How Airlines Compete

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Abstract

Airlines compete in city-pair markets. Each airline in the market plans a schedule of departure times and offers a series of fares. The minimum level of complication must deal with both time-of-day and at least two types of fares. Where customers find both needs met by both airlines, they choose based on secondary characteristics of the competitors, which we call quality. This simple model of the demand side leads to some compelling consequences on the supply side. The discussion below starts with one time of day; two types of fares, business and leisure; and a primitive expression of capacity limits and revenue management. Discussion then adds several levels of realism to that foundation. We find a preferred airline dominates strongly in both average fare and load factor. Also a preferred airline does best by matching fares, rather than getting a surcharge for its quality. It is suggested that if the competing airline can find a non-competitive time of day it might survive on lower costs, but the temptation will be strong to seek its own different markets. The primary lesson about airline competition is that airlines have strong incentives to match. A preferred airline does best matching prices, while a non-preferred airline does poorly unless it can match preference

Introduction

Airlines compete in city-pair markets. Each airline in the market plans a schedule of departure times and offers a series of fares. The fundamentals of airlines competing are this: customers choose based on price and time, and those customers who find both airlines equal choose based on secondary characteristics we call quality. This simple model of the demand side leads to some compelling consequences on the supply side. The discussion below starts with the simplest possible model, and then adds several levels of realism to that foundation. Along the way, discussions trace the effect of the market reality on competing airlines.

The Simplest Market Share Splits the Market

Imagine airline A and airline Z, identical in almost every way. Both serve a single airport-pair at a single time of day and both offer the same two prices. Both offer a discount fare of $100 for all tickets sold 14 days or more in advance. Both offer a fare of $300 for tickets purchased less than 14 days ahead. The market is composed 80% of people who can plan 14 days ahead, and 20% of people who make last-minute plans but who also value the trip enough to pay $300 for it. Demand in total is a total of 180 customers for total of the two flights. Each flight has 100 seats.

If both airlines are identical in quality, the market splits in half and each airline carries 90 passengers, 18 of which are high-fare. Each has a load factor of 90%, and average fare of $140, and a revenue per seat of 90%*$140=$126. For this example, these conditions will define "break even." That is, at $126/seat both airlines are making market returns on investment.

A Preferred Carrier Gains Load Factor and Yield

If airline A is of higher quality than airline Z, the answer is different. Let us assume that 100% of the demand finds airline A the preferred quality. This puts Airline A in a position to do what the industry calls "revenue management." Airline A sees as its demand all 180 passengers, including all 36 high-fare customers. By limiting its discount sales to 64 seats, airline A can carry 64 discount customers and 36 high-fare customers. Airline A has a load factor of 100%, average fare of $172, and average revenue per seat of $172. Load factor is the industry term for the percentage of seats filled, on average.

Airline Z gets what is left over after airline A gets its fill. Airline Z gets the demand "spilled" from airline A. That turns out to be 80 discount customers. Airline Z has an 80% load factor, average fare of $100, and revenue per seat of $80. Not so good.

Airline markets are not as simple as this example. However, the fundamental drivers are the same. Before adding to the complexity and to the reality of the model, let us see what the competitive consequences might be.

Preferred Carrier does not want to have Higher Prices

As currently played out, airline A has over twice the revenue of airline Z. Since this market is at "break even" in total there is enough revenue to cover both airlines' costs. However, at this point in the example, airline A has 68% of the revenues, but only 50% the costs. Airline Z has 32% of the revenues, and 50% of the costs. Airline A is embarrassingly profitable. Airline Z is headed for bankruptcy. This is clearly an unstable state. However, it is also a state very much in airline A's favor.

To get to this enviable position, A had to be higher quality as perceived by all the customers in the market. This could be because it has a better safety record, nicer gates at the airport, a better frequent flyer program, or because airline Z paints its airplanes a nauseating color. It does not matter why. It matters that it is the case.

Airline A gains a very strong revenue advantage without asking higher prices than airline Z. Airline A gains 10% of revenue by filling its seats more often than average. Airline A gains a further 13% of revenue by capturing all the premium fare demand. Airline A gains both load factor and yield. Yield is the industry term for the average fare, per mile.

