each airline if all conditions, such as price and schedule, are the same. If all airlines have preference equal to 1.0 and all other factors are equal, passengers will be equally distributed to each airline. However, it is not the case in our settings, and Airline 2 has a very low market share. Indeed, if we run PODS with current settings and airline preferences equal to 1.0 for all airlines, then market share of Airline 2 increases more than its current share of 20%. Consequently, the airline preference is calculated and adjusted so that the PODS result matches the current market condition, and it is 1.0, 0.45, and 0.9 for Airline 1, Airline 2, and Airline 3, respectively.

It is astounding that Airline 2's preference is about half of other airlines, but some reasons can be postulated. One of the major reasons for Airline 2's low preference is its low brand image.

Airline 2 has long been a minor airline connecting local-to-local cities, and aircraft it owns has been relatively smaller than other airlines, making its image less attractive to passengers accustomed to flying in a large cabin. Also, its frequent flyers program is less appealing than other airlines' program due to its small network.

Table 7-2 Summary of major market conditions

Parameter	Total	Airline 1	Airline 2	Airline 3
Number of flights per day	38	14	11	13
Capacity	15,438	6,303	3,392	5,743
Load Factor	73%	75%	68%	74%
Market share	100%	42%	20%	38%
Airline Preference		1.0	0.45	0.9

Fare structure and demand distribution

Five fare classes are implemented and tested, and four fare classes with three restriction categories are used solely for individual passengers. The typical example of fare class structure used in past research can be found in Lee⁵⁸, and those are Y, B, M, and Q (base fare) with the face value of \$800, \$400, \$300, and \$200, respectively. The highest fare is four times higher than the lowest. For Japan's domestic market, such a difference is rather small, possibly making the effect of the revenue management less than the past results.

Table 7-3 shows the summary of fare classes with restriction categories. The index of the fare is calculated using the information provided by an airline, but due to confidentiality, a current default setting of 207.4 is used as a base fare. The last time frame for each fare class shows when the fare class is closed. For example, FCLS3 is an advanced purchase fare product, so its last time frame is 9, which is 28 days before departure. The far right column of table 7-3 shows the percentage of total enplanements observed.

⁵⁸ Lee (1998), pp. 46-48.

Table 7-3 Summary of fare classes

Description	Value (\$)	Index	Last Time Frame (Days Before Departure)	% Of Total Enplanements
FCLS1	469.3	2.26	16 (1)	26%
FCLS2	391.9	1.89	16 (1)	26%
FCLS3	367.4	1.77	9 (28)	11%
FCLS4	207.4	1.00 (base fare)	11 (14)	19%
GRP	165.9	0.80	1 (70)	18%

Table 7-4 shows the summary of restriction categories applied. Three restrictions are used, and as the value of fare goes down, the number of restrictions applied to the fare class increases. For example, FCLS1 has no restriction, but all restrictions are applied to FCLS4. As for the GRP fare, no restriction is put into effect. This is because only group passengers use this fare so that there is no need to apply restriction categories for differentiation.

Table 7-4 Summary of restriction categories

Restrictions	1	2	3
Description	High Refund Charge	Advance Purchase	Purchase As A Part Of Travel Package
FCLS1	No	No	No
FCLS2	Yes	No	No
FCLS3	Yes	Yes	No
FCLS4	Yes	Yes	Yes
GRP	No	No	No

Passenger type oriented parameters

Based on fare classes and restrictions shown above, as well as passenger distribution over fare classes, we then decide passenger type parameters, such as an elasticity multiplier, disutility costs for each restriction category, and so on. In past research, the disutility costs were based on the market research conducted at Boeing⁵⁹, but they are not applicable to the market we use. In order to decide the parameters, following steps are used:

⁵⁹ Wilson (1995), pp. 59-60.

1) Decide the ratio of passenger type

The route we model connects Tokyo and a major local city, and the city is famous as a business center in this region as well as a gateway for sightseeing tours. From this standpoint, we place an assumption that about 50% of total passengers use this route for business purpose, and the rest for leisure trip. Hence, individual business passengers take almost half of the total demand, and individual leisure and group passengers share the rest. Since group passengers use a different fare class and they account for 18%, determined from the rate of group fare class used, with individual leisure passengers making up the rest, 32%.

2) Create booking curves for each passenger type

Based on the ratio set in step 1 and the booking curve of each fare class, booking curves for two passenger types are created as Figure 7-1. Similar to the booking curves used in the past PODS settings, most individual leisure travelers book earlier than individual business travelers. Group requests, on the other hand, are assumed to make bookings only at 70 days before departure; therefore they have no booking curve. The ratio of each passenger type at the specific time frame is used as an input of PODS to decide the demand at the the given time frame.

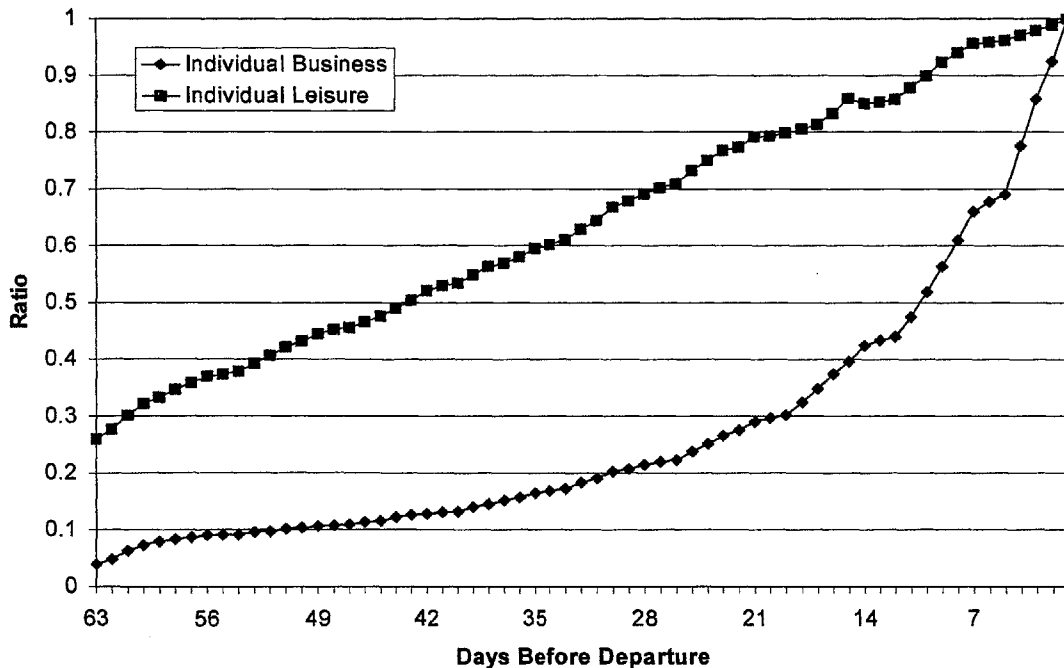


Figure 7-1 Booking curves for business and leisure passengers

3) Set elasticity multiplier, basefare multiplier, and disutility costs for each restriction category

In PODS, there are four parameters that decide the distribution as:

- Elasticity multiplier ($Emult$)
- Business basefare multiplier ($Bfbmult$)
- Leisure basefare multiplier ($Bflmult$)
- Coefficient of disutility cost assigned to restriction category ($Crstint$, $Crstslp$)

The first parameter, $Emult$, is the input multiple of basefare for each passenger type at which the probability a random passenger of each type in market will travel is equal to 0.5⁶⁰. Using $Emult$, the elasticity of demand with respect to the price is described as

$$(\varepsilon_t)_{D,P} = -\left(\frac{f}{fb_t}\right) \times \left(\frac{0.6931}{Emult_t - 1}\right) \quad (7.1)$$

Where

- $(\varepsilon_t)_{D,P}$: Elasticity of demand with respect to price, for passenger type t
- f : Fare
- fb_t : Input base fare, passenger type t

As shown in (7.1), elasticity of demand is set with a combination of $Emult$ and base fare for each passenger type. The second and third parameters, $Bfbmult$ and $Bflmult$, are used to calculate the input base fares of business and leisure passengers, respectively, by multiplying them to the base fare of the market. Since we define the business type passenger as inelastic to the price and leisure type passenger as elastic, the elasticity of demand shall not exceed the absolute value of 1.0 for business passenger at any fare, but shall exceed 1.0 for leisure passenger.

⁶⁰ Lee (1998), pp. 87-89.

The fourth parameter, coefficient of disutility cost assigned to restriction category, specifies the constraint to each fare class, and such constraint prevents business passengers from using lower fare classes while it attracts leisure passengers to use lower fare classes.

In order to match the demand over fare class represented in Table 7-3, we need to run PODS repeatedly with a different set of parameters. The parameters we obtained are presented in Table 7-5. With these settings, the elasticity for business passengers at any fare class falls within -1 and 0 , representing that they are price inelastic. On the other hand, the absolute value of the elasticity for leisure passengers always exceeds 1 , and it indicates that they are always price elastic.

Table 7-5 Emult, base fare multiplier and disutility cost coefficients used

Parameter	Individual Business		Individual Leisure		
Emult	3.10		1.57		
Bfbmult, Bfmult	1.90		1.00		
Disutility cost					
		Crstint	Crstslp	Crstint	Crstslp
	Restriction 1	3.00	0.20	0.70	0.01
	Restriction 2	2.00	0.07	0.70	0.09
Restriction 3	3.00	0.97	3.50	2.95	

Other PODS input parameters

Other input parameters that are not stated above remain the same as the past PODS setting described in the past research, such as Zickus⁶¹.

7.2 Impacts against current market condition

7.2.1 Base Case

The first simulation we ran is a ‘base case’, which represents the Japan’s current domestic market. All airlines in the market are assumed to use First Come First Serve (FCFS) as a revenue

⁶¹ Zickus (1998), pp. 60-61.

management method. A single leg, for which parameters to describe the leg are explained in Table 7-2, is used. Table 7-6 shows the base case result.

Due to different settings given to each airline, the result for each airline is significantly different. Airline 1, which has the largest market share, gains the highest revenue owing to the highest load factor and large capacity. Airline 2, on the other hand, has the lowest revenue because of its low load factor and smallest capacity. The last player in the market, Airline 3, gains lower revenue than that of Airline 1, but still its revenue highly exceeds the revenue of Airline 2.

Table 7-6 Base case result

BASE				LOADS (Absolute Value, Per Day)					
A/L	L/F	REVENUE ⁶²	YIELD ⁶³	TTL	FCLS1	FCLS2	FCLS3	FCLS4	GRP
1	75.00	1,576,965	0.6001	4726.00	1242.10	1205.94	525.29	907.50	845.17
2	68.11	784,358	0.6102	2311.80	638.90	613.00	251.40	428.80	379.70
3	73.96	1,420,005	0.6015	4245.80	1124.30	1088.70	470.60	810.70	751.50

7.2.2 Revenue Management method change by a single airline

The first scenario we test is how a revenue management method change by an airline will affect the market. In the base case, all airlines use FCFS (i.e. no revenue management method is applied), but in this scenario, an airline starts using Fare Class Yield Management (FCYM), based on forecasting and EMSRb optimization. As for the forecasting and detruncation method, three sets of methods are taken into consideration:

- 1) Pick Up forecasting and No detruncation (PU+No Det)
- 2) Pick Up forecasting and Booking Curve Detruncation (PU+BC)
- 3) Regression Forecasting and Booking Curve Detruncation (REG+BC)

It is beyond our scope to discuss the theory of forecasting and detruncation methods used, and exhaustive work as to the effect of those methods can be found in the past research, such as

⁶² Revenues in tables hereafter are all in US dollars.

⁶³ Yields in tables hereafter are all in US dollars.

Zickus (1998)⁶⁴. In order to investigate the effects of the change in methods, these sets are tested in every scenario.

Scenario 1. Only Airline 1 uses FCYM

Figure 7-2 shows the revenue change over the base case in this scenario, and Table 7-7 represents the Major Parameter Changes for each airline.

As expected, the revenue of Airline 1 increases in all cases while other airlines lose their revenue. Such revenue gain and loss comes from the way they accept bookings. The load factor of Airline 1 goes down in all cases, whereas others increase the load factor, accepting more bookings. However, despite the decrease of total bookings, Airline 1 accepts more bookings in FCLS1 and FCLS2 in all cases, and reduces the number of bookings in FCLS4 and GRP. Consequently, the yield goes up, resulting in a revenue increase. Airline 2 and 3 increase their load factor, but contrary to Airline 1, the number of bookings in higher fare classes are reduced but increased in lower fare classes, resulting in a yield decrease.

