TOURISM SECTOR RECOVERY PLAN FOR AIRLINES

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Abstract

The COVID-19 pandemic has negatively affected South Africa's tourism industry and airlines due to the restrictive travel measures put in place to curb the spread of the virus. The tourism industry has a dependence on international tourists and their travel to and from South Africa, mostly via passenger air transport. As part of the COVID-19 Tourism Sector Recovery Plan, which wants to reignite the tourism industry, revenue maximisation for airlines while reducing costs for passengers (for example, in the tax on flight seats) has been suggested. This report investigates a revenue maximisation model based on seat inventory allocation for different scenarios, and comparing the optimal results to draw conclusions which suggest ways forward for airlines and tourism in South Africa.

1 Introduction

Tourism is the second-most important industry in the Republic of South Africa, after the mining industry. The 1996 White Paper on the "Development and Promotion of

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Tourism in South Africa" [3] provides for the promotion of domestic and international tourism. Furthermore, the National Development Plan identifies tourism as a labour-intensive sector with the potential to stimulate economic growth and transformation.

According to Saayman [6], one aspect of tourism is the movement of people from one place to another. This movement takes place within the eight industries which form the tourism sector. The need or desire to travel takes place for various reasons which may include business, leisure and/or visiting friends and relatives.

Transport is used to effect this travel movement and the transport industry makes a vital contribution to the total tourism experience. Transport in tourism has three components:

1. travel to the destination,
2. travel at the destination, and
3. travel from the destination (to a place of residence, for example).

Transport is generally divided into four categories: Air, Water, Rail and Road. Out of these four, air transport is the quickest and most convenient for long distance travel, either nationally or internationally.

Airlines therefore play an important role in the tourism industry, by facilitating bookings of flights, and the logistics, planning and execution of the flights themselves. However, airlines are a business, and must balance revenue generated from fare bookings (and other sales in the pipeline) with the costs involved in their business operations. Costs may include managing and maintaining a fleet of aeroplanes, providing different amenities (such as food and entertainment) during flights, paying salaries to the various staff involved, etc.

Due to global and local travel restrictions because of the global COVID-19 pandemic, the air transportation and, by extension, the tourism industries were severly impacted. This not only affected individual businesses' and countries' economies, but also jeopardised the livelihoods of people employed in the air transportation and tourism industries.

This Study Group Problem focuses solely on passenger air transport and how it may be used to plan for the recovery of the air transportation and tourism industries after the pandemic in the South African context.

The rest of the document is structured as follows. In Section 2, we provide background on the problem and its context within South Africa amidst the backdrop of the COVID-19 pandemic, and a brief introduction to airline revenue management and the associated problems of airline seat inventory control and seat pricing. In Section 3, we formulate the mathematical model for the airline revenue management problem as an optimisation problem by defining the decision variables, constraints, and objective function. In Section 4, we introduce the different scenarios we considered and the numerical results obtained from them. In Section 5, we conclude the report by brief summary and state some considerations for future research in regards to this problem.

2 Literature Review

2.1 COVID-19 impact on local airline travel

The COVID-19 pandemic had a deterimental effect on tourism as a whole due to the enforced lockdowns and travel restrictions that were put place by many of the world's nations. This had a knock-on effect to airlines and their salaried staff members, since minimal air transportation was allowed during the early stages of the pandemic. Which, in turn, negatively affected the tourism industry because it relies on international tourists visiting our shores.

Table 1 shows passenger arrivals at Airports Company South Africa (ACSA) by region for the period from September 2021 compared to the period ranging from July 2020 to September 2020.

Region	**July-Sept 2020**	**July-Sept 2021**	**Difference**	**% change**
International	582	289 743	289 161	49 684%
Regional	0	37 965	37 965	N/A
Domestic	630 845	1 445 885	815 040	129%
Unscheduled	22 666	10 668	-11 998	-53%
Total	654 093	1 784 261	1 130 168	173%

Table 1: Tourism quarterly performance report by region on passenger arrival movement [5, p. 13].

The differences can be attributed to lockdown restrictions which were eased to allow international travel as of 01 October 2020; for comparison, we note that strict lockdown regulations were in place during July 2020 to September 2020.

Table 2 represents the year-on-year change per month for departing passengers, for the year 2021 compared to year 2020.