Airline A could choose to charge for its extra "quality." Imagine that airline A charged a 20% price premium on both discount and standard fares, and that such a premium cancelled out the quality effect so that the demand split half to airline Z, as before. In this case we have assumed the 50% of demand that goes with A is willing to pay at least 20% more for the higher quality. So the total demand is not reduced by the higher prices. All that happens is half the people willingly pay for higher quality. With the preference effect cancelled out, airline A gets an average fare of $168, lower than the previous case. Furthermore, it gains this at the load factor associated with a 50:50 split of traffic. That is 10% lower than before. So airline A's revenue per seat becomes $151.20. This is 13% lower than it had before it increased prices. The assumptions imply that this is correct at 20% higher than the base case.

Even at a high surcharge on fares, airline A is worse off raising fares and splitting the market than it was matching fares and capturing more of the high-yield traffic and getting a higher load factor. This example exaggerates the case, but the conclusions will hold as details are added. A preferred airline does better to match prices, and gather its value with higher share of the higher fares, and with higher load factor.

This result explains two things. First, why higher quality airlines seldom maintain higher fares. Airlines generally match competitor's fares. Second, why lower quality airlines try so hard to improve their quality. There are exceptions, but the revenue management and load factor effects are a strong hill to climb.

Variations in Demand Soften the Distinctions

Most of the time airlines offer the same schedule each day of the month, but demand varies from day to day. The simple example of this imagines three kinds of days: Off peak days with demand of 120 instead of 180, normal days with demand of 180, and peak days with demand of 240. The story continues with airline A still preferred by 100% of the customers and prices, both discount and unrestricted, the same at each airline.

On the off-peak days, airline A still manages to make a profit. It gets all 24 of the high-fare demand, and fills to 100% with discount fares. Its average revenue per seat is $148, which is well above break-even. Meanwhile poor airline Z is in a world of hurt. The leftover demand only gives it a 20% load factor, and all its load is at the discount fare. Airline Z has a revenue per seat of $20, which is impossibly below break even.

On the average days, the story is as before. Airline A has revenue per seat of $172 and a 100% load factor. Airline Z has revenue per seat of $80 and an 80% load factor. Breakeven was $126/seat.

Airline Z cannot even make breakeven on peak days. Peak demand of 240 exceeds the combined capacity of both airlines. Airline A carries 48 high-fare and 52 discount customers. Average fare is $196. Airline Z has 100% load factor, but all at the discount fare of $100. Airline Z is still below breakeven.

If the three seasons are equally likely, Airline A has the same average fare as in the starting case, $172, and also the same average revenue per seat. As the preferred airline, airline A is full even on off-peak days. Airline Z has an average fare of $100, and average load factor of 67%, and revenue per seat of $67. The market as a whole is not profitable, because some revenue is lost ("spilled") on the peak days. Industry average fare is $143, but average load factor is 83%, and average revenue per seat is $119.

"Real" Spill

There are not just 3 types of days for airlines. In practice, there is a whole distribution of demand levels around the mean. It turns out there is a broadly accepted "spill" model used in the airline industry to estimate the average day results for airlines facing a year of demand cycles (Swan, 1997). This case uses a "K-cyclic" of 0.36 to capture the variations of demand through the year. The "C-factor" is set at 0.7[1]. Execution of the spill model in the case of A being preferred is in 3 steps. First, the total industry high-fare demand is spilled against the total A seats. There is very little spill. If there were any, airline Z would have space to carry it. Then the total industry demand, both high and discount fare, is spilled against the total A seats. The average discount load for A is the difference between this answer and the previous answer. Such treatment respects the basic objectives of a revenue management system. Revenue management strives to accommodate high-fare demand first and then leaves open for discount demand any unused space. So the spill calculations are "nested." The third nesting plays the entire industry demand against the entire industry capacity. The difference between this answer and the previous is the Z airline's load. It is all discount traffic.

With these ground rules, the industry load factor is only 79%, not the 90% the simplified example started with. The average fare is $146—higher because of spill losses of discount demand. The industry revenue per seat is $115—below the $126 postulated as breakeven.

Airline A is still doing well. Its revenue per seat is $161 from an 89% load factor and an average fare of $181. Airline Z is not doing so well. Its revenue per seat is $68 on a load factor of 68% and the usual average fare at the discount value of $100.

Not All Choices are Clear-Cut

The final case takes the assumption that not everyone finds airline A preferable. Only 2 out of 3 customers "prefer" A. The rest prefer Z. This represents a situation where the "quality" of airline A is either not obvious to everybody, or appeals only to some of the people some of the time[2]. The most practical case might be one where airline Z moves its flight away from the

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[1] For the true spill affictionado, the load factors on closed flights implied by using a C-factor of 0.7 for both airline A and the industry total (A+Z) capacity in this example is 93% for airline A and 97% for airline Z. The high number for airline Z makes sense because with no high-fare demand, airline Z's reservations system alone has a low C-factor.