⁶⁴ Zickus (1998), pp. 23-37.

Revenue Change, Only AL1 uses EMSRb (L/F=75%)

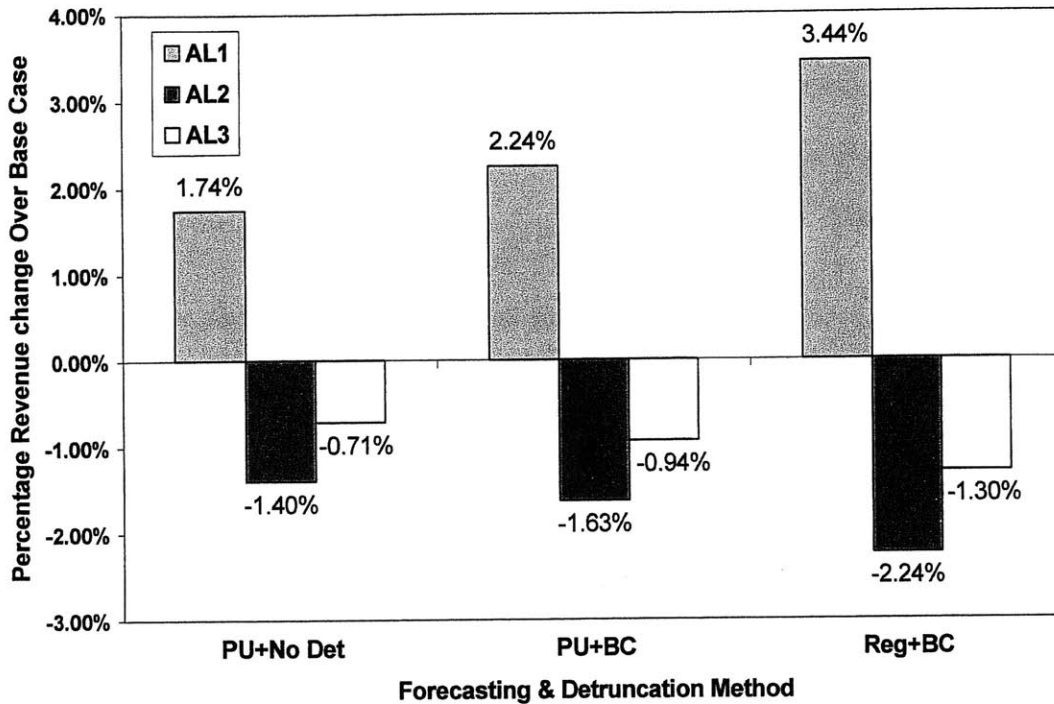


Figure 7-2 Scenario 1. Revenue change over Base case

Table 7-7 Scenario 1. Major parameter changes

Base				Loads (Absolute Value)					
A/L	L/F	REVENUE	YIELD	TTL	FCLS1	FCLS2	FCLS3	FCLS4	GRP
1	75.00	1,576,965	0.6001	4726.00	1242.10	1205.94	525.29	907.50	845.17
2	68.11	784,358	0.6102	2311.80	638.90	613.00	251.40	428.80	379.70
3	73.96	1,420,005	0.6015	4245.80	1124.30	1088.70	470.60	810.70	751.50
Case 1. PU+No Det				Loads change (compared to base case)					
1	74.50	1,604,428	0.6148	-0.68%	5.70%	4.38%	3.20%	-10.75%	-8.87%
2	68.52	773,408	0.5982	0.59%	-3.80%	-3.41%	-5.29%	8.62%	9.28%
3	74.16	1,409,884	0.5956	0.28%	-1.83%	-1.60%	-3.24%	3.36%	5.05%
Case 2. PU+BC				Loads change (compared to base case)					
1	73.76	1,612,249	0.6240	-1.66%	7.67%	5.57%	7.09%	-8.59%	-23.71%
2	69.08	771,596	0.5919	1.42%	-4.75%	-4.22%	-7.67%	4.05%	23.95%
3	74.52	1,406,718	0.5914	0.77%	-2.50%	-2.10%	-5.41%	0.40%	14.06%
Case 3. REG+BC				Loads change (compared to base case)					
1	73.77	1,631,204	0.6312	-1.65%	17.62%	2.80%	-1.65%	-13.60%	-23.47%
2	69.05	766,800	0.5885	1.37%	-7.15%	-4.96%	-7.00%	8.15%	23.82%
3	74.52	1,401,612	0.5893	0.76%	-3.93%	-2.58%	-5.21%	2.81%	14.13%

In order to review effects of forecasting and detruncation methods, we then give a brief review of each case. In Case 1, we used pickup forecasting, and it contributed a revenue increase by accepting more bookings in higher fare classes while reducing bookings in lower fare classes. Of the lower fare classes, load in FCLS4, the lowest fare for individual passengers, decreased more than the load in GRP fare class.

The tendency for accepting booking requests at each airline is mostly the same in Case 2, but the change in the total number of bookings is more significant than Case 1. Especially, in this case, the reduction of the load in GRP fare class is substantial (-23.7%), owing to the booking curve detruncation method adopted in Case 2. Also, in this case, the decrease of load in FCLS4 is less than Case 1.

In Case 3, regression forecasting is used instead of pickup forecasting, but the method of detruncation remains the same. The change in total load is almost the same for all airlines, but loads of higher fare classes changed significantly. There is a high rate of increase in FCLS1 (17.6%) for Airline 1, making the revenue gain the highest. Other fare classes for individual passengers, from FCLS2 to FCLS4, decreased the ratio of increase compared to Case 1 and 2. As for GRP load, the change in forecasting method does not affect them, and the load for GRP decreased a little.

Scenario 2. Only Airline 2 uses FCYM

Figure 7-3 and Table 7-8 show the result of scenario 2, where only Airline 2, the weaker carrier in this market, uses FCYM.

Revenue Change, Only AL2 uses EMSRb (L/F=75%)

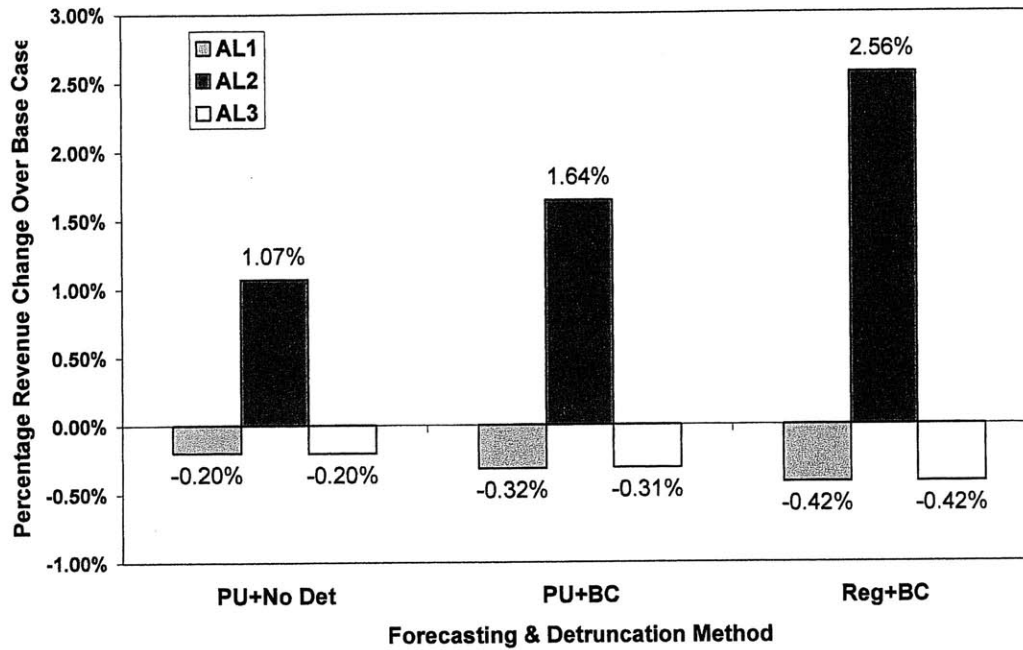


Figure 7-3 Scenario 2. Revenue change over Base case

As illustrated in Figure 7-3, Airline 2 gains a revenue increase from 1 to 2.6%, depending on the forecasting and detruncation method it uses. As for other carriers in the market, their revenue losses are less than the revenue loss of Airline 2 and 3 in Scenario 1, where a dominant carrier adopts a revenue management method.

The tendency of the load change in each case shown above is the same in Scenario 1, but the magnitude of change of load is much smaller than the previous scenario. This might be because of its low market share results in less significant effects of the implementation of FCYM.

Table 7-8 Scenario 2. Major parameter changes

Base				Loads (Absolute Value)					
A/L	L/F	REVENUE	YIELD	TTL	FCLS1	FCLS2	FCLS3	FCLS4	GRP
1	75.00	1,576,965	0.6001	4726.00	1242.10	1205.94	525.29	907.50	845.17
2	68.11	784,358	0.6102	2311.80	638.90	613.00	251.40	428.80	379.70
3	73.96	1,420,005	0.6015	4245.80	1124.30	1088.70	470.60	810.70	751.50
Case 1. PU+No Det				Loads change (compared to base case)					
1	75.00	1,573,844	0.5990	-0.01%	-0.45%	-0.38%	-0.69%	0.99%	0.53%
2	68.06	792,733	0.6172	-0.07%	3.17%	2.31%	0.91%	-6.45%	-2.81%
3	73.98	1,417,095	0.6001	0.04%	-0.55%	-0.42%	-0.75%	1.31%	0.69%
Case 2. PU+BC				Loads change (compared to base case)					
1	75.08	1,571,980	0.5976	0.10%	-0.75%	-0.63%	-1.40%	0.75%	2.64%
2	67.72	797,217	0.6239	-0.58%	4.78%	3.53%	4.34%	-7.05%	-12.18%
3	74.08	1,415,610	0.5986	0.17%	-0.82%	-0.70%	-1.51%	1.02%	3.06%
Case 3. REG+BC				Loads change (compared to base case)					
1	75.10	1,570,377	0.5969	0.12%	-1.32%	-0.68%	-1.19%	1.43%	2.81%
2	67.67	804,455	0.6300	-0.65%	13.38%	-0.25%	-2.12%	-10.69%	-12.62%
3	74.09	1,414,065	0.5979	0.18%	-1.43%	-0.74%	-1.18%	1.74%	3.11%

Scenario 3. Only Airline 3 uses FCYM

The last scenario in this section is that only Airline 3 uses EMSRb and changes its forecasting and detruncation method. Figure 7-4 and Table 7-9 show the result. Again, revenue for Airline 3 increases, but slightly lower than revenue increase of Airline 1 in Scenario 1. Airline 2 suffers revenue loss, and the ratio of decrease is much the same as the ratio of decrease observed in Scenario 1.

The tendency of the load change in each case shown above is similar to Scenario 1, and the magnitude of change of load is close to the change of Airline 1 in Scenario 1.

