

Overbooking: A Sacred Cow Ripe for Slaughter?

This paper examines the economic rationale behind Ryanair's no-overbooking policy by using a simple overbooking model that describes the number of surviving bookings as a binomial process. The resulting decision rule allows determining a booking limit on the number of reservations based on empirical data on yields, variable costs, costs per denied boarding and no-show probabilities. Two types of uncertain events have an impact on the overbooking decision – cancellations and no-shows.

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Common wisdom in airline revenue management holds that selling more seats than the capacity on a given flight is the only way to compensate for passengers that fail to show up at departure, which causes loss of revenue due to empty seats. More than 5.5 million passengers did not show up on flights operated by Lufthansa German Airlines in 2004. This corresponds to 14,000 full Boeing 747. Overbooking allowed Lufthansa to carry more than 640,000 additional passengers. Lufthansa credits the practice of selling a number of tickets for a flight that is greater than the flight capacity for a revenue increase of €126 million in 2004 (denied boarding costs already deducted) making overbooking not only one of the oldest revenue management techniques applied by Lufthansa but also one of the most powerful.

Like Lufthansa, most major American and European airlines overbook their flights above the physical capacity of the aircraft. However, at least two leading low-cost airlines, Ryanair in Europe and US-American JetBlue, do not overbook their flights and therefore eliminate the possibility of passengers being involuntarily denied boarding as a result of overbooking. As the CEO of JetBlue, David Neeleman, puts it: 'People want to go to the airport knowing they have a seat. We also do not want our people to get beat up when customers find out the plane is overbooked' (quote from USA TODAY).

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booking policy by using a simple overbooking model that describes the number of surviving bookings as a binomial process. The resulting decision rule allows determining a booking limit on the number of reservations based on empirical data on yields, variable costs, costs per denied boarding and no-show probabilities. Two types of uncertain events have an impact on the overbooking decision – cancellations and no-shows. According to Talluri and Van Ryzin (2004), cancellations are defined as 'reservations terminated strictly prior to the time of service' whereas no-shows occur when customers do not cancel their reservations but fail to show up at the time of service. The optimal overbooking limits derived in this paper compensate for no-show passengers at flight departure. In practice, overbooking limits are recomputed periodically during the booking period of a flight and account for cancellations of individual or group reservations or re-bookings on other flights. Early in the booking period (e.g. 90 days before scheduled flight departure), an airline may set high overbooking limits to capture as much demand as possible. The overbooking limits decrease over time as the departure date approaches. This downward adjustment of overbooking limits, which Lufthansa calls 'decrementing', is not considered in this paper.

Ryanair is not just one of the few airlines with an official no-overbooking policy, but also Europe's most successful low-cost airline (LCA). Lufthansa is one of the fully-fledged network airlines (FNAs) in Europe,

besides British Airways and Air France. The paper considers the impact of Lufthansa's significant operational differences to Ryanair's low-cost approach on optimal overbooking. The empirical analysis is based on data from Ryanair and Lufthansa and the new European denied-boarding compensation system according to EC-Regulation 261/2004 with a focus on intra-European routes of less than 1,500 km.

We conclude that for network airlines especially, overbooking is not 'ripe for slaughter', but that underlying principles should be reviewed in order to capture the last-minute passenger who is willing to pay the full fare while keeping control over seat sales and avoid involuntary denied boardings.

A simple overbooking model

In a simple model, optimal overbooking balances spoilage costs due to empty seats and oversales costs when the airline is faced with more demand than available capacity. The overbooking model stated below follows the inverse newsvendor framework as described by Bodily and Pfeifer (1992) and Netessine and Shumsky (2002). In practice, airlines like Lufthansa apply sophisticated forecasting tools that analyze individual bookings to calculate flight-specific overbooking limits. However, 'real world' models add complexity and details not needed to tackle the basic question of this paper whether overbooking makes sense or not.

The following terms are used: the bookings, denoted by B , that show up

at departure are called survivals, S . The difference between bookings and survivals is the number of no-shows. Capacity, N , is the number of seats available on the flight. If the number of survivals is greater than capacity, the excess is oversales. If the number of survivals is less than the capacity, the difference between capacity and survivals is spoilage.