[2] Not everyone evaluates airlines the same way, or has perfect information. A good model has tastes for various characteristics, a utility function that is the sum of tastes, an error term that captures variations in tastes, variations in values of characteristics, variations in measurements of characteristics, and uncertainty in assessment. . The result

departure time of airline A, so that some customers prefer the new departure time, in spite of the otherwise superior "quality" of airline A.   In this example, one third of the customers find airline Z's departure time preferable. The rest prefer airline A, if they can get a seat. Meanwhile, the usual rules of revenue management and nested spill apply.

The results show a diminished dominance by airline A.   Revenue per seat is $133. This is 16% above the market average of $146 but quite noticeably less than the wildly profitable $161 in the case where everybody prefers A. The industry averages in this case the same as for the simple spilled case. The ground rules imply no change.   In this case, Airline Z suffers at $97/seat. This is 42% better than the case where everybody prefers A, but still only 85% of the market average. If airline Z has 15% lower costs, this arrangement is lucrative for airline A, and still sustainable for airline Z.   Unless airline A drops fare to drive Z under, both can survive in the market.

Reviewing the Games

We can look at the progression of cases:

Airline A	$/seat	Load Factor	Avg Fare
Simple Case	$172	100%	$172
3-season case	$172	100%	$172
Annual Spilled	$161	89%	$181
2/3 Preferred	$133	85%	$157

Airline Z	$/seat	Load Factor	Avg Fare
Simple Case	$ 80	80%	$100
3-season case	$ 67	67%	$100
Annual Spilled	$ 68	68%	$100
1/3 Preferred	$ 97	73%	$133

Industry Total	$/seat	Load Factor	Avg Fare
Simple Case	$126	90%	$140
3-season case	$119	83%	$143
Annual Spilled	$115	79%	$146
2:1 Preferred	$115	79%	$146

Most of what has happened moving from the 3-season case to the more realistic spill model case is the recognition that airline A cannot use all 100 of its seats in practice, as had been assumed in the simpler discussions. Practical aspects of demand variations, uncertainties in no-show rates, and the strategies of revenue management holding seats for possible late-booking high-fare demand mean that the maximum annual average load factor is closer to 90% than to 100%.

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is a logit model of share. The smaller the difference in quality, measured by the uncertainty "sigma," the smaller the difference in share

The final "2/3 preferred" case could be the most realistic comparison. If the preferred airline would let it, the less-preferred airline should seek out its own unique time of day, reducing the direct competition and isolating some share of the high-yield demand and of the total loads for itself. With realistic but substantial cost advantages[3], Z can cling to its place in the market. What is interesting is how powerful the preference for A is, even in this case. Should airline A choose either to move towards airline Z's unique departure time, or should airline A choose to forego some of its 15% above-average revenues by lowering market fares, airline Z would again be loosing money and likely withdrawing from the market.

Why Aren't all Airlines High Quality?

If being the preferred airline is so powerful, why is it airlines are not racing to make their services better and better? There would seem to be two answers to this. First, most major airlines strive to match their competitor's quality. Knowledge that any improvement by one will be matched by an improvement by the competitors means the temptation to improve is inhibited. Indeed, if the game theory answer of always being matched is widely known, then it pays to set just that amount of quality the market willingly pays for, and no more. This maximizes the market size, with out adding cost beyond its value. The second proposition is that airlines spend more time avoiding head-to-head competition than they do trying to win it. Picking out a different departure time is one way. Picking out a different market or different airport within a market to serve is another. As travel has grown, it has grown very much by adding new nonstop markets and new frequencies at new times of day. The average number of airlines per airport pair has remained unchanged (cf. "Consolidation in the Airline Industry," William M. Swan, Oct 2003, working paper, available at cyberswans.com).

In any case, the counter-examples rarely exist. There are few cases where distinctly inferior quality airlines compete head-to-head with standard airlines. They compete at different airports, or at least different times of day. Indeed, the mantra of many competitors starting up is to "give the customer no reason to avoid my airline." The matching of amenities is scrupulously observed.