Revenue Change, Only AL3 uses EMSRb (L/F=75%)

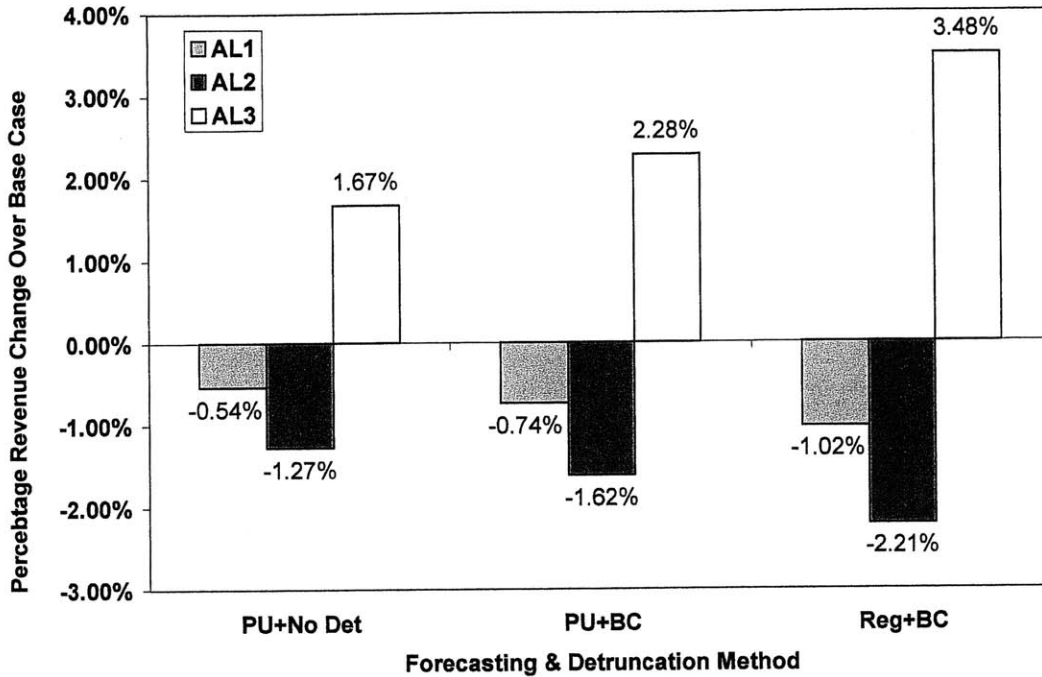


Figure 7-4 Scenario 3. Revenue change over Base case

Table 7-9 Scenario 3. Major parameter changes

Base				Loads (Absolute Value)					
A/L	L/F	REVENUE	YIELD	TTL	FCLS1	FCLS2	FCLS3	FCLS4	GRP
1	75.00	1,576,965	0.6001	4726.00	1242.10	1205.94	525.29	907.50	845.17
2	68.11	784,358	0.6102	2311.80	638.90	613.00	251.40	428.80	379.70
3	73.96	1,420,005	0.6015	4245.80	1124.30	1088.70	470.60	810.70	751.50
Case 1. PU+No Det				Loads change (compared to base case)					
1	75.08	1,568,519	0.5963	0.10%	-1.25%	-1.05%	-2.36%	2.17%	3.05%
2	68.42	774,365	0.5998	0.45%	-3.36%	-2.96%	-4.97%	7.99%	7.44%
3	73.62	1,443,714	0.6144	-0.46%	5.15%	3.96%	3.09%	-9.79%	-7.38%
Case 2. PU+BC				Loads change (compared to base case)					
1	75.34	1,565,302	0.5931	0.44%	-1.79%	-1.50%	-4.25%	0.58%	9.26%
2	68.93	771,657	0.5932	1.20%	-4.63%	-4.07%	-7.11%	4.99%	20.77%
3	72.95	1,452,354	0.6237	-1.36%	7.34%	5.41%	6.92%	-8.93%	-21.17%
Case 3. REG+BC				Loads change (compared to base case)					
1	75.32	1,560,826	0.5915	0.42%	-2.93%	-1.83%	-4.06%	2.46%	9.13%
2	68.87	767,009	0.5902	1.11%	-7.04%	-4.59%	-6.18%	8.57%	20.44%
3	72.98	1,469,482	0.6308	-1.32%	17.33%	2.31%	-1.47%	-13.79%	-20.94%

7.2.3 Two airlines change methods

In this section, we investigate how the change of methods of two airlines will affect the market. Three scenarios are tested, with different combination of airlines using FCYM. All airlines that used FCYM increased revenues, but the rate of increase changes in each scenario.

Scenario 1. Airline 1 and 2 implement FCYM

In this scenario, a dominant carrier and a weaker carrier use EMSRb and the same forecasting and detruncation method, whereas the second-best carrier, Airline 3, makes no change. Figure 7-5 and Table 7-10 show the result of simulation.

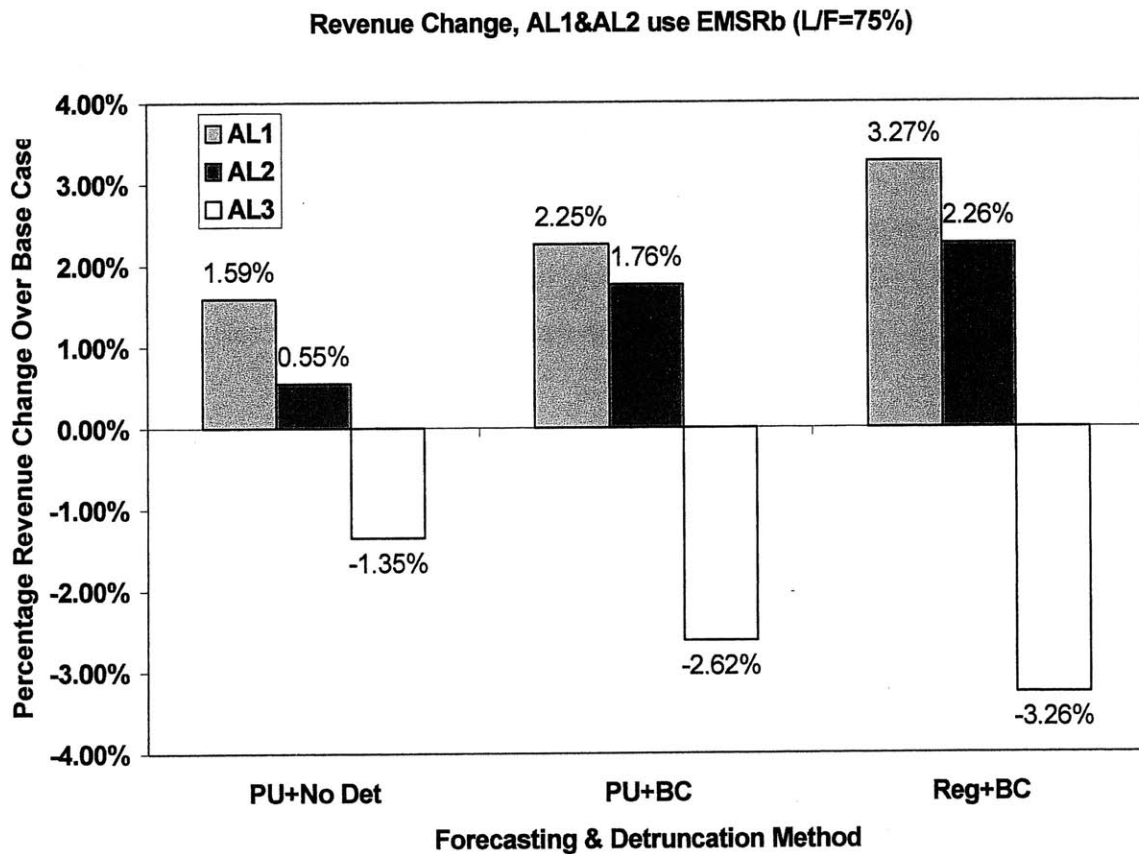


Figure 7-5 Scenario 1. Revenue change over Base case

Table 7-10 Scenario 1. Major parameter changes

Base				Loads (Absolute Value)					
A/L	L/F	REVENUE	YIELD	TTL	FCLS1	FCLS2	FCLS3	FCLS4	GRP
1	75.00	1,576,965	0.6001	4726.00	1242.10	1205.94	525.29	907.50	845.17
2	68.11	784,358	0.6102	2311.80	638.90	613.00	251.40	428.80	379.70
3	73.96	1,420,005	0.6015	4245.80	1124.30	1088.70	470.60	810.70	751.50
Case 1. PU+No Det				Loads change (compared to base case)					
1	74.46	1,602,041	0.6141	-0.72%	5.15%	4.32%	3.33%	-10.49%	-8.60%
2	68.25	788,688	0.6123	0.21%	1.25%	0.96%	0.80%	-3.47%	0.99%
3	74.09	1,400,826	0.5923	0.19%	-2.85%	-2.52%	-6.29%	4.09%	8.49%
Case 2. PU+BC				Loads change (compared to base case)					
1	73.80	1,612,522	0.6237	-1.61%	6.97%	5.69%	8.77%	-7.74%	-24.50%
2	68.24	798,152	0.6198	0.18%	2.89%	2.54%	9.12%	-3.70%	-9.70%
3	74.26	1,382,795	0.5834	0.41%	-4.37%	-3.84%	-14.45%	-6.13%	30.10%
Case 3. REG+BC				Loads change (compared to base case)					
1	73.78	1,628,527	0.6301	-1.64%	14.78%	4.89%	0.09%	-12.55%	-24.44%
2	68.09	802,052	0.6242	-0.03%	8.24%	1.19%	2.32%	-5.52%	-11.24%
3	74.17	1,373,678	0.5802	0.29%	-6.49%	-4.45%	-14.98%	-3.17%	30.60%

Compared to Scenario 1 of 7.2.2 where only Airline 1 uses FCYM, the revenue gain of Airline 1 goes down slightly. It is especially noticeable in Case 3 that the load increase in FCLS 1 for Airline 1 changes from 17.62% to 14.78%, resulting in the yield decrease. Unlike the high fare class, a huge load decrease in GRP for Airline 1 observed in the former scenario is also seen in this scenario.

As for Airline 2, the ratio of revenue increase drops from 1.07% to 0.55% in Case 1, compared to the Case 1 in the scenario that only Airline 2 uses FCYM. Compared to the loads change for Airline 2 in the former scenario, the breakdown of loads change for the airline in this case shows that the increase of load in FCLS1 is smaller than the former scenario, but the load in GRP increased, resulting in the yield decrease.

Airline 3, the ‘laggard ‘carrier in the market, loses revenue in the range of 1.35% to 3.26%. This revenue loss is larger than the sum of revenue loss in Scenario 1 and Scenario 2 in the previous section, indicating that the penalty for its laggardness becomes enormous if other airlines implement FCYM.

Scenario 2. Airline 2 and 3 implement FCYM

Figure 7-6 and Table 7-11 represent the result of simulation. The tendency of revenue change is similar to Scenario 1, and the revenue loss of Airline 1 is larger than the sum of the revenue loss of Airline 1 in Scenario 2 and 3 of section 7.2.2, in which Airline 2 and 3 use FCYM independently.