Let R denote the contribution (equal to revenue less variable cost) from each surviving booking that is not an over-sale. C is the cost penalty of a booking that survives only to be denied boarding at flight departure. Included in C would be compensatory awards and loss of goodwill that are associated with refusing a seat to a passenger holding a confirmed reservation.

Reservations managers facing a booking request have to make a decision to extend bookings from B to $B+1$ or curtail bookings at B . In line with Bodily and Pfeifer (1992), we derive a simple decision rule as follows: If survivals S exceed seat capacity N , the airline has oversales costs C , sometimes also referred to as spillage costs. Otherwise ($N > S$) it has spoilage costs R . $P(S=N)$ is the probability of spoilage and $P(S > N) = 1 - P(S=N)$ the corresponding probability of oversales. Assuming that the reservations manager's objective is to minimize total costs, it is lucrative to increase B to $B+1$ if the following condition holds:

$$P(S \leq N) \cdot R - P(S > N) \cdot C = P \cdot R - (1 - P) \cdot C > 0.$$

Solving the above expression for P , we have

$$(1) \quad P > \frac{C}{C + R},$$

where P is probability of spoilage if the reservations manager curtails bookings at B . Stated another way: curtail bookings when the probability of spoilage has decreased to the ratio $C/(C+R)$. The reservations manager can implement this decision rule directly using estimates for R and C and by assessing P subjectively at each decision point.

The simple decision rule can be easily extended. Assume a booked customer

has a probability of λ of surviving that does not depend on when the booking was made, and that booking survivals are independent of one another. Then we have a binomial process for the number of bookings that survive, with mean and variance. Using the normal approximation to the binomial, we have the following decision rule, which is derived in detail by Bodily and Pfeifer (1992) allowing bookings up to the point at which

$$(2) \quad \Phi = C/(R + C) + \phi(1 - \lambda)^{1/2} / [2 \cdot (B \cdot \lambda)^{1/2}],$$

where ϕ is the unit normal probability density function and Φ is the left-tail unit normal cumulative distribution function, both evaluated at:

$$(N - B \cdot \lambda) / [B \cdot \lambda \cdot (1 - \lambda)]^{1/2}$$

This rule includes the familiar $C/(C+R)$ plus an additional term to account for the change in variance of the probability distribution for survivals when adding one more booking. This second term goes to zero as B gets large. In the following calculations, we assume that the distribution of S is the distribution of survivals, given that we sell exactly N tickets, and that any overbooked passenger is guaranteed to show up. Hence, we do not consider the second term of decision rule (2). The decision rule

$$\Phi = C/(R + C)$$

allows determining a fixed booking limit on the number of reservations based on empirical values for C , R , N and λ .

Note the simplifying assumptions of the overbooking model stated above:

All tickets cost the same which implies that for each flight there is only one compartment.

On flights operated by fully-fledged network airlines (FNAs), there are often physical compartments (e.g. Business/Economy Class) that divide the aircraft and booking classes as kind of "virtual compartments" within the physical compartments. Each of these booking classes has a fare level assigned to it. Several booking classes can be simultaneously available for sales, during the booking period of a

flight. Overbooking limits are defined for each available booking class of a flight.

The vast majority of low-cost airlines (LCAs) operates with only one compartment, but also divides their cabins in several booking classes. However, with regard to the overbooking of booking classes, there is an important difference with FNAs. In simplified terms, there is only one booking class available at any point of time during the booking period. Once the physical contingent of seats in a lower booking class is sold, the booking class is closed and the booking class that is one step higher becomes available for sales. Hence, only the highest booking class of a flight can be overbooked by LCAs and the overbooking of the highest booking class equals the total overbooking of a flight.

Constant compensation costs per bumped passenger

The compensation costs tend to increase non-linearly with the number of passengers that were denied boarding. In addition, the resentment against the airline varies to a great extent with flight times and dates (see Ratliff, 1998). A passenger who has been denied boarding on the last flight home on Christmas Eve is going to be much more upset than a passenger denied boarding on a mid-week flight at 9 a.m. with several flights available later in the day.