Exceptions to this case are airlines with costs so much lower they can compete without the high-fare traffic. There is even a counter-punch for the low-cost carrier: it can drop its high fares in the market. Airline A has to match, and thereby give up its premium average fare. That leaves airline A with only the preferred load factor. This diminishes its financial edge. Most low cost carriers do not totally eliminate the pattern of higher fares closer to departure. Indeed, they often price them between 2 and 3 times the normal discount fare, even when there are plenty of seats available. This is because the demand becomes inelastic in the days close before departure time, so higher fares generate more revenue than lower fares but higher loads.

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[3] Interestingly enough, a number of low-cost carriers have realized that lower labor costs mean they can produce "quality" at a lower cost than older carriers that have unionized service employees. Some have matched or exceeded the market quality of service. Arguably Southwest, America West, Continental, and Jet Blue have used their cost advantages this way. However, this is not a "magic bullet." Some failed carriers have done this, too.

Time-of-Day Games

In the next set of complications, we would like to investigate more fully the issue of time-of-day competition. We choose to return to the simple model where there is only one demand, not a distribution, and where airplanes can operate up to 100% average load factor. This means that readers can confirm the calculations without resort to spill modeling. However, revenue differences will be exaggerated. In doing this we sacrifice numerical nicety to gain clarity of exposition. At least, that is our hope.

The time-of-day distribution will also be simplified. We imagine only three useful times of day: morning, midday, and evening. We imagine that airlines A and Z will be choosing to schedule 1, 2, or 3 flights at their choice of 1, 2, or 3 of these times of day. We characterize the full-fare demand as having 6 kinds of people. 5% will go at any of the three times, and distribute themselves equally if they have multiple choices. If the preferred carrier has a flight at any time, they will go on that carrier. 10% of the full-fare demand prefer without prejudice the morning or midday flight, and will go in the evening only if neither is available. If the preferred carrier offers either a morning or a midday service, this group will take that carrier's flight(s). A second 10% has similar tastes for the evening or midday flights. If one of these two times is completely unserved, the demand moves to the other, served, time. The bulk of the market has a specific preferred time and will not change that time for the preferred carrier. That means 25% each prefer morning, midday, and evening times. If a preferred time is not offered by either carrier, the demand will replan their trip and divide to the served time(s). Finally, passengers will seek out available empty seats if all the flights they prefer are full.

The discount demand divides in the same pattern as full fare. That is, some have no time preference, some prefer AM or PM, and some insist on one of the more specific times--morning, midday, or evening.. However, the discount has 30% willing to go at any time, and only 10% insistent on a specific third of the day.

Full-Fare	**morning**	**midday**	**evening**
only	25%	25%	25%
AM	10%		
PM			10%
any		5%	

Discount	**morning**	**midday**	**evening**
only	10%	10%	10%
AM	20%		
PM			20%
any		30%	

In the first case, both airline A and airline Z have morning departures. The result is all customers have to travel in the morning. The market divides exactly as it did in the first, simple example. Airline A has 100% load factor, and all the full-fare demand. Airline Z has 80% load factor, but only discount fares onboard. Airline Z is not profitable. Losses are 37%.

Time-of-Day Games: The Second-Choice Airline Runs and Hides

The first move in the game is airline Z moving to the neglected evening time slot. With this arrangement and speaking of the full-fare demand, airline A gets the 25% that prefers the morning, all the 10% that prefers AM flights, and all the 5% that will go anytime. In addition, the midday demand is unserved. It splits equally to the morning and evening times, giving airline A a 52.5% share in total. Airline Z gets 47.5%.. We assume as before a market of 180 total passengers, 20% full-fare, and 100-seat airplanes for each airline.

The new result gives airline A 18.9 full-fare passengers. Airline Z gets the rest, 17.1. Airline Z has gained nicely by moving away from the time slot of airline A and gaining a good share of the time-insistent full-fare demand.

Airline A attracts a larger share of the discount demand than of the full-fare demand. If it had room, airline A would carry fully 65% our of 144 discount passengers. However, there are only seats for 81.1. As a result airline A has a 100% load factor, average fare of $138, and average revenue per seat also $138. With break-even at $126, airline A has a 9% excess profit.

Airline Z gets an 80% load factor, average fare of $142, average revenue per seat of $114, and a only a 9% loss. Although airline Z has the same load factor as when head-to-head, revenues are up substantially. Airline Z has found a niche in time that minimized the degree of head-to-head competition with the favored airline A. The consequence is that airline A maintains its load factor advantage, but surrenders a good part of its average fare advantage, to airline Z’s benefit.