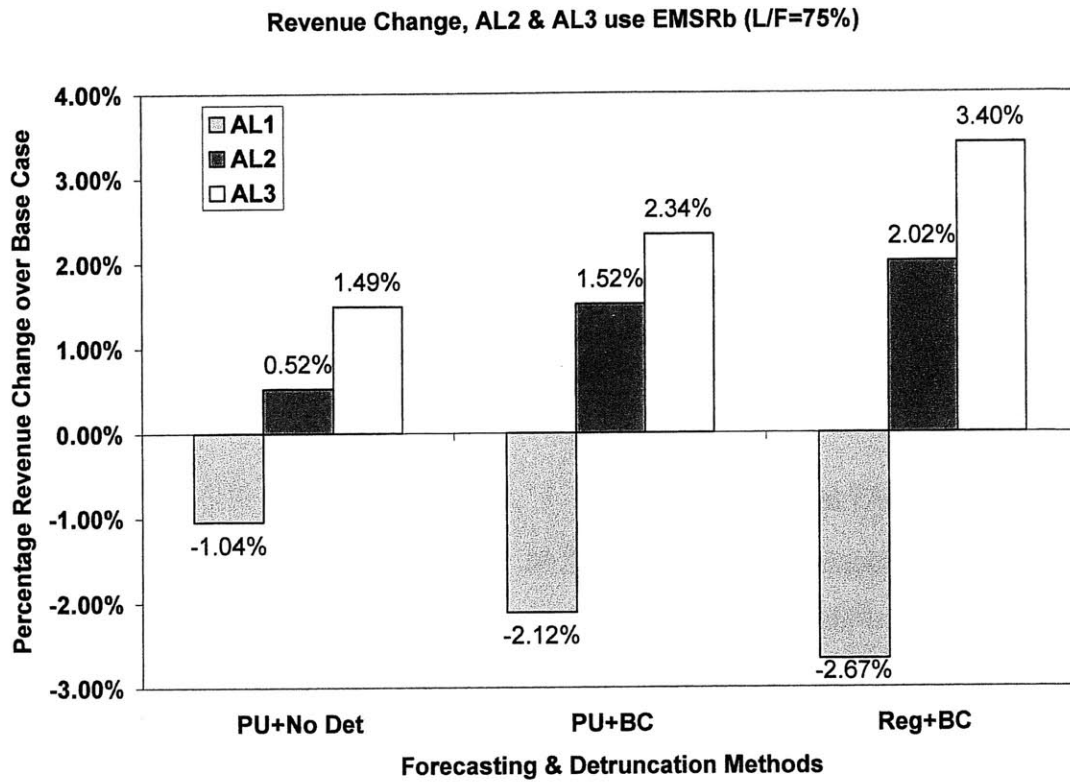


Figure 7-6 Scenario 2. Revenue change over Base case

Table 7-11 Scenario 2. Major parameter changes

Base				Loads (Absolute Value)					
A/L	L/F	REVENUE	YIELD	TTL	FCLS1	FCLS2	FCLS3	FCLS4	GRP
1	75.00	1,576,965	0.6001	4726.00	1242.10	1205.94	525.29	907.50	845.17
2	68.11	784,358	0.6102	2311.80	638.90	613.00	251.40	428.80	379.70
3	73.96	1,420,005	0.6015	4245.80	1124.30	1088.70	470.60	810.70	751.50
Case 1. PU+No Det				Loads change (compared to base case)					
1	75.06	1,560,529	0.5935	0.07%	-2.09%	-1.86%	-4.96%	3.25%	5.71%
2	68.19	788,458	0.6128	0.11%	1.32%	1.15%	0.42%	-3.78%	0.57%
3	73.54	1,441,185	0.6139	-0.56%	4.64%	3.83%	3.27%	-9.67%	-7.27%
Case 2. PU+BC				Loads change (compared to base case)					
1	75.18	1,543,592	0.5861	0.23%	-3.49%	-3.01%	-11.62%	-4.05%	22.27%
2	68.12	796,277	0.6194	0.02%	2.73%	2.37%	7.76%	-3.56%	-9.42%
3	73.00	1,453,211	0.6236	-1.29%	6.80%	5.55%	8.67%	-8.27%	-22.00%
Case 3. REG+BC				Loads change (compared to base case)					
1	75.12	1,534,883	0.5833	0.15%	-5.36%	-3.65%	-12.02%	-1.10%	22.55%
2	67.95	800,175	0.6240	-0.24%	8.31%	0.69%	1.40%	-5.94%	-10.76%
3	73.04	1,468,332	0.6298	-1.24%	14.78%	4.47%	0.03%	-13.06%	-21.51%

Scenario 3. Airline 1 and 3 implement FCYM

In this scenario, two dominant carriers adopt FCYM. Figure 7-7 and Table 7-12 show the result. Airline 1 and 3 have a slight decrease of revenue gain compared to the case where only one airline implements FCYM, but still obtains 1%-3% of revenue increase. On the contrary, Airline 2, the weaker carrier, suffers a huge revenue loss.

Loads change in Table 7-12 shows the fact that Airline 2 loses its high fare class passengers, and accepts a large amount of group passengers instead. An astoundingly higher rate of 76% load increase is observed for GRP in Case 2 and Case 3. Even if we take the smaller number of total load for Airline 2 into consideration, such an increase is worth noting. The booking curve detrunctation, which is applied to both cases, evidently contributed to the result. Another aspect to notice is that the FCLS4 loads of Airline 2 decreased in Case 2 and 3. In the previous scenario where Airline 2 suffers a revenue loss, such as Scenario 1 where Airline 1 uses EMSRb, the increase of load in FCLS4 contributed to the yield decrease (refer to Table 7-7), whereas only GRP load made a significant increase in this case. However, an opposite result occurred here.

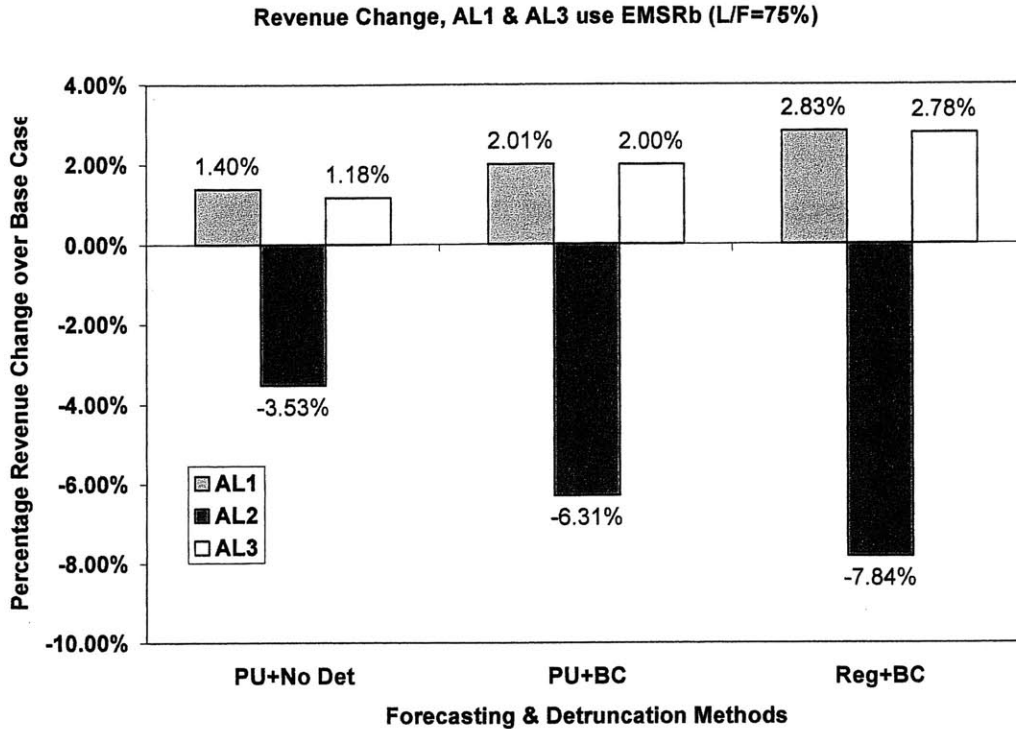


Figure 7-7 Scenario 3. Revenue change over Base case

Table 7-12 Scenario 3. Major parameter changes

Base				Loads (Absolute Value)					
A/L	L/F	REVENUE	YIELD	TTL	FCLS1	FCLS2	FCLS3	FCLS4	GRP
1	75.00	1,576,965	0.6001	4726.00	1242.10	1205.94	525.29	907.50	845.17
2	68.11	784,358	0.6102	2311.80	638.90	613.00	251.40	428.80	379.70
3	73.96	1,420,005	0.6015	4245.80	1124.30	1088.70	470.60	810.70	751.50
Case 1. PU+No Det				Loads change (compared to base case)					
1	74.37	1,599,058	0.6138	-0.85%	4.71%	4.17%	3.36%	-10.47%	-8.48%
2	68.56	756,681	0.5849	0.65%	-7.56%	-6.83%	-15.49%	10.00%	26.69%
3	73.46	1,436,810	0.6128	-0.67%	3.87%	3.41%	3.19%	-9.21%	-6.57%
Case 2. PU+BC				Loads change (compared to base case)					
1	73.73	1,608,614	0.6228	-1.70%	6.32%	5.34%	8.68%	-6.70%	-24.63%
2	68.65	734,856	0.5672	0.79%	-10.64%	-9.51%	-31.62%	-15.32%	76.33%
3	72.93	1,448,342	0.6222	-1.39%	5.81%	4.95%	8.91%	-6.86%	-21.90%
Case 3. REG+BC				Loads change (compared to base case)					
1	73.67	1,621,532	0.6283	-1.78%	12.23%	5.68%	1.12%	-11.15%	-24.78%
2	68.27	722,868	0.5611	0.23%	-14.91%	-11.27%	-32.04%	-9.21%	76.32%
3	72.90	1,459,480	0.6272	-1.43%	11.23%	5.42%	1.76%	-11.06%	-21.90%

7.2.4 All airlines change methods

The last possible situation is that all airlines implement FCYM at the same time. We expected a revenue increase for all airlines, but it turned out to be wrong.

Figure 7-8 displays the revenue changes over the base case, and Airline 1 and 3 made small revenue increases. However, surprisingly, Airline 2 loses revenue, even if it uses FCYM. In order to analyze the reason for such a revenue loss, we need to look at the Major Parameter Changes represented in Table 7-13. Compared to the base case, both load factor and yield of Airline 2 go down, causing a revenue decrease. Since the load factor for other airlines decreased as a result of using FCYM, we need to focus on how load in each fare class changed in Airline 2. The tendency of load change in Airline 2 is opposite to the pattern observed for the airline that adopted FCYM in the previous scenarios. Like Airline 1 and 3 in this case, loads increase in higher fare classes, and decrease in lower fare classes if an airline adopts FCYM. However, in Airline 2, loads decrease in higher fare classes, and increase in lower fare classes.

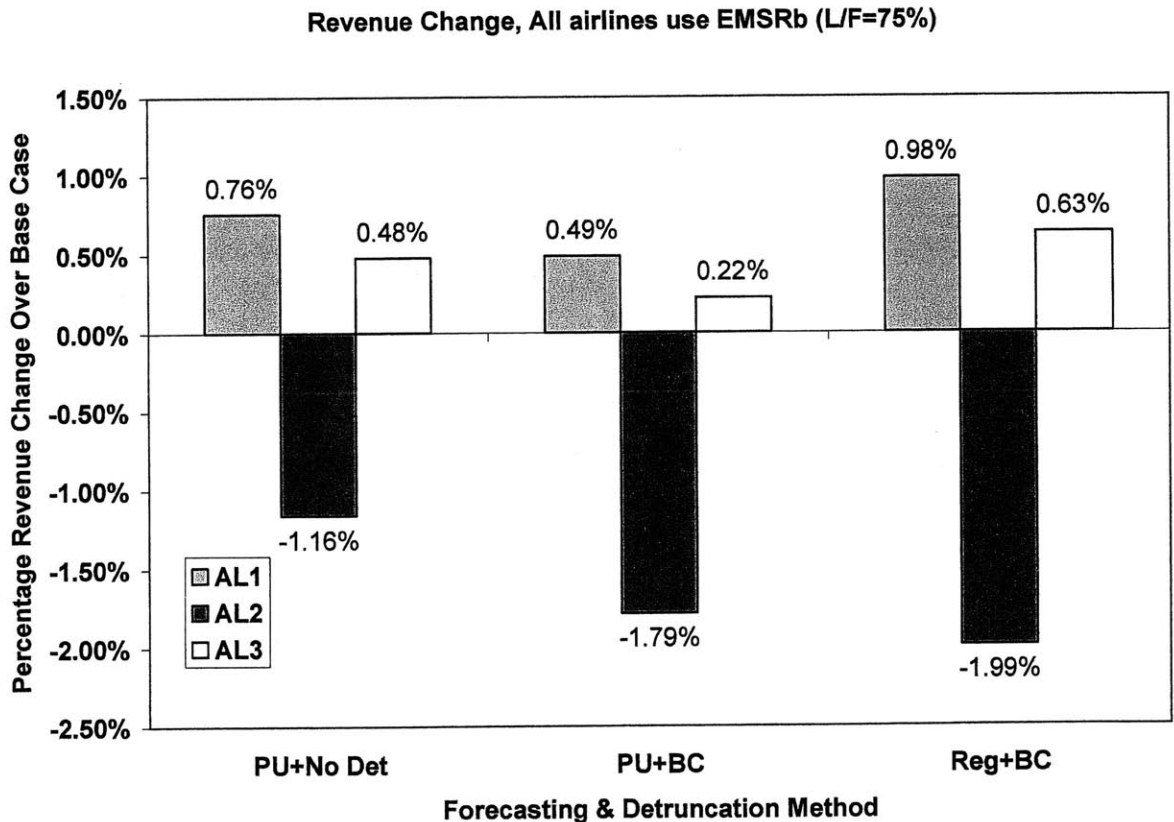


Figure 7-8 Revenue change over Base case, all airlines use FCYM

Table 7-13 Major parameter changes – all airlines use FCYM

Base				Loads (Absolute Value)					
A/L	L/F	REVENUE	YIELD	TTL	FCLS1	FCLS2	FCLS3	FCLS4	GRP
1	75.00	1,576,965	0.6001	4726.00	1242.10	1205.94	525.29	907.50	845.17
2	68.11	784,358	0.6102	2311.80	638.90	613.00	251.40	428.80	379.70
3	73.96	1,420,005	0.6015	4245.80	1124.30	1088.70	470.60	810.70	751.50
Case 1. PU+No Det				Loads change (compared to base case)					
1	74.04	1,588,914	0.6126	-1.29%	3.91%	3.50%	1.57%	-10.37%	-7.78%
2	67.75	775,281	0.6064	-0.54%	-1.71%	-1.27%	-3.29%	-1.47%	5.49%
3	73.06	1,426,783	0.6118	-1.21%	3.04%	2.81%	1.12%	-9.12%	-6.29%
Case 2. PU+BC				Loads change (compared to base case)					
1	72.95	1,584,628	0.6201	-2.74%	4.88%	4.15%	2.53%	-8.54%	-20.85%
2	67.17	770,348	0.6078	-1.39%	-2.07%	-1.60%	-3.21%	-4.61%	4.92%
3	72.00	1,423,126	0.6192	-2.64%	4.15%	3.52%	1.98%	-8.73%	-18.07%
Case 3. REG+BC				Loads change (compared to base case)					
1	72.79	1,592,428	0.6245	-2.95%	8.65%	4.85%	-2.59%	-11.77%	-21.90%
2	67.05	768,726	0.6076	-1.57%	-2.20%	-1.79%	-4.83%	-2.39%	2.95%
3	71.94	1,428,982	0.6223	-2.72%	7.11%	4.10%	-2.56%	-11.29%	-18.16%