As part of the COVID-19 Tourism Sector Recovery Plan [?], which is aiming to reignite the tourism sector in South Africa, optimisation of profit or revenue through

Month	**International**	**Regional**	**Domestic**	**Unscheduled**
July	147 091%	N/A	156%	-79%
August	674 587%	N/A	154%	-80%
September	200 363%	N/A	106%	-70%

Table 2: Year-on-year percentage change by month for departing passengers [5, p. 13].

a reduction in the tax on available seats has been suggested. In Table 3, for example, a cost breakdown for a fare booking on a domestic flight is given.

	Example 1	**Example 2**
Adult ($\times$ 1)	R1 220.00	R1 590.00
Taxes and fees	R3 298.00	R1 998.00
Booking details via WhatsApp	R 27.00	R 27.00
Flexible Travel Dates	R 650.00	R 520.00
Subtotal	R5 195.00	R4 135.00

Table 3: Domestic aeroplane cost breakdown example. Data from: travelstart `https://www.travelstart.co.za`

It illustrates a possible way of achieving the aim of selling all available seats through tax reduction and allowing the airline to still maximise its profit or revenue.

With the COVID-19 Tourism Sector Recovery Plan in mind, the following questions were posed by the industrial representative:

i What changes need to be implemented?

ii How many seats need to be sold, and how should seat costing be calculated, taking into account that airlines are not permitted to carry at full capacity?

iii How can airlines find ways to increase their profit using the available seats, considering COVID-19 regulations and the new Omicron variant?

As we started our investigation, we were informed by the industrial representative that the COVID-19 restriction on the number of passengers per flight has been relaxed and that airlines were permitted to carry at full capacity again. Therefore, we could consider scenarios where revenue is generated from selling all available seats per flight.

2.2 Airline revenue management and seat inventory control

There are many areas where optimisation may be applied in the airline industry [**?**], such as:

- flight schedule planning,
- fleet assignment,
- yield management,
- crew/staff scheduling,
- aircraft maintenance routing,
- schedule recovery.

Yield management is the process by which revenues are maximised by considering various different aspects, the two most prominent being airline seat inventory control and seat pricing [1].

The Study Group decided to focus on this revenue maximisation problem per single flight for an hypothetical airline. Under the most basic assumptions, the revenue generated per flight is mostly determined by seat inventory control and seat pricing.

Seat inventory for airlines tend to be fixed, even when considering the different scales at which the airline might be operating, either single or multiple flights and whether a single leg or multiple leg flights. This is because the physical seats in a aeroplane is fixed. However, different fare classes arise because a unit in the seat inventory may be given different purchase conditions and/or service amenities [1]. An example of these different conditions include distinguishing cabins (physically or otherwise) within the aeroplane itself, with associated differences in amenities available and/or served to these different cabins. Another example is a differentiation in fare pricing due to pricing discounts being applied to the fare [1]. More examples of fare class differentiation may be determined from the following:

- the person for whom the fare is being booked, distinguishing between infants, children, adults and senior citizens;
- the fare booking may allow for flexible booking dates, that is, flight dates may be altered after the fare has been booked;
- how the fare was booked in particular (in-person or online);

- the fare booking may also distinguish between a vaccinated or a non-vaccina-ted individual, which may be used to determine a further discount on the ticket.

Seat pricing can either be static or dynamic. Pricing processes can either be deterministic or stochastic. Static seat pricing assumes that each fare class has a constant and fixed price for the fare. Dynamic seat pricing introduces and considers other aspects which might contribute or detract from the fare price, such as demand and supply, time of booking, over- and underbooking, cancellations and no-shows.

For our problem, we will consider different scenarios constructed from changing the fare booking prices, and the addition or removal of constraints on the flight itself, or constraints on the manner in which the fare booking pricing is determined. Our aim was to compare the different generated revenues to determine if there would be significant differences in revenue if the pricing of taxes and fees, determined by airlines and playing a role in the overall fare booking price, were changed. (Unfortunately, the Study Group did not have sufficient time to investigate dynamic pricing models and how they would affect the revenue management problem.)

3 Mathematical Models

Let $\mathbb{R}_{>0}$ denote the set of positive real numbers and let $\mathbb{N}$ denotes the set of natural numbers without zero, that is, $\mathbb{N} = \{1, 2, 3, \dots\}$.