The biggest surprise is that the average fare on airline A is lower than the average fare on airline Z. This is because the discount demand is more willing to shift departure time to get the preferred airline than the full-fare demand is. In the example this “willingness” was by assumption. Yet it is a reasonable assumption; the distributions used are realistic. For example, there are markets in the US with a single nonstop service competing with not one, but a whole menu of connecting services. A single nonstop service tends to get between 50% and 60% of the market. However, it does not necessarily capture a premium average fare in the local market. At least that is what the ticket sample data implies. What is happening is that the local discount demand is filling up the seats and bringing down the average. The result is that a sole non-stop in a market does not necessarily end up with higher average local fare.

Time-of-Day Games: The Preferred Airline Tries to Dominate

Airline A can improve its position. It can move its departure to the midday time. This crowds airline Z into a smaller corner of the time-of-day choices. Indeed, the midday slot satisfies both the AM and the PM divisions of demand. It gives more customers their first choice than the morning departure alone does. On that basis, airline A might have chosen it to begin with. The less valued morning departure was used for its exposition value. It could have been selected by airline A because it eased scheduling constraints.

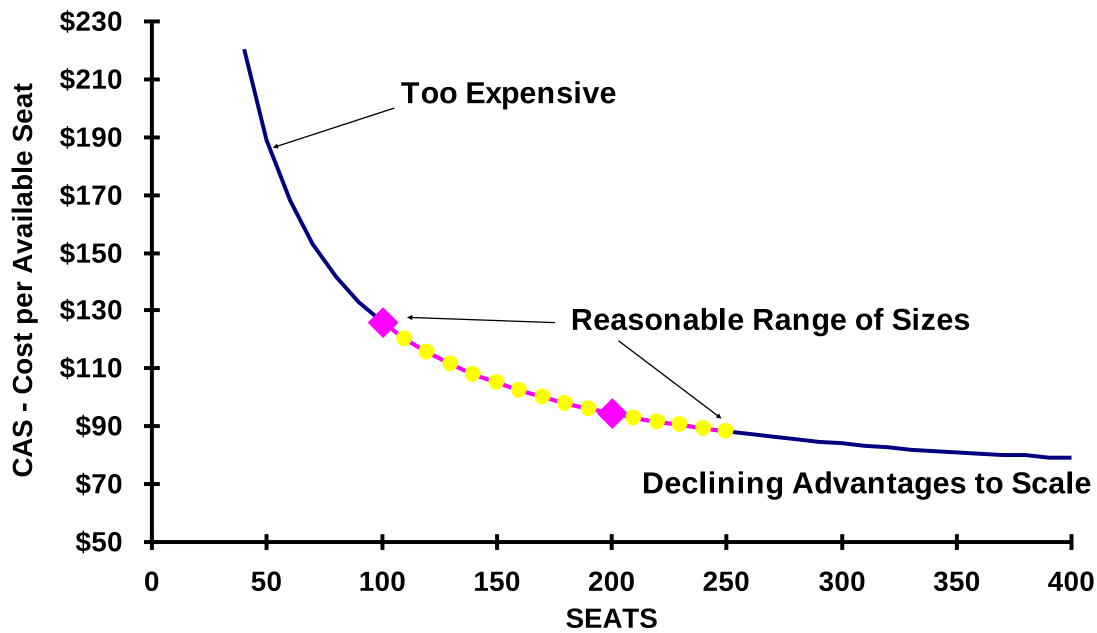
With this new arrangement, Airline A no longer shared that division of the demand that prefers PM (either midday or evening) times. A attracts 62.5% of the full-fare demand and 95% of the discount demand. Load factors are unchanged, but A gains 4.4 full-fare customers. Average fares are now $145 and $134, for A and Z respectively. Average revenues per seat are $145 and $107, and profits are plus 15% for A and minus 15% or Z, based on equal costs. Airline A's move to minimize the under-served time of day has doubled the "hurt" for airline Z.

However, the situation is still not as good for airline A as it was when the two airlines had the same time slot. In this parlor game, airline A's best move is to chase airline Z's time changes around the schedule, always trying to be head-to-head. Airline Z's best move is to avoid airline A's time choice. This game is not real life. In practice, the airline Z's of the world let the airline A's get first pick of time slots. Afterwards, airline Z decides whether it is better to share that first-choice time, or find a less-desired time-of-day where it can have some market power.