Constant no-show probability of booked passengers

In practice, the survival probability will depend on the time the reservation was made. For example, reservations that were made only a few days before flight departure may produce survivals with greater likelihood than reservations made earlier in the booking period of a flight. Clearly, certain conditioning events (e.g. weather conditions) may also affect λ . Bodily and Pfeifer (1992) show that decision rule (2) can be extended to allow for time-varying probabilities and conditional dependencies of survival.

Overbooking policies at Ryanair and Lufthansa

If we can predict the percentage of no-show passengers for a future flight, estimate the lost contribution associated with empty seats (spoilage) and are also able to estimate the oversales costs associated with denied boarding passengers, then we can derive optimal overbooking limits using the simple overbooking model stated in the previous section.

In the following, we derive the optimal number of overbooked seats only for intra-European flights less than 1,500 kilometers (e.g. Frankfurt – Rome or London – Nice). A stage length of less than 1,500 kilometers is typical for European low-cost airlines like Ryanair. In the empirical analysis, we use the contribution and no-show probabilities of such flights when operated by Lufthansa and Ryanair respectively. Besides the average contribution of a sold seat (the average amount of revenue per passenger minus the variable costs per passenger), we will also calculate overbooking limits for Ryanair using the contribution of the last seat sold on Ryanair's flights. Clearly, the absolute number of overbooked seats also depends on the aircraft type operated by these two carriers:

Ryanair currently operates a single B737 fleet-type including 82 new B737-800 with a 1-class capacity of 189 seats and 9 older B737-200 with 130 seats.

Lufthansa operates with significantly different aircraft sizes within Europe. It operates the A300-600 with 280 seats on routes between its hub in Frankfurt/Main to airports such as London-Heathrow. Destinations such as Amsterdam are served with B737 or A320/321 and 2-class seating configurations between 103 (B737-500), 123 (B737-300), 150 (A320) and 182 (A321). Direct point-to-point services for example between Hamburg and Milan are operated with Canadair Jet offering 50 seats on the aircraft.

Estimated costs associated with denied-boarding passengers

A new regulation by the European Community (EC) came into effect on

17 February 2005 to protect the rights of air passengers when facing denied boarding and cancellations or long delays of their flights. This new regulation repealed a weaker regulation that dated from 1991. Every passenger who becomes an involuntary denied boarding, is entitled to a minimum compensation of €250 for all flights of 1,500 kilometers or less.

The new EC regulation 261/2004 also requires air carriers, when expecting to deny passengers boarding, to first call for volunteers to surrender their reservations, in exchange of benefits, instead of denying passengers boarding against their will. Even before this regulation, airlines point to the great success in luring passengers off over-sold flights with vouchers or money payments, minimizing the number of involuntary denied boardings.

Lufthansa currently offers equal compensation for voluntary and involuntary denied boardings. Hence, in the following calculation of optimal overbooking limits, €250 will be used as the estimate for the minimum compensation – regardless whether the denied boarding is voluntary or involuntary. As Ryanair officially does not overbook its flights, there is no Ryanair policy for compensating passengers denied boarding. This paper assumes that in case Ryanair changes its policy to allow overbooked flights the compensation will correspond to the minimum stipulated in the EC regulation (€250). Clearly, Ryanair could also try to apply cost-saving voluntary denied-boarding procedures as applied in the US market such as a policy of gradual compensation where the compensation package offered to the passenger will depend on the response to the request for volunteers.

Estimated lost contribution associated with empty seats

In order to estimate the contribution R , one needs data on ticket prices and variable costs per passenger. In our empirical analysis, the ticket price B will be approximated by the yield: the average amount of revenue per passenger on a flight route received by the operating airline. Ryanair's average fare in December 2003 was €35.6. Adding Ryanair's ancillary revenue

(car rental, in-flight, etcetera) per passenger of €6.7 leads to €42.3 as yield (Ryanair, 2003). As variable costs per passenger amounted to approx. €6.5, the average contribution of a sold seat on Ryanair's flights was €35.8. In comparison, Lufthansa figures for intra-European flights less than 1,500 kilometers show an average contribution per passenger of approx. €120.