3.1 Revenue optimisation model

For the revenue management and seat inventory control problems, we describe a basic revenue maximisation problem with constraints, for a single flight/leg of a hypothetical flight of a hypothetical airline. We start with the following assumptions:

- there are d different fare classes for the flight,
- these fare classes are distinct from each other,
- the demand for each fare class is separate and not correlated to any of the other fare classes,
- there are no overbookings, cancellations or no-shows,
- pricing for each fare class is static,
- the flight has a constant and fixed capacity for passengers, that is, a constant and fixed number of seats available.

Now let f_i denote the ith fare class ($i \in \{1, 2, \ldots, d\}$), $p_i \in \mathbb{R}_{>0}$ denote the associated price of fare class f_i, $n_i \in \mathbb{N}$ denote the number of bookings made for fare class f_i, and $N \in \mathbb{N}$ denote the total number of seats available on the flight, which we shall also call the *carrying capacity* of the flight. Each of the n_i are considered decision variables of the problem, while each of the p_i are considered constant or given parameters of the problem.

Let R_i denote the revenue generated when n_i bookings for fare class f_i are made, which is calculated as the product of the price p_i and the number n_i of bookings of fare class f_i, that is,

$$R_i = R_{p_i}(n_i) = p_i n_i. \tag{1}$$

The total revenue R generated by the flight is calculated as the sum of these individual revenues, that is,

$$\begin{aligned} R(n_1, n_2, \ldots, n_d) = \sum_{i=1}^{d} R_i &= R_1 + R_2 + \cdots + R_d \\ &= p_1 n_1 + p_2 n_2 + \cdots + p_d n_d. \end{aligned} \tag{2}$$

If we introduce the vectors $\boldsymbol{n} \in \mathbb{N}^d$, $\boldsymbol{p} \in \mathbb{R}^d_{>0}$ such that

$$\boldsymbol{n} = \begin{bmatrix} n_1 \\ n_2 \\ \vdots \\ n_d \end{bmatrix}, \qquad \boldsymbol{p} = \begin{bmatrix} p_1 \\ p_2 \\ \vdots \\ p_d \end{bmatrix}, \tag{3}$$

then we may rewrite the total revenue function (2) more compactly in vector form as

$$R(\boldsymbol{n}) = \boldsymbol{p}^T \boldsymbol{n}. \tag{4}$$

For the constraints of the problem, we have two possibilities: general constraints and specific constraints. General constraints will be applicable to each scenario which we shall be considering, while specific constraints will be determined by the different individual scenarios that will be under our consideration.

First, we consider and specify the general constraints. We require positivity for each of our variables and strict positivity for the carrying capacity of the flight:

$$n_i \geq 0 \ (i \in \{1, 2, \ldots, d\}), \qquad N > 0. \tag{5}$$

Although we could realistically impose negtivity on the price p_i for the fare class f_i (that is, $p_i < 0$), which would correspond to a loss in revenue for that specific fare class, we shall also assume that these prices are strictly positive:

$$p_i > 0,\ i \in \{1, 2, \dots, d\}.$$

The total number of tickets booked may not exceed the carrying capacity of the flight:

$$n_1 + n_2 + \cdots + n_d \leq N. \tag{6}$$

We also impose a lower-bounded constraint on the number of bookings for a flight. For our problem, we require the total number of bookings must exceed at least half of the flight's carrying capacity, that is,

$$n_1 + n_2 + \cdots + n_d \geq \frac{N}{2}. \tag{7}$$

Recall that specific constraints will be determined by the individual scenario under consideration. For example, in one scenario, we may require that there is a fare class associated with vaccinated passengers and that at least half of the flight's carrying capacity be filled with bookings from this fare class. As another example, we may require that a majority of the flight's bookings be done online.

With all of the definitions and constraints as given above, we may now formulate the basic revenue maximisation problem as

$$\begin{array}{ll} \text{maximise} & R(\boldsymbol{n}) = \boldsymbol{p}^T\boldsymbol{n} = p_1 n_1 + p_2 n_2 + \cdots + p_d n_d, \\ \text{subject to} & \quad n_1 + n_2 + \cdots + n_d - N \leq 0, \\ & -n_1 - n_2 - \cdots - n_d + \dfrac{N}{2} \leq 0, \\ & \qquad g_j(n_1, n_2, \dots, n_d) \leq 0 \end{array} \tag{8}$$

where the g_j are specific constraints added depending on the specific scenario.

