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Budget Airline Operations Optimization using Linear Programming

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Abstract

Linear programming (LP) technique is a vital technique in the optimization of resource allocation and achieving efficiency in planning particularly in achieving profit for the budget airline by flying more often to more profitable route among the top 5 airports in the United States of America. In this paper, a Linear programming technique is applied to determine the optimum no of time a budget airline need to fly between 2 cities to make maximum profit with respect to various factors such as Fuel Price and staff salary for the year 2017. The proposed LP model is solved by standard simplex algorithm and solver. It is observed that the proposed LP model is appropriate for finding the optimal no of times budget airlines need to fly between cities and making maximum profit.

Keywords
Optimization techniques, Simplex Algorithm, Decision, Hedging.

1. Introduction

Budget Airline or Discount Airlines originated with the airline which operates on very low operating cost. The main Objective of the budget airline is to provide transport medium at cheapest fares to the public in today's competitive market. The main operating concept of budget airlines is not to provide the traditional type of services which is offered in most of the airlines and is included in the fare charged to the customer, resulting in lower fares and very few comforts. To compensate for the loss in the fare budget airline often charge their customer for some special service such as food, priority boarding, seat selection and extra baggage. Along with Reduced fare the other objective is to keep the cost of the aircraft maintenance as low as possible. Aircraft maintenance is one of the biggest expenses for any airline in airline industries. Cost of aircraft maintenance reduces the margin of profit by a great extent. The budget airline is low-cost airline but they don't comprise on aircraft safety or its passenger safety. Safety regulation is common for all the airline whether its budget airline or legacy airline. All airlines are only supposed to use FAA certified Aircraft (Federal Aviation Administration). To reduce the aircraft maintenance cost budget airline mostly uses only one type of aircraft which helps them to lower the inventory for the replacement part. Budget airlines tend to operate short-haul flights that suit the range of single-aisle which is known as narrow-body planes. The wide-body aircraft are typically too expensive for low-cost carriers. As all the aircraft are of same type budget airlines also save a large amount of time and training expense for their staff as they don't have to train their staff specially for all the various types of aircraft in their fleet. Budget Airline operates on the minimum sets of equipment, further reducing costs of acquisition and maintenance, as well as keeping the weight of the aircraft lower and thus saving fuel. A budget airline like Ryanair does not have reclining seats they also don't have rear pockets, to reduce the weight of the aircraft as well as eliminate cleaning and maintenance costs.

Budget airlines also don't provide any special type of seating configuration or any special class of flying experiences like business class or premium economy. Budget airlines have only one type of seating arrangement i.e. is economy seating arrangement. Unlike other airlines, budget airlines make a profit by flying to its full capacity. A budget airline like Southwest airline in the United States of America does not offer any type of seat reservation, with hope to encourage passengers to board the flight as early and quickly, thus decreasing turn around time. It also helps the budget airline to fly always on time which reduces delay on a busy airport. Business class and premium economy class take up large floor space on an aircraft as compared to economy class. The traditional airline on other hand has various configuration such as business class, Premium Economy, and many others. Traditional Airline make their profit from these various services as the fare in budget airlines is less they are not targeting any premium customers there are looking forward to making maximum use of floor space available on the aircraft thus they only use the economy class as a there seating arrangement. Also, there are large losses if these premium seats are not booked as compared to the economy class seat. Empty seats represent additional losses. And it is observed that for short haul flights majority of the customer are willing to go for the economy class as it will be much more affordable as compared to these premium seats.

Budget Airlines often don't make use of main terminal and gates in the airport. Budget airline aircraft are mostly parked in open space in the airport which is much cheaper than using main gates in the terminal. For instance, Budget airlines like Indigo (India) uses bus service to take their customer from terminal to the aircraft parked in the open space at most of the airport. By taking such steps in airline industries budget airlines are able to keep the operating cost to a minimum which helps them to offer cheaper fare to their customer. Thus, the service is much more affordable to the public. As the airlines are well-known for the fastest mode of transport, the service and the traveling time of budget airlines would be of lower quality than the other airlines in the market. Budget airline also doesn't appoint special persons for specific jobs. For example, air hostage will check tickets before flying and continue as air hostage when the journey starts thus reducing staff requirement of a budget airline. On the same line of action, Traditional Airline has their own alliance such as "Star Alliance", "Oneworld" and "SkyTeam" and many others. An Airline Alliance in an Aviation Industry is a mutual agreement between two or more airlines to cooperate on a substantial level. Such Airline Alliance helps airlines to fly to many places and provide better connectivity throughout the country or the world. This is challenging for the budget airline as they lack such connectivity across the country or around the world.

