Airline Pricing Model

History

Up until the late 1970s airline pricing was a tame and understood system. Through a 1938 act of congress, the Civil Aeronautics Board (CAB) regulated the airline industry similarly to the regulation of public utilities. It controlled which new airlines could enter the market, had antitrust authority, determined which routes would be flown, and, most importantly, established the rates for each flight. Unfortunately, large infrastructure investments with the expectation of a boom clashed with recession of the early 70s, yielding record losses for all the major airlines. Airline executives blamed the CAB, and legislation listened. Admiring the efficiency of unregulated intrastate airlines like Southwest, which flew Texas flights at the time, Congress passed the Airline Deregulation Act of 1979. At that point, the industry changed forever, becoming a totally free market.

Current Airline Pricing

Today, just about every individual flying on a particular aircraft paid a different price for his or her ticket, and it’s not uncommon for two people sitting next to each other to have paid a difference of over 300 percent. These seemingly chaotic prices for airline tickets arose out of necessity. After deregulation, many small, low-cost airlines came into the market. Focusing on cost effective facilities, using non-unionized workers, and saving on amenities, the smaller airlines had a strong price advantage and were able to capture a significant part of the major airline’s business. The major airlines could not lower prices because of their higher costs, and their hopes that customers would continue paying higher prices because of brand loyalty and a higher level of service were proven wrong.

The major airlines fought back using technology – the computerized reservations systems that started in the 1960’s could be used to increase the number of passengers. Since the costs associated with flying an aircraft were mostly fixed and did not depend on how many passengers it carried, the airlines realized that the goal to maximize the number of people flying on each plane was just as important, if not more so, than maximizing the price paid for each ticket. Through the computerized reservation system, they were able to vary the price for each passenger. Such price variations are known in economics as Market Segmentation.

Each passenger on a flight has a different reason for travel, associated with a different elasticity. The goal of the airlines became to segment based on these reasons and charge higher rates to people with a lower elasticity. The simplest example is the difference between a business traveler and a vacationer. Business travelers usually have very little advance warning, must fly specifically when they want to, and want to do so a quickly as possible. Vacationers usually plan their vacations well in advance and are usually flexible about the times during which they travel; they would rather get a better price. They also usually include a weekend in their stay, as opposed business travelers who do their business on weekdays only. Other segmentation techniques
isolated loyal customers (frequent flyer miles / coupons), indecisive customers (unrestricted & last minute fares), etc.

Fredrik Wallenberg, in his paper “A Study of Airline Pricing” proposed that all airline prices can be deconstructed into the following components.

1. The origin/destination pair.
2. 3 advanced purchase periods, each carrying a separate influence
3. Whether or not there is a \textit{Saturday stayover}.

Wallenberg tested the model against 49,000 airfare transactions and achieved good results. This proposed TAC airline pricing model will incorporate #2 and #3 from Wallenberg’s model (we set the city pair as fixed), while adding some randomness and sales.

\textbf{Proposed Model}

\textbf{Time Frame:} to most effectively represent the range in ticket prices with respect to the advanced purchase periods, the window of time studied should be four weeks. The actual runtime of a TAC game is 9 minutes. To simulate the four weeks, each week should be played in 2.25 minutes.

\textbf{Initial Pricing:} The starting price at the beginning of the 4 weeks – the most advance purchase period – should reflect observed influences of market segmentation described above. The largest segmentation practiced is the Saturday stay-over which differentiates business travelers from vacationers. Since the TAC game only utilizes 5 days, we will map Day 1 as Saturday, and Days 2, 3, 4, and 5 as weekdays. Thus a potential Saturday evening stay-over would occur between Day 1 and Day 2.

Additionally, since only one-way tickets are sold in TAC, the price influence of the Saturday stay-over will be relative to the probability that the particular one-way flight is paired with another flight that would span a Saturday. For example, an outbound flight on Saturday morning suggests a 100\% probability that there will be a Saturday before the corresponding inbound flight. Likewise, outbound flights on Monday have a low probability of having a Saturday before the respective inbound flight.