3.2 Base fare price model

As previously stated, seat pricing may either be static or dynamic, determined by either deterministic or stochastic processes.

Recall that we assume that our fare classes are distinct from each other, and that the demand for each fare class is separate and not correlated to any of the other fare classes.

For our problem, we considered a model to generate fare prices based around what we shall call a *base fare* together with a *base fare price* P_b from which all our other fare classes and prices are derived.

This model allows us to generate fare classes and fare pricing data for our optimisation problem (8) from a single input value. Our motivation was a lack of actual data from airlines. However, a drawback is that the generation of the data is dependent on certain assumptions and parameters which need to be provided from the start, and that the parameters are constant and fixed.

To each fare class, taxes and fees are added as a separate fee P_t as determined by the airline, which we shall consider a given once-off parameter.

We derive the different fare classes from the base fare based on the following yes/no questions:

- Is the fare for a child passenger?
- Is the fare for an infant passenger?
- Was the fare booked online?
- Was the fare booked with flexible booking dates in mind?

If the fare is for neither a child passenger or an infant passenger, we assume that the fare is for an adult passenger. There is no distinction between adults and senior citizens (pensioners) in this model.

Discounts are applied if the fare is for a child or an infant passenger. The discounts are determined as the product of the base ticket price and some discount percentage for the specific cases, that is,

$$\text{discount} = P_b \times (\text{discount percentage}).$$

For children passengers, the discount percentage was chosen to be 75% of the base ticket price and, for infant passengers, the discount percentage was chosen to be 10% of the base ticket price. All discounts are subtracted from the base ticket price.

A penalty fee will be applied if the fare is booked with flexible booking dates in mind. This penalty is determined as the product of the base fare price and a penalty percentage, that is,

$$\text{penalty} = P_b \times (\text{penalty percentage}).$$

We considered a penalty percentage of 30% of the base fare price for bookings with flexible dates. The penalty fee is added to the base fare price.

The booking fee is determined as follows: if the fare is booked online, a fee of R27 is added to the booking price; if the ticket is booked in person, a fee of R250 plus a percentage value-added tax (VAT) is added. The current VAT percentage in South

Africa is 15%, which yields an in-person booking fee of R287,50. (This is essentially a discount when the booking is done online.) This booking fee is added to the base fare price.

In light of the COVID-19 pandemic, we asked the additional question:

- Is the passenger vaccinated?

The idea is to incentivise passengers to get vaccinated by applying a discount to the ticket price if the passenger is vaccinated. Furthermore, for comparison purposes, we will apply an extra constraint based on the number of vaccinated passengers to see if this incentive will have an impact on the revenue per flight.

The final price of the ith fare class is then given by

$$\begin{aligned} p_i = P_b + P_t &+ (\text{flexible-booking penalty fee}) \\ &+ (\text{booking fee}) - \sum(\text{discounts}). \end{aligned}$$

From the yes/no questions above, we are able to generate a total of $2^4 = 16$ different fare classes and their associated prices—when we do not consider vaccinated passengers as part of the model—for a given base fare price, the associated rates and taxes, and the various discounts and penalty. If vaccinated passengers are taken into consideration as part of the model, we generate a total of $2^5 = 32$ different fare classes. However, we may exclude certain combinations from these generated sets. For example, we consider it impossible for a passenger to be both a child and an infant, so we cannot apply both these discounts simultaneously. And at the time of the Study Group, it was still impossible for children or infant passengers to be vaccinated, so we cannot apply a vaccination discount for children or infants. This will result in a data set for fare classes with less than the 16 or 32 total combinations.

4 Results

First, we describe the various scenarios that we considered and the parameters determined by these scenarios. Then we describe how the numerical results were obtained and the numerical results for each individual scenario.

4.1 Scenarios

For all of the following scenarios, we set the carrying capacity of the flight at 92 seats, that is, $N = 92$. (This is the carrying capacity of an average domestic flight in South Africa.)

4.1.1 Scenario 1

First we consider a basic scenario where we only have three different fare classes based on different airline cabin classes (in order of increasing fare price): economy, business, and first class.

We let f_1 = economy class, f_2 = business class, and f_3 = first class. We shall assign each of these fare classes the following fare prices (in Rands):

$$p_1 = \text{R1 500}, \qquad p_2 = \text{R1 850}, \qquad p_3 = \text{R2 000}.$$

for a single seat of each fare class, respectively.