Note that the actual contribution depends on flight and booking class. Overbooking is primarily relevant to flights that are in high demand. The last tickets on full Ryanair's flights are often sold for more than €200. For this reason, the contribution of the last minute passenger who is willing to pay the highest Ryanair fare is a more adequate estimate to be used in the calculation for Ryanair's optimal overbooking limit. Later we will calculate with different values for Ryanair's lost contribution, the average €35.8 per passenger and a reasonable estimate of €120 for the last minute passenger whose accepted booking request leads to an overbooked flight.

Prediction of the percentage of no-show passengers on a future flight

No-show rates depend on several factors such as time of reservation during the booking period of a flight, ticket price paid, the route, departure time, day of the week and also seasonality. Other factors that influence the no-show rate are the share of business travelers, the flight frequency with higher frequencies leading to increased no-show rates, and special events (e.g. holidays, fairs), the group share and cultural factors. No-show rates tend to be significantly lower among low-cost airlines (LCAs) than among fully-fledged network airlines (FNAs), because of the following reasons:

Misconnections. FNAs offer a network of feeding and connecting flights: a no-show passenger on the first flight, also booked on the second, will be a no-show on the second.

Customer segments. FNAs have a higher share of business travelers which leads to higher no-show rates and late cancellations.

Pricing structure. The low fare tickets of LCAs like Ryanair are non-refundable. However, passengers can call the airline in advance to rebook a flight on another day for a charge. FNAs fear that non-refundable tickets could scare off business travelers. Instead, FNAs offer fully refundable, anytime tickets. If the business traveler does not show up for a flight, he or she can get a full refund or take another flight without penalty. This certainly brings up no-show rates at FNAs.

Direct bookings. LCAs are able to control inventory better as passengers directly book with the airlines and not through travel agents. For example, more than 94 % of Ryanair's tickets are booked online through the airlines' own internet site. This significantly reduces double bookings of passengers who have been assigned two seats on the same plane, and it thus reduces the number of no-shows.

These reasons indicate significantly lower no-show rates among LCAs than the average 10.5 % on European flights encountered by Lufthansa. Indeed, in March 2003, Michael O'Leary, CEO of Ryanair, stated in front of the joint committee on transport of the parliament of Ireland, that Ryanair's total no-show in a year is about 900,000 passengers. Relating this figure to the 15.7 million passengers transported by Ryanair, the period of March 2002 until March 2003 leads to a no-show rate of 5.7%. In direct comparison, Ryanair's no-show rate is half that of Lufthansa.

Optimal overbooking limits

Optimal overbooking limits (OBL) for Ryanair and Lufthansa can be derived using the simple overbooking model of section 2 and the empirical values for lost contribution associated with

empty seats, costs per denied boarding and no-show rates presented above. In different numerical scenarios for Ryanair and Lufthansa, we can now calculate the optimal number of overbooked seats for an average European flight of 1,500 kilometres or less operated by these carriers using EXCEL's Norminv function (see Table 1).

Scenario S1 leads to a low OBL allowing reservations to exceed seating capacity $N=150$ by 5 seats. The low OBL results from oversales costs ($C=€250$) which are many times larger than spoilage costs ($R=€35.8$), and the high survival rate of Ryanair's bookings. One could argue that a no-overbooking policy becomes viable if one does not account for the direct compensation costs of €250 only, as stipulated by the EC regulation, but also include provision costs of hotel and meal, re-accommodation costs on another flight or airline and ill-will costs¹. Scenario S2 assumes that these additional costs amount to approx. €500, leading to a total average cost penalty for a denied boarding of €750. As a result, the optimal overbooking limit compared to S1 only decreases by one reservation. Hence, Ryanair's decision not to overbook seems to be wrong even if spoilage costs for empty seats are as low as in the numerical examples of S1 and S2.

Both, FNAs and LCAs sell their capacity in different booking classes. Each of these booking classes has a fare level assigned to it. However, with regard to overbooking there is an important difference in the booking procedures. Overbooking of booking classes at FNAs can, generally speaking, occur during the whole booking period, whereas overbooking at LCAs is limited to the highest booking class that is sold relatively close to flight

departure. To calculate the overbooking limit, the highest available fare on a specific flight should therefore be taken as lost revenue for LCAs and not the yield. In other words, the last tickets on a full Ryanair flight will not be sold for the infamous €9.99 but for much more, typically €150 to €250. In S3 we assume a contribution of €120. We then derive $OBL=158$. Hence, by not overbooking Ryanair foregoes an expected additional total contribution of approx. €960 ($= 8 \cdot €120$) on a fully booked flight.