One of the ways to keep operating cost low for the budget airline is known as Fuel Hedging. All airline uses fuel hedging but budget airlines are more particularly. Hedging is a gamble against the future price of Jet Fuel. If a budget airline thinks that the jet fuel price will rise in the future budget airline can sign contracts locking down the current price for months or year. If fuel price increases the airline will still get the fuel at the locked price. For Example, Southwest airline in the United States of America has slashed its fuel bills for years by hedging more of its fuel purchases than any other rival airline. This helps budget airline like southwest to make more profit by controlling its one of the major expense that is fuel. But due to rapid changes in fuel Price, it is sometimes also risky for the airline as they might be forced to pay more for the fuel as compared to the current fuel price.

Airlines often offer a simpler fare scheme, such as charging one-way ticket half that of the round-trips. Often, the low-cost carriers fly to smaller, less congested secondary airports and/or fly to airports during off-peak hours to avoid air traffic delays and take advantage of lower landing and take-off fees. This Cost cutting technic helps the budget airline to give a more affordable low price to its customer and the traditional airline. Making the concept easy for understanding Budget Airlines is an airline without most of the traditional services resulting in lower fares and fewer comforts.

2. Literature Review

Budgeting is a tool for estimating expected incomes and expenses. Budgeting helps you to show how you plan finances over a period and to examine the actual financial transactions. Budgeting helps many industries to take necessary steps in order to grow their business. Companies will have an overview of their financial situation well in advance which will assist them in taking necessary decisions for their business. When it comes to budget airline budgeting is one of the key tools which decided their future in the current competitive market.it helps them to take major decisions such as buying a new fleet of aircraft or buying fuel in advance to keep the operating cost as low as possible. Budget airlines use the budgeting system to sustain the competition from the well-established legacy airlines.

Budgeting help companies to consider how the conditions might change and what are the steps to be taken now to avoid the negative outcomes due to changing conditions. Budgeting also helps them to identify their major expenses and help them to focus on how they can reduce that cost. Budgeting helps to control all the available resources and make sure that all the resources are used to their maximum capacity. For example, Staff in budget airlines. Which helps companies by providing a vision on company's performance. Budgeting provides a forecast of profit and expenses which kind of model on how the business might perform and make some strategical plan for the same.

Thus, Budgeting is one of the most vital tools for budget airlines as it helps them to take major steps in airline industries as compared to their competitors.

3. Problem Statement

To increase profit by flying more plans between five major cities in the USA. To increase the number of flights between high demanding cities by keeping the minimum fare. To utilize the maximum number of landing and take-off slots available in all the five airports.

1. To improve the profits by comparing the present situation.
2. To make proper utilization of all the available resources to improve the financial Situation of the company.

4. Budget Airlines

Table 1 Shows the Distance between Top 5 Airports in the United States. These airports are the busiest and most Important airport for both Domestic and International Travel

Cities	Atlanta	Los Angles	Chicago	Dallas	New York
Atlanta	–	1942	607	730	759
Los Angles	1942	–	1741	1232	2469
Chicago	607	1741	–	802	738
Dallas	730	1232	802	–	1389
New York	759	2469	738	1389	–

Table 1. Distance Between City

Table 2 Shows the Fare Charged by budget airlines to its customer's. The value shown below is One-way travel fare between the cities. The Fare is for one Passenger between the city.