We impose the constraints that more economy class tickets be sold than business and first class tickets, and that more business class tickets be sold than first class tickets. That is,

$$n_1 \geq n_2, \qquad n_1 \geq n_3, \qquad n_2 \geq n_3.$$

With this in mind, the revenue maximisation problem (8) may be written as

$$\begin{aligned} \text{maximise} \qquad & R(\boldsymbol{n}) = \boldsymbol{p}^T \boldsymbol{n} = p_1 n_1 + p_2 n_2 + p_3 n_3, \\ \text{subject to} \qquad & n_1 + n_2 + n_3 \leq N, \\ & -n_1 - n_2 - n_3 \leq \frac{N}{2}, \\ & -n_1 + n_2 \leq 0, \\ & -n_1 + n_3 \leq 0, \\ & -n_2 + n_3 \leq 0, \end{aligned}$$

or, equivalently and more compactly, as

$$\begin{aligned} \text{maximise} \qquad & R(\boldsymbol{n}) = \boldsymbol{p}^T \boldsymbol{n} = p_1 n_1 + p_2 n_2 + p_3 n_3, \\ \text{subject to} \qquad & A\boldsymbol{n} \leq \boldsymbol{b}, \end{aligned}$$

where

$$A = \begin{bmatrix} 1 & 1 & 1 \\ -1 & -1 & -1 \\ -1 & 1 & 0 \\ -1 & 0 & 1 \\ 0 & -1 & 1 \end{bmatrix}, \quad \boldsymbol{b} = \begin{bmatrix} N \\ \frac{N}{2} \\ 0 \\ 0 \\ 0 \end{bmatrix}.$$

Clearly, this is a linear programming problem which may be solved algorithmically using a suitable optimisation algorithm (for example, the simplex algorithm). We can use this scenario as a test case for the numerical solver we used for the following scenarios.

i	**Ticket Price (R)**	**Online?**	**Flexible?**	**Child?**	**Infant?**
0	5795.50	False	False	False	False
1	5540.50	False	False	False	True
2	3883.00	False	False	True	False
3	6560.50	False	True	False	False
4	6305.50	False	True	False	True
5	4648.00	False	True	True	False
6	5535.00	True	False	False	False
7	5280.00	True	False	False	True
8	3622.50	True	False	True	False
9	6300.00	True	True	False	False
10	6045.00	True	True	False	True
11	4387.50	True	True	True	False

Table 4

4.1.2 Scenario 2 (Base Fare Price Model)

As per the base fare pricing model discussed in Section 3.2, we consider a base fare price of R2 550 with associated taxes and fees of R2 958, with percentages as given in Section 3.2. These values for the base fare price, as well as the taxes and fees, were taken from a public travel booking website. We illustrate the generated fare class data without considering vaccinations in Table 4, and the data when considering vaccinations in Table 5, both taking into account the disallowed combinations mentioned in Section 3.2.

For both non-vaccinated and vaccinated cases, we imposed the following specific constraints:

- at least 5% of fares must be booked for children passengers;
- at least 5% of fares must be booked for infant passengers;
- at least 50% of fares booked must allow for flexible booking dates;
- at least 75% of fares booked must have be booked online.

When we consider the case with vaccinated passengers, we add the following constraint to the above ones:

- at least 50% of the passengers must be vaccinated.

i	**Ticket Price (R)**	**Online?**	**Flexible?**	**Child?**	**Infant?**	**Vaccinated?**
0	5795.5	False	False	False	False	False
1	5285.5	False	False	False	False	True
2	5540.5	False	False	False	True	False
3	3883.0	False	False	True	False	False
4	6560.5	False	True	False	False	False
5	6050.5	False	True	False	False	True
6	6305.5	False	True	False	True	False
7	4648.0	False	True	True	False	False
8	5535.0	True	False	False	False	False
9	5025.0	True	False	False	False	True
10	5280.0	True	False	False	True	False
11	3622.5	True	False	True	False	False
12	6300.0	True	True	False	False	False
13	5790.0	True	True	False	False	True
14	6045.0	True	True	False	True	False
15	4387.5	True	True	True	False	False

Table 5

4.1.3 Scenario 3

This scenario is similar to the previously described one, but we reduce the taxes and fees in the base fare price model. We consider both a reduction of R1 000 and a reduction of R2 000, for both the non-vaccinated and vaccinated cases from Scenario 2.