Then, why does it happen? One factor we can use to explain this result is the low airline preference of Airline 2. As presented in Table 7-2, the airline preference of Airline 2 is 0.45, about half of other airlines. And in the case where all airlines use FCYM, they are eager to accept more high willingness to pay passengers than they use FCFS, and accept such passengers until their inventory is full. On the other hand, passengers first choose airlines with a high preference unless the booking limit for such airlines is closed. Consequently, the number of bookings in a higher fare class for Airline 1 and 3 increases, but a small number of passengers selects Airline 2 as their last choice, resulting the decrease of bookings in its higher fare class. Hence, Airline 2 inevitably shares a large booking limit for its lower fare class due to a small number of high fare class bookings, resulting in the increase of loads in lower fare classes.

7.2.5 Sensitivity analysis - Airline Preference

A similar result of the revenue decrease observed in Airline 2 in the last scenario is hardly found in the past research, but this might be because of the airline preferences we set. In order to understand how airline preference affects the revenue gain, we made a sensitivity analysis with regards to preference. Figure 7-9 illustrates the result.

AL2 Revenue Change over Base Case of Each Preference

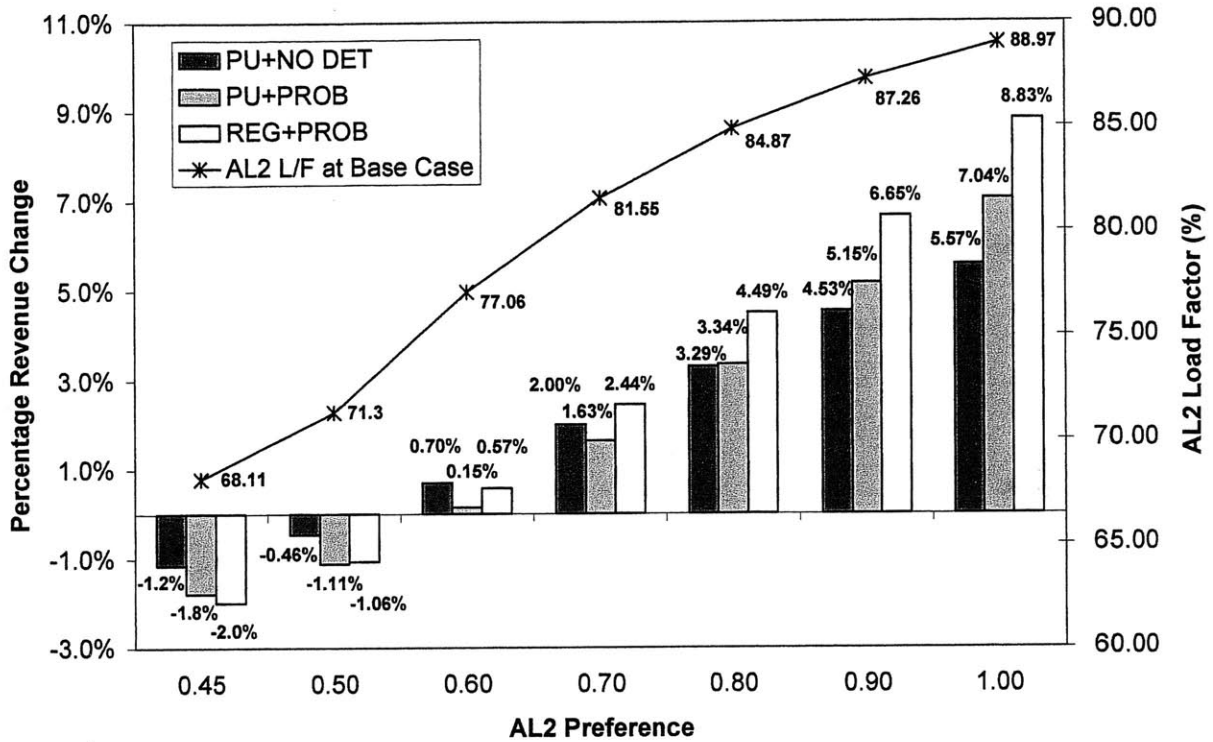


Figure 7-9 AL2 revenue change over Base case of each preference

In this analysis, Airline 2 preference is changed from 0.45 (current setting) to 1.0 (Equal to Airline 1) to see how Airline 2 revenue gain changes. Preferences of other airlines remain the same as current setting, 1.0 and 0.9 for Airline 1 and Airline 2, respectively. The base case, used for comparison, differs in accordance with the preference of Airline 2. In each preference, base case and a scenario that all airlines use FCYM are tested, and the revenue of Airline 2 in the scenario is compared to the revenue of Airline 2 in the base case of the same preference.

As shown in Figure 7-9, as preference goes up, revenue of Airline 2 improves and revenue loss in the low preference turns into a revenue gain within 0.5 and 0.6, and keeps increasing. A line graph in Figure 7-9 shows the load factor of Airline 2, and it goes up as Airline 2 preference improves, resulting in a large revenue gain in high preference. Another subject we need to look at is how the load changes as preference increases. Table 7-14 displays loads change of Airline 2, compared to the base case in each preference. With a low preference, such as 0.45, we see an

increase in GRP load, but the increase turns into a decrease as airline preference advances. In a high preference, higher than 0.60, the rate of increase of GRP load goes negative, just as the case we see with airlines using FCYM.

Table 7-14 Airline 2 loads change over Base case of each preference

AL2 Preference	Loads change (compared to the base case of each preference)					
	TTL	FCLS1	FCLS2	FCLS3	FCLS4	GRP
0.45	-0.5%	-1.7%	-1.3%	-3.3%	-1.5%	5.5%
0.50	-0.9%	0.4%	0.7%	-1.4%	-5.5%	0.0%
0.60	-1.7%	4.1%	4.0%	1.6%	-11.4%	-9.8%
0.70	-1.9%	7.6%	6.9%	5.2%	-15.3%	-16.5%
0.80	-1.8%	10.5%	9.2%	9.7%	-17.4%	-22.3%
0.90	-1.7%	12.9%	11.0%	15.2%	-18.4%	-27.2%
1.00	-1.4%	14.4%	12.0%	21.4%	-18.3%	-30.4%

7.2.6 Results with different load factor settings

In a preceding part of this chapter, we tested the case in which the load factor of Airline 1 is set as 75%. However, demand of the market, one of factors that affects load factor, changes depending on the seasonality, economy, and so on. In order to see how demand will affect the revenue gain, we ran PODS with different load factor settings, and obtained results.

Two different load factor settings, 72% and 78%, were tested for comparison. It might be of interest to readers if we show the results of all scenarios we used with 75% load factor, but since the pattern of the revenue gain and load change is the same even with different load factors, we selected some sample cases to avoid showing graphs and tables similar to those presented. Three cases, which might draw the attention of management of Airline 1, are presented below.

Case 1. Airline 1 uses FCYM

As shown in 7.2.2, every airline can expect a revenue increase if such an airline is the only one that implements EMSRb. In addition, as the best combination of forecasting and detrunctation method is regression forecasting and booking curve detrunctation throughout the scenarios we tested, we show the result of this combination to know how the best revenue gain will differ in relation to the load factor change.

Revenue Change, Only AL1 uses EMSRb, Regression + Booking Curve

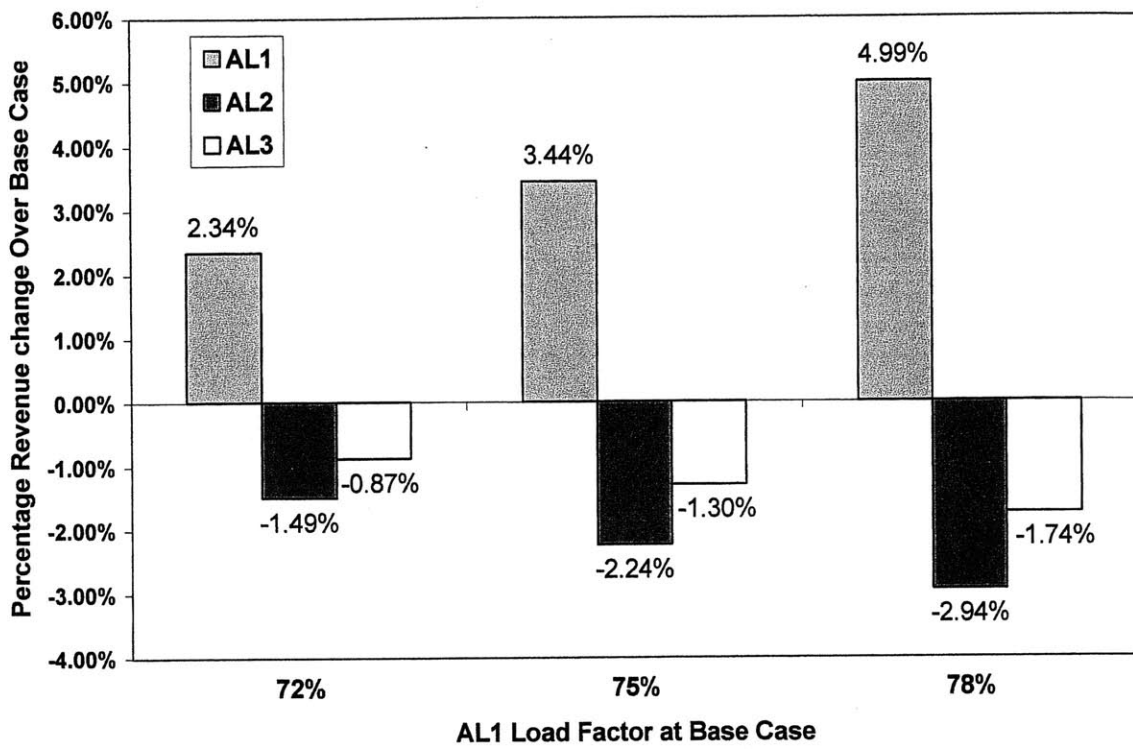


Figure 7-10 Case 1. Revenue change, Airline 1 uses FCYM

Figure 7-10 shows the revenue change over the base case of each load factor setting. The ratio of change constantly rises up as load factor increases, but the ratio of increase is not proportional to the load factor increase. Since the absolute value of revenue in base case also increases as the load factor becomes higher, so the change in absolute value of revenue increase among load factors is more evident than the change shown above.

Case 2. Airline 2 and 3 use FCYM

Contrary to Case 1, the worst scenario for the management of Airline 1 is that Airline 2 and 3 use FCYM and Airline 1 suffers revenue loss for not introducing that method. The combination of regression forecasting and booking curve detruncation is a critical weapon to inflict revenue loss on Airline 1, and this combination is tested in this case.

As shown in Figure 7-11, Airline 1 experiences revenue loss, more than 4% at 78% load factor. It is 1.76% at 72% load factor, but such loss is big enough to motivate the management to think about the implementation of revenue management method promptly.