Cities	Atlanta	Los Angles	Chicago	Dallas	New York
Atlanta	–	$219	$85	$119	$163
Los Angles	$219	–	$115	$145	$262
Chicago	$85	$115	–	$125	$105
Dallas	$119	$145	$125	–	$100
New York	$163	$262	$105	$154	–

Table 2. Fare

Table 3 Shows the fuel required to complete the journey between 2 cities. We have also considered 5% extra fuel to complete the journey.
Fuel Required = Distance Between Cities / Fuel Economy of the Airplane

Cities	Atlanta	Los Angles	Chicago	Dallas	New York
Atlanta	–	4097	1623	1851	1906
Los Angles	4097	–	3724	2782	5073
Chicago	1623	3724	–	1985	1867
Dallas	1851	2782	1985	–	3072
New York	1906	5073	1867	3072	–

Table 3. Full Required to fly the distance between cities (in U.S Gallons)

Table 4. Shows the Cost of fuel for completing the journeys between the cities. Fuel Cost = Fuel Required in Table 4 * Fuel Cost ($2)

Cities	Atlanta	Los Angles	Chicago	Dallas	New York
Atlanta	–	$8193	3247	3703	3812
Los Angles	$8193	–	7448	5564	10146
Chicago	3247	$7448	–	3970	3734
Dallas	3703	$5564	3970	–	6143
New York	3812	$10146	3734	6143	–

Table 4. Fuel Cost

Table 5. Shows the total Expenditure for flying between 2 cities. Total Expenditure = Fuel Cost + Staff Expenditure ($3000).
There are many other factors which are related to the expense of a budget airline such as Landing/ Take-off Fees, Parking Fees, and many others.

Cities	Atlanta	Los Angles	Chicago	Dallas	New York
Atlanta	–	$11193	6247	6703	6812
Los Angles	$11193	–	10448	8564	13146
Chicago	6247	$10448	–	6970	6734
Dallas	6703	$8564	6970	–	9143
New York	6812	$13146	6734	9143	–

Table 5. Total Expenditure

Table 6 Shows the Total Revenue which can be generated by flying to maximum capacity.
Total Income = (Fare per person * No of Seats) – (Fuel Required * Fuel Cost) – (Fix Salary for staff ($3000))

Cities	Atlanta	Los Angles	Chicago	Dallas	New York
Atlanta	–	$31783	12353	17283	23663
Los Angles	$31783	–	16703	21053	37974
Chicago	12353	$16703	–	18153	15253
Dallas	17283	$21053	18153	–	14528
New York	23663	$37974	15253	22358	–

Table 6. Total Income

Table 7. Shows the Profit earned by flying between 2 cities. (Profit = Total Income – Total Expenditure)

Cities	Atlanta	Los Angles	Chicago	Dallas	New York
Atlanta	–	$20589	6106	10580	16850
Los Angles	$20589	–	6254	12489	24828
Chicago	6106	$6254	–	11182	8519
Dallas	10580	$12489	11182	–	5384
New York	16850	$24828	8519	13214	–

Table **7.** Profit

Table 8. Shows current utilization of slots in all 5 cities. Slots are right granted by the airport owner which allows slot holder to schedule a landing or departure during a specific time.
Various Airport around the world has a varying number of slot depending on various factors such as length of the runway, number of runways, Maintenance Schedule of the airport and many others. Slots have to be purchased by the airline or any private user before starting their journey towards the destination. Slots are very expensive in an airline industry. Thus, selling or purchasing of the slot at an airport is an important move for ant airline.

Cities	Atlanta	Los Angles	Chicago	Dallas	New York	No of Slots
Atlanta	–	7	3	4	4	18
Los Angles	5	–	7	5	8	25
Chicago	2	6	–	2	2	12
Dallas	3	5	4	–	2	14
New York	4	7	2	4	–	17
No of Slots	14	25	16	15	16	–

Table 8**.** Slot Utilization before Optimization

Table 9. shows the formation of Variables for each city from x1, x2, x3, x4, x5….xn.