We look at Lufthansa and its higher average no-show rate in S4 in comparison with Ryanair. Scenario S4 results in $OBL=166$ which clearly justifies the practice of overbooking at Lufthansa. Comparing S4 with S5 shows the limited dissuasive impact of the new EC denied-boarding compensation on Lufthansa's OBL. The old regulation stipulated a minimum of €150 as compensation for passengers that have been denied boarding on flights of 3,500 kilometers or less. The increased mandatory compensation for involuntarily denied boardings of €250 reduces the OBL in our numerical example by only one reservation. So far, we have not varied the seat capacity N . Varying capacity only alters the absolute number of overbookings in our model, but not the overbooking rate. Comparing OBL of S4 ($N=150$) and S6 ($N=280$ as seat capacity of Lufthansa's A300-600) shows that the overbooking rate of approx. 10.7 % in both scenarios is independent of capacity for the simple overbooking model.

Scenario	Airline	N	C	R	λ	OBL
S1	Ryanair	150	€250	€35.8	0.943	155
S2	Ryanair	150	€750	€35.8	0.943	154
S3	Ryanair	150	€250	€120	0.943	158
S4	Lufthansa	150	€250	€120	0.895	166
S5	Lufthansa	150	€150	€120	0.895	167
S6	Lufthansa	280	€250	€120	0.895	310

Table 1: Optimal overbooking limits (OBL) for Ryanair and Lufthansa

Conclusions

In this paper, we used a simple overbooking model, estimates for spoilage costs associated with empty seats, oversales costs and no-show probabilities of booked passengers to derive optimal overbooking limits at flight departure. More specifically, we analyzed intra-European flights operated by the network airline Lufthansa and the low-cost airline Ryanair respectively on intra-European routes of less than 1,500 kilometres. Whereas Lufthansa currently practices overbooking on its European flights, Ryanair claims not to overbook their flights.

Ryanair should allow for overbooking on high-demand flights, but with a more conservative rate than network airlines reflecting its lower average ticket price and no-show probability. Overall, overbooking is not 'ripe for slaughter' and remains one of the most powerful tools of revenue management even for low-cost airlines. Ryanair and also JetBlue are forgoing a revenue opportunity by allowing some no-show passengers without reselling those seats. Their management teams seem to have decided that the goodwill earned from avoiding involuntary bumps is a better long-term strategy than maximizing revenue in the short term. However, overbooking is not only a significant source of incremental revenue to most airlines, but it also creates economic benefits to the traveling public, such as increased seat availability and reduced overall costs of travel through more efficient use of airline seats.

By looking at low-cost airlines and their relatively low no-show rates, network airlines like Lufthansa are prompted to review underlying principles of their own overbooking policy. First, network airlines should pursue ways to control seat inventory better, even when travel agents remain the most important sales channel. Second, fare conditions for lower and medium fares should be reviewed. Low fare tickets should become non-refundable. Main lessons for network airlines from this paper can be summarized as follows: Keep overbooking in the revenue management tool box, but better control inventory and sell more non-

refundable tickets to bring no-show rates down and hence, the need for high overbooking limits.

Further research could extend the analysis of our paper by using a model framework that considers time-varying or conditional survival probabilities. For network airlines the relation between physical compartments (i.e., Business, Economy) that divide the aircraft is an important factor for optimal overbooking not considered in this paper. Having several physical compartments allows an upgrading of passengers if oversales occur in the lower compartment. The possibility of ticket upgrading increases the propensity to overbook. The downside for network airlines is the problem of downgrading as a special case of denied boarding. Being denied access to business class as a holder of a business-class ticket creates loss of goodwill among an airline's highest-value customers². Further, it will be interesting to see how different regulations in Europe and the United States for mandatory compensation and different airline practices concerning voluntary denied boarding will affect optimal overbooking. Finally, our paper has focused on overbooking limits at departure time. The problem gets more complicated when dynamic overbooking over the whole booking period of a flight is considered.

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