Revenue Change, AL2 &3 use EMSRb, Regression + Booking Curve

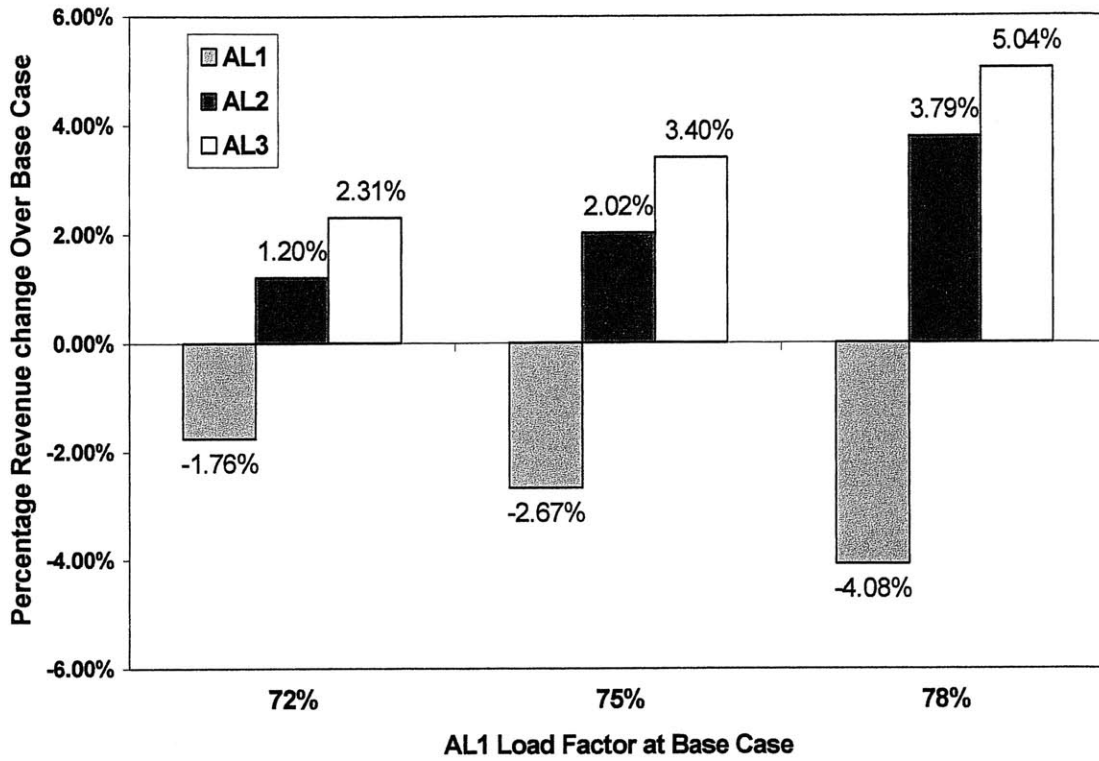


Figure 7-11 Case 2. Revenue change, Airline 2 and 3 use FCYM

Case 3. All airlines use FCYM

The last case presented is that all airlines use EMSRb. Figure 7-12 shows the result of the case, and the revenue increase of Airline 1 exceeds 1% at 78% load factor. Owing to its low preference, Airline 2 cannot expect revenue gain even in high load factor setting, but the rate of revenue loss in 78% load factor is 2.1%, slightly higher than the rate of revenue loss in 75% load factor.

Revenue Change, All airline use EMSRb, Regression + Booking Curve

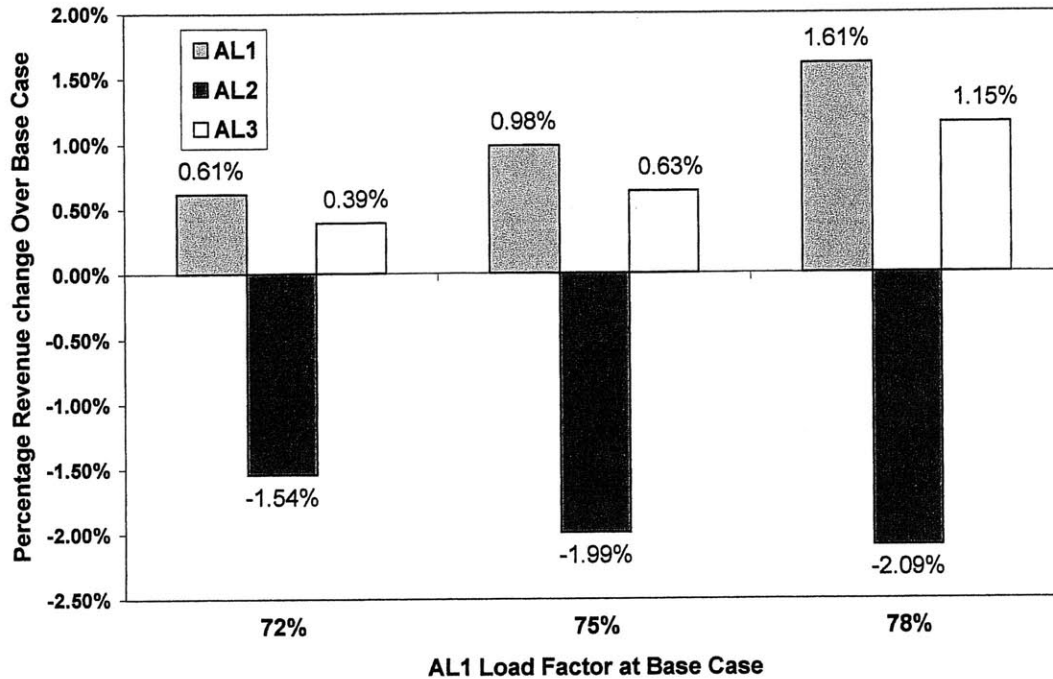


Figure 7-12 Case 3. Revenue change, All airlines use FCYM

7.2.7 Summary

Various scenarios of the current market condition are tested in this section. EMSRb, together with effective forecasting and detruncation method, is proven as an effective tool for an airline, but it is not always the case if airline preference is too low to attract high willingness to pay passengers. Sensitivity analysis by changing the airline preference from low to high is made to examine the effect of preference on revenue gain, and the revenue loss observed in low preference turned into revenue gain in high preference. As for the forecasting and detruncation method, a combination of regression forecasting and booking curve detruncation is the best in the market.

7.3 Impacts of 'after the integration' scenario

It was announced on November in 2001, that Japan Airlines and Japan Air System have reached a basic agreement on integration of the two air transport groups through an incorporated holding company, after obtaining the necessary approvals from the government bodies concerned and the companies' shareholders⁶⁵. The Japanese Fair Trade Commission (FTC) had pointed to a number of issues, especially related to the domestic passenger market, where they had concerns. However, after the submission of a revised proposal, including the return of 9 turnaround slots at Haneda airport in Tokyo, the FTC issued an approval of the integration. The integration consists of two steps, first the formation of a holding company in October 2002, followed secondly in April 2004 by the establishment of separate divisions to operate the domestic market, international market, and cargo transport⁶⁶. After merger of the two airlines, we will have a new 'merged' airline that will possess half the total market share, and drastic change will inevitably follow in Japan's domestic market.

In order to analyze the impact of the integration, we ran PODS with new settings. Three scenarios, current Airline 1 adopts FCYM, new Airline 2, the aggregate of the current Airline 2 and 3, adopts FCYM, and all airline using FCYM, are tested. The result of each scenario is shown below.

7.3.1 Market used

The first step we need to take is to create the base case with new settings. Table 7-15 shows the settings we used. Assumptions we used for the settings are as follows:

- 1) The number of flights per day for new Airline 2 will be 24, if the airline can take over the current flights for Airline 2 and Airline 3. However, as mentioned above, they have to reduce its total number of flight to induce strong competition, so that five flights are reduced as a result. On the contrary, Airline 1 adds two flights to compete with new Airline 2, and the total number of flights per day increases from 14 to 16.
- 2) Airline preference is set at 1.0, equal for both airlines.

⁶⁵Japan Airlines (2002a).

⁶⁶Japan Airlines (2002b).

3) Other parameters, such as the fare structure and so on, are the same as the base case in 7.2.1., where the load factor of Airline 1 is equal to 75%.

The summary of major market conditions is described in Table 7-15. As shown, new Airline 2 is superior to Airline 1, but the difference in terms of flight frequency and capacity is moderately small to induce strong competition.

Table 7-15 Summary of major market conditions

Parameter	Total	Airline 1	Airline 2
Number of flights per day	35	16	19
Capacity	14,263	6,986	7,277
Airline Preference		1.0	1.0

7.3.2 Base Case Result

Similar to the base case in the previous section of this chapter, all airlines use FCFS. Base case result is shown in Table 7-16.

Table 7-16 Base case result

BASE				LOADS (Absolute Value, per day)					
A/L	L/F	REVENUE	YIELD	TTL	FCLS1	FCLS2	FCLS3	FCLS4	GRP
1	78.17	1,817,893	0.5987	5461.21	1423.94	1381.92	613.79	1056.48	985.09
2	76.49	1,861,010	0.6013	5566.33	1473.06	1424.97	617.95	1061.44	988.91

Due to the decrease of total flights in the market, from 38 to 35 flights per day, both airlines now have a higher load factor than the load factor observed in the previous base case. Compared to the base case of the current market, Airline 1 obtained more revenue, because of such a high load factor and high flight frequency. Airline 2, on the contrary, gained lower revenue than the sum of the revenues of the previous Airlines 2 and 3, mainly because of the decrease in flight frequency. As for the loads distribution over fare classes, there is no noticeable change, so that yield change for Airline 1 and 2 is considered negligible.

7.3.3 Revenue Management methods change by a single airline

The first and second scenario we present here is that Airline 1 or Airline 2 changes revenue management method. Three combinations of forecasting and detruncation method are tested, together with the implementation of EMSRb.

Scenario 1. Airline 1 uses FCYM

Figure 7-13 shows the result of Case 1. As expected, Airline 1 increased revenue, and the best result is obtained in case it uses regression forecasting and booking curve detruncation. On the other hand, Airline 2 lost revenue, and the worst case is in which Airline 1 gained the highest revenue.

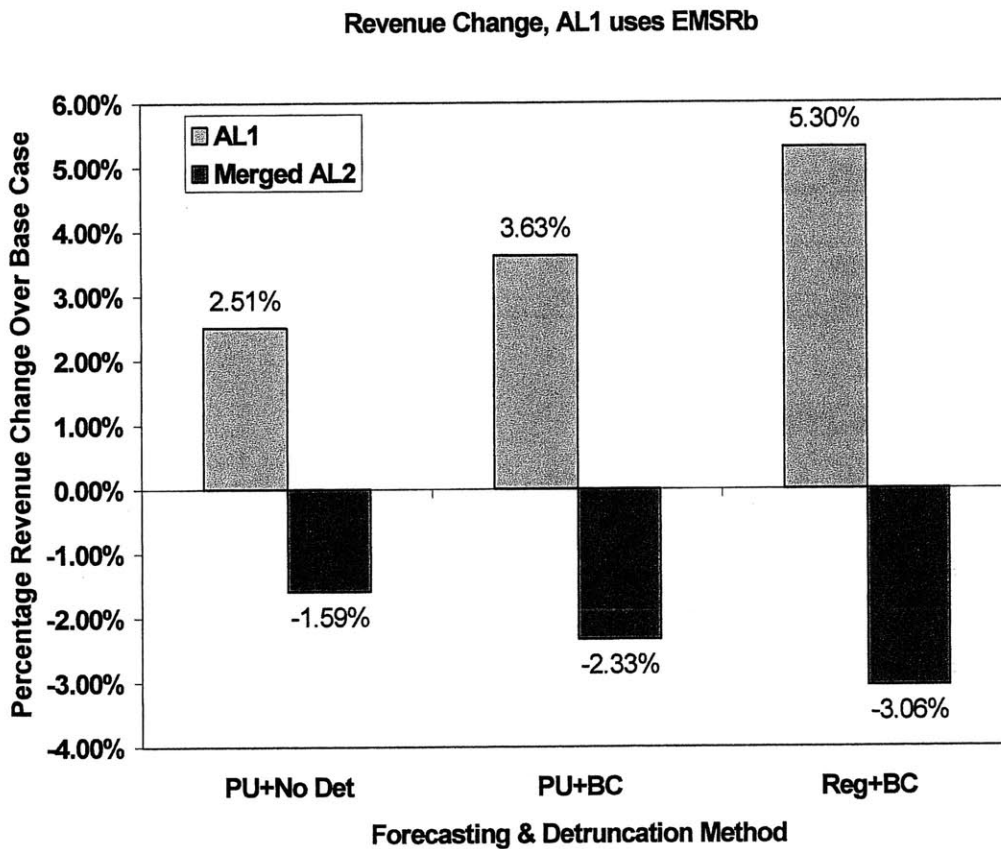


Figure 7-13 Scenario 1. Revenue change over Base case

Table 7-17 shows the major parameter of each airline. Both the change in load factor and yield are more evident than those in the current market settings. With the introduction of a new revenue management method, Airline 1 accepts more passengers in higher fare classes, and limits the amount of bookings for lower fare classes, especially for GRP. Instead, Airline 2, still using FCFS, accepts more passengers in lower fare classes, resulting in a large yield decrease.