Cities	Atlanta	Los Angles	Chicago	Dallas	New York
Atlanta	-----	X12	X13	X14	X15
Los Angles	X21	-----	X23	X24	X25
Chicago	X31	X32	-----	X34	X35
Dallas	X41	X42	X43	-----	X45
New York	X51	X52	X53	X54	-----

Table 9**.** Variable table

Lindo Programming

Max 20589x12 + 6106x13 + 10580x14 + 16850x15 + 20589x21 + 6254x23 + 12489x24 + 24828x25 + 6106x31 + 6254x32 + 11182x34 + 8519x35 + 10580x41 + 12489x42 + 11182x43 + 5384x45 + 16850x51 + 24828x52 + 8519x53 + 13214x54

s.t.

x12+x13+x14+x15<=18
x21+x23+x24+x25<=25
x31+x32+x34+x35<=12
x41+x42+x43+x45<=14
x51+x52+x53+x54<=17
x21+x32+x41+x51<=14
x12+x32+x42+x52<=25
x13+x23+x43+x53<=16
x14+x24+x34+x54<=15
x15+x25+x35+x45<=16

x12>=1 x21>=1 x31>=1 x41>=1 x51>=1
x13>=1 x23>=1 x32>=1 x42>=1 x52>=1
x14>=1 x24>=1 x34>=1 x43>=1 x53>=1

x15>=1 x25>=1 x35>=1 x45>=1 x54>=1

x12<=7 x21<=7 x31<=7 x41<=7 x51<=7
x13<=7 x23<=7 x32<=7 x42<=7 x52<=7
x14<=7 x24<=7 x34<=7 x43<=7 x53<=7
x15<=7 x25<=7 x35<=7 x45<=7 x54<=7

end

GIN x12 GINx21 GINx31 GINx41 GINx51
GINx13 GINx23 GINx32 GINx42 GINx52
GINx14 GINx24 GINx34 GINx43 GINx53
GINx15 GINx25 GINx35 GINx45 GINx54

Solution

Cities	Atlanta	Los Angles	Chicago	Dallas	New York	No of Slots
Atlanta	–	7	3	1	7	18
Los Angles	7	–	4	7	7	25
Chicago	1	4	–	6	1	12
Dallas	1	7	5	–	1	14
New York	5	7	4	1	–	17
No of Slots	14	25	16	15	16	–

Table 11. Slot Utilization After Optimization

Frequency	Total Income
7	$144,125
3	$18,317
1	$10,580
7	$117,951
7	$144,125
4	$25,017
7	$87,421
7	$173,799
1	$6,106
4	$25,017
6	$67,095
1	$8,519
1	$10,580
7	$87,421
5	$55,912
1	$5,384
5	$84,251
7	$173,799
4	$34,076
1	$13,214

Frequency	Total Income
7	$144,125.29
3	$18,317.32
4	$42,318.50
4	$67,400.72
5	$102,946.64
7	$43,779.00
5	$62,443.68
8	$198,627.07
2	$12,211.54
6	$37,524.86
2	$22,364.88
2	$17,038.06
3	$31,738.87
5	$62,443.68
4	$44,729.76
2	$10,768.95
4	$67,400.72
7	$173,798.68
2	$17,038.06
4	$52,857.90

Income After Optimization	$1,292,709
Income Before Optimization	$1,229,874
Improvement	$62,835

5. Result

The result shows the optimization in operation of Budget airlines. The Optimized result now makes proper use of the available slot in the different airport which in turn results in an increase in profit of the airline. There is an increase in revenue by $60000 every day which is equal to $21 Million annually. The results are only based on 5 airports this technique can be used across all the airport for the airlines and there will be much better revenue generation as compared to the present situation. Due to optimal slot utilization, we can use the same data can be useful for Staff Scheduling, Aircraft Maintenance, Selecting Hub Airport for the airline and many others.

6. Conclusion.

By using Lingo programming and Solver for Integer programming we can identify the number of flight required between two cities to maintain the connectivity and get maximum profit for a budget airline. This helps the budget airline to be a game changer in the airline industry. By taking such steps airlines can operate efficiently and avoid wastage of resources.
The same kind of Technique can be used to optimize the Bus service in a city by the changing the frequency of the bus across the city. It can also be used to optimize Train Service across the vast country. In this case, no of trains or no of couches in a train can be changed to get an optimized result in operation.

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Biography

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