This is done to compare the effect which taxes and fees imposed by the airline may have on the revenue generated by the flight.

4.2 Numerical Results

We made use of the Python MIP library[1] and the `milp` method from the SciPy Optimize library[2] to solve the optimisation problems in each scenario[3].

[1] `https://python-mip.com`
[2] `https://scipy.org`
[3] Computer code and data available upon request.

4.2.1 Scenario 1

For the first scenario, we obtain

$$n_1 = n_2 = 31, \qquad n_3 = 30.$$

Hence, 31 economy class fares, 31 business class fares, and 30 first class fares must be booked to maximise the revenue, which amounts to R163 850.

4.2.2 Scenario 2 (Base Ticket Price Model)

For the non-vaccinated case, the numerical solvers return

$$n_3 = 13, \quad n_5 = 5, \quad n_4 = 5, \quad n_9 = 69,$$

with all other quantities equal to zero and for fare classes given in Table 4. This combination yields a revenue of R574 754.00.

Next we consider the case with vaccines, for which the numerical solvers return

$$n_4 = 23, \quad n_{12} = 36, \quad n_{13} = 23, \quad n_{14} = 5, \quad n_{15} = 5,$$

with all other quantities equal to zero and for fare classes given in Table 5. This combination of tickets yields a revenue of R551 294.00. This is a decrease of R23 460 or approximately 4% from the revenue of the non-vaccinated case.

4.2.3 Scenario 3

We use the same base fare price as for Scenario 2, but with the taxes and fees being R1 958 (R1 000 reduction) and R958 (R2 000 reduction).

For the R1 000 reduction, we obtain data similar to that in Tables 4 and 5, but with fare prices being R1 000 cheaper for each fare class. Similarly, for the R2 000 reduction, we obtain data similar to that in Tables 4 and 5, but with fare prices being R2 000 cheaper for each fare class.

For each of the reductions and non-vaccinated/vaccinated cases, we obtained the same number of each fare class that needs to be sold as compared to the scenario where there were no taxes and fees reductions. For the reduction of taxes and fees by R1 000, the revenue was reduced by R92 000 or 16% of the similar non-reduction scenario. Similarly, for the reduction of taxes and fees by R2 000, the revenue was reduced by R184 000 or 32% of the similar non-reduction scenario.

4.3 Discussion

From the results in the previous section, we see that a comparison of the different revenues across the different scenarios implies the following:

- a vaccination incentive might not reduce revenues significantly,
- reduction in the taxes and fees leads to a more sizeable reduction in revenues.

Of course, these scenarios and results are very specific, because they are dependent on the input parameters and constraints we chose and provided. More scenarios need to be considered and simulated, and more results obtained before any general assumptions about revenue differences may be made.

5 Conclusions

We investigated the problem of airline revenue management via seat inventory management for a single hypothetical flight/leg of a hypothetical airline. Different fare classes, with associated prices, were generated based on a single base fare price. Our aim was to find optimal seat inventory allocations based on different scenarios for revenue comparison purposes.

From our generated data and imposed constraints, we learned that requiring at least 50% of passengers to be vaccinated, while keeping other constraints in place, led to a 4% reduction in revenue compared to a flight without any vaccinated passengers. However, reducing the taxes and fees in the base fare price model led to a more significant reduction in revenue, approximately 16% and 32% for both non-vaccinated and vaccinated cases, respectively, compared to the scenario without any reductions.

These very specific results would suggest that airlines rather consider incentivising passengers to vaccinate, rather than change the taxes and fees, if they want to maintain similar revenue from flights. However, due to the specificity of the data and results, revenue could still be maintained even with a reduction in fees and taxes, if the loss is made up for in another revenue stream or in a reduction in a cost somewhere.

The models and data considered in this work were very elementary. For future work and further research, we should consider an increase in the complexity of the models, for a more realistic reflection of dynamics of airline revenue management, seat inventory management, and seat pricing, by also considering:

- different fare classes/ticket types not generated from a single base price;

- generating more realistic fare pricing;
- a dynamic model for fare pricing;
- the introduction of dynamic ticket demand and supply,
- considering multiple flights and/or legs of flights for the airline.

We were also hampered by a lack of data of airline fare prices, from an airline itself, and how they are determined, which led us to obtain pricing from a public travel booking website and generating a data set from a single price.

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