Table 7-17 Scenario 1. Major parameter changes

Base				Loads (Absolute Value)					
A/L	L/F	REVENUE	YIELD	TTL	FCLS1	FCLS2	FCLS3	FCLS4	GRP
1	78.17	1,817,893	0.5987	5461.21	1423.94	1381.92	613.79	1056.48	985.09
2	76.49	1,861,010	0.6013	5566.33	1473.06	1424.97	617.95	1061.44	988.91
Case 1. PU+No Det				Loads change (compared to base case)					
1	77.69	1,863,479	0.6175	-0.61%	7.45%	5.90%	5.28%	-13.69%	-11.06%
2	76.77	1,831,494	0.5897	0.36%	-3.46%	-3.08%	-7.89%	5.40%	10.75%
Case 2. PU+BC				Loads change (compared to base case)					
1	76.88	1,883,794	0.6308	-1.65%	10.01%	7.27%	14.96%	-8.13%	-34.44%
2	77.19	1,817,626	0.5820	0.92%	-4.14%	-3.40%	-15.58%	-6.75%	33.21%
Case 3. REG+BC				Loads change (compared to base case)					
1	76.96	1,914,309	0.6404	-1.56%	24.35%	3.29%	1.29%	-14.93%	-33.24%
2	77.01	1,804,026	0.5790	0.68%	-6.65%	-4.02%	-15.63%	-2.57%	32.03%

Scenario 2. Airline 2 uses FCYM

Figure 7-14 and Table 7-18 show the details of the results. Similar to the results we obtained in Scenario 1, Airline 2 gained a significant revenue increase as a result of the implementation of a new method. A combination of regression forecasting and booking curve detrunction best contributed to the increase of revenue, and the combination also induces the worst revenue loss to Airline 1. The pattern of loads change, presented in Table 7-18, is almost the same as Scenario 1, and the revenue gain of Airline 2 comes from the yield increase. This is caused by the increase of loads in higher fare classes, and the decrease of loads in lower classes, as seen in many scenarios.

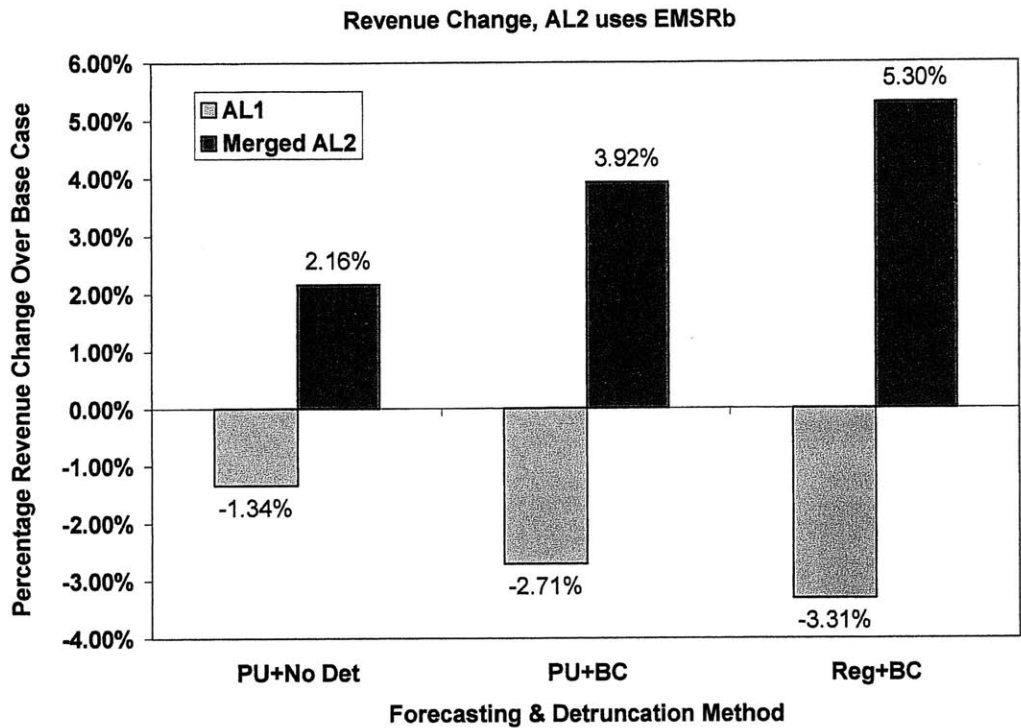


Figure 7-14 Scenario 2. Revenue change over Base case

Table 7-18 Scenario 2. Major parameter changes

Base				Loads (Absolute Value)					
A/L	L/F	REVENUE	YIELD	TTL	FCLS1	FCLS2	FCLS3	FCLS4	GRP
1	78.17	1,817,893	0.5987	5461.21	1423.94	1381.92	613.79	1056.48	985.09
2	76.49	1,861,010	0.6013	5566.33	1473.06	1424.97	617.95	1061.44	988.91
Case 1. PU+No Det				Loads change (compared to base case)					
1	78.19	1,793,587	0.5905	0.03%	-2.42%	-2.01%	-7.28%	2.65%	8.16%
2	76.29	1,901,131	0.6159	-0.26%	5.83%	4.66%	4.97%	-10.75%	-8.43%
Case 2. PU+BC				Loads change (compared to base case)					
1	78.51	1,768,652	0.5799	0.44%	-3.94%	-3.15%	-17.75%	-9.97%	34.29%
2	75.44	1,933,872	0.6336	-1.38%	9.61%	7.48%	17.57%	-7.56%	-35.70%
Case 3. REG+BC				Loads change (compared to base case)					
1	78.31	1,757,666	0.5779	0.17%	-6.06%	-3.48%	-17.52%	-6.94%	32.94%
2	75.51	1,959,668	0.6414	-1.28%	22.26%	3.72%	3.75%	-12.86%	-34.28%

7.3.4 All airlines change methods

The last scenario to present is where two airlines use FCYM. Since we set airline preference at equal to 1.0 for each airline, we can expect revenue increase for both airlines. In fact, as illustrated in Figure 7-15, both airlines gain revenue increase, and the best combination is again the regression forecasting and booking curve detruncation, but the second best combination is pickup forecasting and no detruncation.

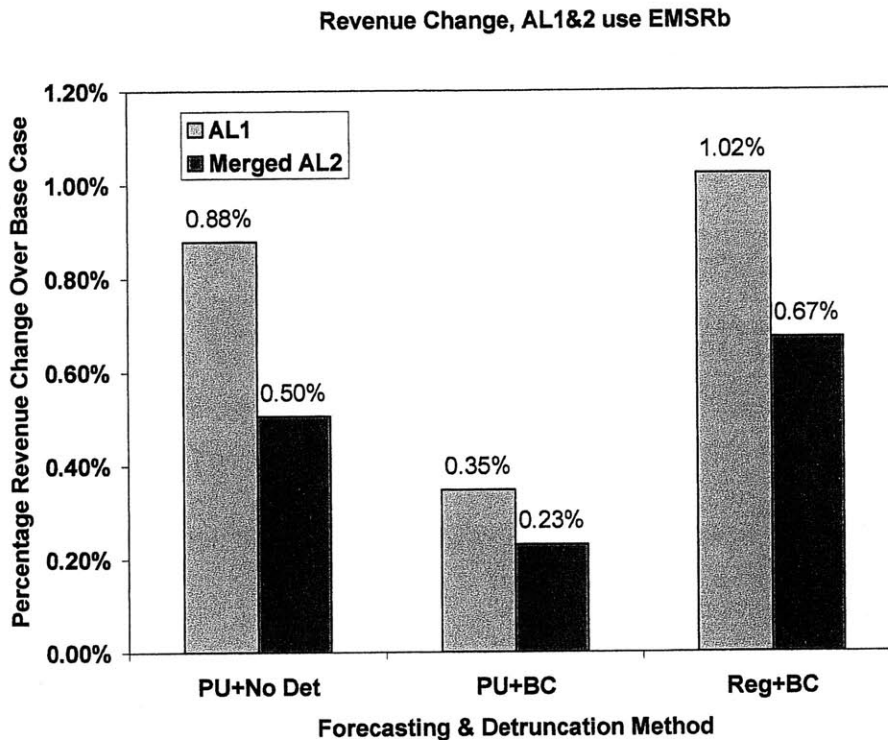


Figure 7-15 Scenario 3. Revenue change over Base case

Table 7-19 shows the loads change in this scenario. In comparison with the yield increase in Scenario 1 and 2, yield increase in Scenario 3 is small. Also, load factors for both airlines go down from 1 to 3 points, counteracting some of the effect of yield increase.

Table 7-19 Scenario 3. Major parameter changes

Base				Loads (Absolute Value)					
A/L	L/F	REVENUE	YIELD	TTL	FCLS1	FCLS2	FCLS3	FCLS4	GRP
1	78.17	1,817,893	0.5987	5461.21	1423.94	1381.92	613.79	1056.48	985.09
2	76.49	1,861,010	0.6013	5566.33	1473.06	1424.97	617.95	1061.44	988.91
Case 1. PU+No Det				Loads change (compared to base case)					
1	76.89	1,833,857	0.6140	-1.64%	4.81%	4.57%	1.14%	-12.75%	-9.49%
2	75.54	1,870,403	0.6120	-1.24%	3.15%	2.99%	1.17%	-9.79%	-6.24%
Case 2. PU+BC				Loads change (compared to base case)					
1	75.32	1,824,195	0.6235	-3.65%	5.77%	5.02%	2.35%	-9.48%	-26.92%
2	73.77	1,865,303	0.6250	-3.56%	5.23%	4.51%	2.62%	-9.00%	-26.29%
Case 3. REG+BC				Loads change (compared to base case)					
1	75.26	1,836,490	0.6283	-3.73%	10.33%	5.54%	-3.07%	-13.11%	-27.42%
2	73.73	1,873,505	0.6280	-3.61%	8.49%	4.36%	-1.32%	-10.17%	-27.52%

7.3.5 Summary

Three scenarios are tested with new settings. In any case, airlines with a new method gain a revenue increase, and the combination of regression forecasting and booking curve det truncation is the best method for revenue increase. Even after the integration, airlines can expect a certain amount of revenue gain so that prompt implementation of new revenue management method is critical for Japanese airlines.

Chapter 8

Conclusions

The final chapter of this thesis first summarizes of the analysis of Japan's domestic market, model of group passenger booking process, and the results obtained in the PODS simulation performed. Then, areas for future research, which are generated from unanswered questions, are presented.

8.1 Summary

The objective of this thesis was to investigate the impacts of revenue management on Japan's domestic market, where group passengers cannot be neglected. In order to understand the characteristics of the market, a brief overview of the market is presented in Chapter 2. External components of the market, such as major transportation policy changes, are explained. Following external components, internal components, such as airlines, airports, and so on, are described in detail. Of the many aspects presented, the trend of the market from 1988 to 2000 according to major parameters shows the effect of a long lasting economic recession, as well as the effect of deregulation.

In Chapter 3, current revenue management practices employed are presented by using an example obtained from a carrier. The practice is split into two parts, differential pricing and seat inventory control. In the first part of the chapter, fares are classified into two types, published and unpublished, and fare products involved are explained in relation to the demand segment. In the second part, current seat inventory control is explained with a detailed example of booking process. The current booking process for group passengers is also presented with a booking process for individual passengers, and the nature of the group booking process is complicated enough to necessitate its own model. Admittedly, current seat inventory control is a First Come First Serve (FCFS), leg-based control, and requires a lot of manpower and experience to cope with uncertainties. From that standpoint, the implementation of a new revenue management method will benefit Japanese airlines from both a revenue and cost perspective.