The Kons paper indicates a 55\% discount for flights with a Saturday stay-over. Combining the starting price of $250 and with the relative influences described above yields the following initial prices for each day.

\begin{center}
\begin{tabular}{|c|c|c|c|c|c|}
\hline
& Day 1 & Day 2 & Day 3 & Day 4 & Day 5 \\
\hline
Outbound & 250 & 400 & 350 & 300 & N/A \\
Inbound & N/A & 300 & 350 & 400 & 250 \\
\hline
\end{tabular}
\end{center}

Since flights in each direction are only sold for 4 out of 5 days, we miss the last day, which would yield the most expensive price of $450.

\textbf{Price Transition Points:} There should be three price transition points signifying the instantaneous transitions between adjacent advance purchase periods. Starting from the initial price at the beginning of the purchasing period, each transition carries with it a
percentage penalty that should be added to the last price before the transition. The following is a table for each pivot point.

<table>
<thead>
<tr>
<th>Pivot Point</th>
<th>Penalty</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 week</td>
<td>0%</td>
<td>Initial price</td>
</tr>
<tr>
<td>2 week</td>
<td>20%</td>
<td>Kons Fig. 9, diff b/w 3wk and 2wk fare</td>
</tr>
<tr>
<td>1 week</td>
<td>46%</td>
<td>Kons Fig. 8, diff b/w 2wk and 1wk fare</td>
</tr>
<tr>
<td>3 day</td>
<td>33%</td>
<td>Orbitz.com sampling</td>
</tr>
</tbody>
</table>

**Short-term Sales:** Airlines offer short-term airfare sales for two reasons: 1. to attract new customers and reward existing customers and 2. to fill empty seats (or the likelihood thereof) since the marginal cost of additional passengers is close to zero. Because the certainty of whether or not there will be empty seats grows over time and becomes definite right before takeoff, sales will become more frequent towards the latter part of the selling period. I.e. well before the end of the selling period it would be prudent to have fewer sales because the first goal is to fill the plain with full-paying customers. As tickets sell, and comparisons with previous flights indicate that it is probable for seats to be unsold, sales should commence to fill those likely vacancies.

Unfortunately, the only data that could be obtained concerning sales consists of email offers from US Airways and American listing advanced purchase sales to specific destinations and last minute sales for underbooked flights. A skim of these offers reveals that advance purchase sales range from 20-40% discounts, while last-minute sales are discounted 40-60%. Frequency of sales is harder to quantify. During the last two months of weekly last-minute sales, US Airways posted over 100 sales and American Airlines posted over 50 sales in each mailing on average. A subjective guess would be that 20-30% of routes will have at least one sale sometime during the selling period. A model to approximate the increasing likelihood of a sale would be to linearly increase the probability 0 to 5% per day over the course of the selling period. Likewise, the discount percentage would also linearly increase from 30% at the beginning of the period to 50% at the end. Each sale would last for 20-30 seconds of simulation time.

**Price Fluctuations:** While the model described above does represent the most significant changes in airfare over time, there are minute fluctuations that still occur. Usually, these are simply responding to how quickly tickets are being bought. From observing flight prices on Orbitz.com, it seems these price fluctuations are very small – oftentimes just a dollar or two. Thus the model should include this variable, which may signify an underlying unknown trend in ticket sales. To implement this, we should pick the floor and ceiling bounds for the random variable at the beginning of the game. The ceiling bound will actually have different values at the beginning and end of the game, linearly interpolating in between. For example, if the floor is -2% and the ceiling is +1% at the beginning of the game and +3% at the end, the price will initially trend lower and then start trending higher at the midpoint. In real life, this could signify a flight that was selling very poorly to begin with and then had sales rush in towards the end. This provides an interesting learning problem where agents would have to watch the price and make a determination about where it will go.
References