More Games: Airline A adds Capacity with a Larger Airplane

Let us imagine the demand is 50% higher—high enough to fill 3 airplanes. Airline A is making money, and might well be tempted to switch to a larger airplane in its midday slot. (Airline Z has 100% load factor and revenues 5% above break-even.) A's available larger airplane has 200 seats. (Relative costs in this example are realistic; they are take from Adler and Swan xxxx.) Because larger airplanes are cheaper per seat, the cost per seat drops from $126 to $95. With the same preference rules, Airline A continues to attract demand in excess of capacity, and continues its 100% load factor. Average revenue is down to $134. Profits are now 42% on a larger base. This looks pretty good to airline A. Meanwhile airline Z in the evening slot now has a 70% load factor and is loosing 12% against costs. This is worse than before, when demand was smaller and airline A had a smaller airplane. It looks like the dominant airline would be the first to add capacity, and the less-preferred airline might not grow.

Larger Airplanes Have Economies of Scale



Counter-move: Airline Z adds a Flight before Airline A adds capacity

Airline Z could add a second flight. By picking the morning time slot, airline Z gains another chunk of demand. Airline A now attracts 50% of the full-fare market, and 60% of the discount market. Load factor is 100% and profits are 22%.

Airline Z ends up with both morning and evening flights at 85% load factor and a revenue per seat 11% below standard costs. What does this say about the real world? If airline Z's costs are a little below standard, it can survive in mixed competition with a preferred airline, if the preferred airline is satisfied with a minority position in the market. This is a pretty difficult "if." Few examples will be found in the market.

Alternate Airline A move: add frequency

Airline A could add a morning departure to the situation of its having the midday departure and airline Z having the evening departure. The higher demand case would support 3 departures at 100 seats, overall. If airline A added its flight in the morning, customers would have the best deal: all three times of day would be available. Airline A would have a 99% load factor and 11% profits. (Some of the discount spill from the midday flight gets on the morning flight.) Airline Z's would have 72% load factor and 21% loss against standard costs. Airline Z no longer gets half the high-yield morning customers, the half who re-planned their trips to the evening time slot.

If airline A added its flight in the evening instead, it does better. By going head-to-head with airline Z, airline A captures all the high-yield traffic entirely, leaving airline Z with only the spilled discount traffic. Airline A's profits rise to 22%, and airline Z now looses 44%. Dominant airlines do better going head-to-head against non-preferred carrier's time slots, rather than seeking unserved times of day, as we saw before.

If this were a parlor game, airline Z might try to run to the morning slot when airline A moved "on top" of its evening slot. Airline A might move its midday flight to the morning, and the chase around the clock would continue. In practice, airline A is never 100% preferred. If A is 100% the preferred carrier, airline Z is better advised to go to another city pair.

Discussion of Time-of-Day Games

These time-of-day games suggest that the strong advantages the preferred airline had in the single departure cases are only weakly mitigated when time-of-day is allowed to complicate the picture. It suggests that there are reasons for airlines that are not preferred to investigate times of day that are neglected by the dominant carriers. In practice, different times of day are easier for some carriers than others, because of the rest of their route networks. Either airplane routings or connecting traffic may influence decisions. The cleanest cases are international markets over the Atlantic or Pacific. Some have one large peak, often the overnight flight time, and another smaller morning peak. Two matched carriers usually fight it out in the prime time. At some point a 3rd or 4th carrier finds it wise to serve the secondary peak. If one of the resident carriers has not already figured out to add a second flight time. The multiple-player game with differentiated route network and connect traffic feeds gets quite complicated, whether or not qualities "match."

Summary and Conclusions

The primary lesson about airline competition is that airlines have strong incentives to match. A preferred airline does best matching prices, while a non-preferred airline does poorly unless it can match preference.

A preferred airline gains substantial revenue from higher load factor in the off peak and higher shares of the full-fare passengers in the peak. These revenue gains are greater than realistic gains from trying to have higher prices. So preferred airlines tend to match on price and get their profit gains from yield and load factor advantages.

A less-preferred airline has a difficult time covering costs. Losses can be large. Such an airline has strong incentives to become competitive in preference. Failing that, the less-preferred airline can better its position by moving to times or markets without competition.

Spill, partial preference, and time-of-day distributions modify the strength of the preferred airline's advantage. However, the advantage remains fairly strong even as more realistic assumptions are added.

References

Adler, Nicole and Swan, William M, “Aircraft trip cost parameters: A function of stage length and seat capacity.” Transportation Research Part E 42 (2006), 105-115.

Swan 1997: spill model