In Chapter 4, a literature review of past research is made, mainly focused on the leg based seat inventory control method, Fare Class Yield Management (FCYM), using EMSRb. Advanced traffic control methods, such as DAVN, are touched on briefly, and past research of group seat inventory control is reviewed.

As a prelude to the modeling of the group booking process, an analysis and modeling of group passengers is made in Chapter 5. Group passengers are classified into two types, ad hoc and series, and the difference between the types, in terms of behavior and so on, is presented. Parameters that represent group passengers, such as the number of groups per flight, size of group, and utilization rate, are described using data obtained from the market.

Based on the group booking process explained in Chapter 3 and parameters of group passengers discussed in Chapter 5, a group booking process model is created in Chapter 6, with the brief explanation of the function of PODS – the Passenger Origin Destination Simulator – developed by Boeing.

Finally, in Chapter 7, results of simulations are presented. The function of PODS9DJ, specially modified to simulate Japan's domestic market, is explained first by highlighting the difference between previous versions of PODS that focused on individual passengers. Major implementations from the model herein created into PODS9DJ are also presented. After that, parameters of the route used for simulation, a single but major route that connects Tokyo and a major local city, are presented, and the current market setting with three carriers in the market is tested first.

In general, airlines using FCYM experience a revenue gain, and a combination of regression forecasting and booking curve detruncation brings the best revenue increase to the airline using that combination, but it also results in the worst revenue loss to other airlines that do not implement the FCYM. There is an exception in terms of the revenue gain described above, that a weak carrier with low airline preference suffers revenue loss when other dominant carriers adopt FCYM, even if the weak carrier uses FCYM simultaneously. The cause of such a revenue loss is discussed briefly, and it is owing to the weak carrier's low preference that the airline fails to

attract high willingness to pay passengers, and results in the increase of low fare class passengers, even if the weak airline uses FCYM. A sensitivity analysis with regards to the airline preference of the weak carrier is made to investigate how it will affect the revenue of the airline, and the revenue loss observed turns into a revenue gain as the preference goes up from 0.5 to 0.6. It assures us that the cause of revenue loss comes from low preference. Finally, settings with a different load factor resulting from the change of demand are tested. As demand increases, the effect of revenue management methods grows by producing more revenue gain. On the contrary, airlines without FCYM suffer more revenue loss as demand increases.

The second scenario we tested is how revenue management impacts the market after two carriers integrate. After the integration, the power balance between carriers will change drastically, so that we need to create new settings such as the number of flights and capacity of two airlines to reflect the effect of integration. Even after integration, airlines can expect a certain amount of revenue gain, and the combination of regression forecasting and booking curve detruncation is again the best method to increase revenue.

Overall, FCYM is a powerful tool to increase revenue, and it impacts significantly on Japan's domestic market where group passengers are a major demand segment.

8.2 New Research Direction

There are some unanswered questions that deserve further research. First, the essence of the group booking process we modeled was included in PODS9DJ, but admittedly not the model in its entirety. Consequently, further simulation with a new PODS that fully accommodates the model in total shall yield results closer to real conditions.

Second, we imposed an assumption that we can adopt FCYM to the group booking process, but it cannot be achieved without support from travel agents, which send group requests to airlines. However, it will take time, since travel agents do not always willingly accept booking limits to group requests. For example, in the case of series type group passengers, travel agents require airlines to accept as many group requests as possible, irrelevant of the utilization rate of such

requests. This is because they want to sustain the flexibility of their travel itineraries, sacrificing the flexibility of airlines' seat inventory control. However, if airlines apply FCYM to group booking process, it directly leads to the refusal of group requests, thus annoying travel agents. Airline sales staffs, who have a close relationship with travel agents, will be negative towards implementing the FCYM, as it is sales staffs that have to cope with complaints from travel agents. From this standpoint, further research shall be made in which FCYM is applied only to the seat inventory control of individual passengers. The revenue gain obtained from such a situation is much smaller than the revenue gain demonstrated in this thesis, and it can be used to persuade airline internal staff to implement a new revenue management method.

Third, the effect of business process change on the group booking process is left unanswered. What will happen if we change the day to ask travel agents to materialize their group request? Currently, it is 14 days before departure, but how will it impact the revenue gain if we change from 14 to 28 days before departure? Also, what will happen if travel agents quit making pseudo group requests and thus utilization rate goes up? Further analysis in relation to such unanswered questions will help airline management to direct the way to improve the revenue from group bookings.

As to the 'after the integration' scenario, which evaluates impacts of forthcoming merger of Japan Airlines and Japan Air System in 2004, settings used herein are created based upon the current obtainable information. Especially, fare structure its restrictions will most likely change, but there is no clue as to the new structure. Since we are not sure if the real situation will be the same as herein designed, further research using real market settings draw airlines' interest.

Finally, this simulation is done by only one major single leg in this market. Actually, 150 routes in Japan's domestic market are used by 95% of total passengers, and each route has a unique characteristics. For instance, the route presented in this thesis is half business, half leisure route so that the mix of business and leisure demand is set at 50:50. However, this is not always the case with every route, and some are highly business oriented while others are highly leisure oriented. It goes without saying, fare class structure and load distribution over fare classes will be different, so that we first need to investigate the characteristics of each route, classify them

into a considerable number of types, and run simulations for each type. It is very cumbersome work, but it shall be required if airlines really desire to know the overall revenue gain over the entire network.

Bibliography

Belobaba, Peter P. Air Travel Demand and Airlines Seat Inventory Management. Cambridge, MA: Massachusetts Institute of Technology, Flight Transportation Laboratory Report R87-7, May, 1987.

Belobaba, Peter P. "The Evolution of Airline Yield Management: Fare Class to Origin-Destination Seat Inventory Control." Handbook of Airline Marketing, 1st Ed. Aviation Week Group, 1998, pp285-302.

Belobaba, Peter P. "The Revenue Enhancement Potential of Airline Yield Management Systems." Advanced Software Technology for Air Transport Proceedings. Nov. 9-11, 1992a.

Belobaba, Peter P. Optimal vs. Heuristic Methods for Nested Seat Allocation. Presented at AGIFORS Yield Management Study Group, Brussels, Belgium: May 4, 1992b.

Belobaba, Peter P. Airline O-D Seat Inventory Control Without Network Optimization. Cambridge, MA: Massachusetts Institute of Technology, June, 1995.

Belobaba, Peter P. and Weatherford, L. "Introduction: The Evolution of Revenue Management Systems." 16.75 Airline Management Course Notes. Cambridge, MA :Massachusetts Institute of Technology, Apr. 2001.

Bhatia, A.V. and Parekh, S.C. Optimal Allocation of Seats by Fare. Presentation by Tran World Airlines to AGIFORS Reservation Study Group, 1973.

The Boeing Company. Decision Window Path Preference Model (DWM). Feb, 1994.

Bratu, Stephane. Network Value Concept in Airline Revenue Management. Cambridge, MA: Massachusetts Institute of Technology, May, 1998.

Bureau of Transportation Statistics, The office of Airline Information. Air Traffic Statistics and Airline Financial Statistics. <<http://www.bts.gov/oai/>> (May 3, 2002)

Busuttil, Louis. "Managing the Group Sales Process." The 35th AGIFORS Symposium Proceedings. 1995, pp153-160.

Cross, Robert G. Revenue Management: Hard-core Tactics for Market Domination. New York: Broadway Books, 1997.

Darot, Jeremy F. J. Revenue Management for Airline Alliances: Passenger Origin-Destination Simulation Analysis. Cambridge, MA: Massachusetts Institute of Technology, Jun, 2001.

Descroix, D. "An Expert System for Groups Reservations." The 29th AGIFORS Symposium Proceedings. 1989, pp79-96.

Doganis, Rigas. Flying Off Course: The Economics of International Airlines, 2nd Ed. London and New York: Routledge, 1991.

Glover, Fred., et al. "The Passenger Mix Problem in the Scheduled Airlines," Interfaces 12 (1982): 73-79.

Gorin, Thomas O. Airline Revenue Management: Sell-up and Forecasting Algorithms. Cambridge, MA: Massachusetts Institute of Technology, Jun, 2000.

Hasegawa, Toru. Airline Economics. Tokyo: Chuo-shoin, 1997.

Hopperstad, Craig A. PODS: Modeling Update. Presented at the AGIFORS Yield Management Study Group, Canada: May 14-16, 1997.

International Air Transport Association(IATA), .travel TLD Application. Aug, 2000. Section C-2. <<http://www.iata.org/dottravel/application/sectionC2-1.htm>> (May 3, 2002)

Japan Air Lines. "JAL and JAS Merger – New Names, Organization." News Release. Jan. 29, 2002a. <http://www.news.jal.co.jp/EJAL_NEW.ns4> (Apr. 28,2002)

Japan Air Lines. "JAL/JAS Integration Approved by Japan's Fair Trade Commission." News Release. Apr. 26, 2002b. <http://www.news.jal.co.jp/EJAL_NEW.ns4> (Apr. 28,2002)

Kaduwela, Vijitha, P. "A Stochastic Overbooking Model to Account for Retail/Group Passenger Cancellations." The 36th AGIFORS Symposium Proceedings. 1996, pp105-118.

Lee, Alex Y. H. Investigation of Competitive Impacts of Origin-Destination Control Using PODS. Cambridge, MA: Massachusetts Institute of Technology. Jun, 1998.

Lee, Seonah. Modeling Passenger Disutilities in Airline Revenue Management Simulation. Cambridge, MA: Massachusetts Institute of Technology, Aug, 2000.

Littlewood, Kenneth. "Forecasting and Control of Passenger Bookings." The 22nd AGIFORS Symposium Proceedings. 1982. pp95-117.

Mak, Chung Y. Revenue Impacts of Airline Yield Management. Cambridge, MA: Massachusetts Institute of Technology, Jan, 1992.

Meyer, Stuart L. Data Analysis for Scientists and Engineers. New York: John Wiley & Sons, 1975.

The Ministry of Foreign Affairs. Japan's Approach to Deregulation to the Present. Apr.1999. <http://www.mofa.go.jp/j_info/japan/regulate/approach9904.html>

The Ministry of Land, Infrastructure and Transportation. Monthly Aviation Statistics. Aug. 2001.

The Ministry of Land, Infrastructure and Transportation. Annual Aviation Statistics 2000. Aug. 2001.

Richter, Helmut. "The Differential Revenue Method To Determine Optimal Seat Allotments By Fare Type." The 22nd AGIFORS Symposium Proceedings. 1982, pp339-362.

Skwarek, Daniel K. Competitive Impacts of Yield Management System Components: Forecasting and Sell-Up Models. Cambridge, MA: Massachusetts Institute of Technology, Jun. 1997.

Smith, B. "A Group Decision Support Model." The 30th AGIFORS Symposium Proceedings. 1990.

Statistics Bureau & Statistics Center. Japan Statistical Yearbook 2002. <<http://www.stat.go.jp/data/nenkan>> (May 3, 2002)

Sugiura, Kazuki. War over Tokaido Line- Nozomi vs. Air shuttle service. Tokyo:Soshisya,2001.

Svrcek, Tom. Modeling Airline Group Passenger Demand for Revenue Optimization. Cambridge, MA: Massachusetts Institute of Technology, May, 1991.

Wei, Julie. Airline O-D Control Using Network Displacement Costs. Cambridge, MA: Massachusetts Institute of Technology, June, 1997.

Williamson, Elizabeth L. Airline Network Seat Inventory Control: Methodologies and Revenue Impacts. Cambridge, MA: Massachusetts Institute of Technology, May, 1992.

Wilson, John L. The Value of Revenue Management Innovation in a Competitive Airline Industry. Cambridge, MA: Massachusetts Institute of Technology, May, 1995.

Wollmer, Richard. An Airline Reservation Model for Opening and Closing Fare Classes. Unpublished Internal Report, McDonnell-Douglas Corporation, 1985.

Zickus, Jeffrey S. Forecasting for Airline Network Revenue Management: Revenue and Competitive Impacts. Cambridge, MA: Massachusetts Institute of Technology, Jun, 1998.