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Revenue generating model for transportation companies

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Abstract
This work considers the seats on airplanes, trains, buses and cars as non-regular fixed lifetime inventories and developed a revenue generating function for each trip embarked upon by any of these means of transportation. Numerical examples on the use of the revenue generating function was also discussed.

Keywords: Seats, transportation, revenue, function, inventories

1. Introduction

Non regular fixed lifetime inventory is any inventory system where items that outdate in one period become useful at the start of the next period. Examples of non-regular inventories include; seats on an airplane, seats on a train, seats on a bus and seats on a car, Igbinosun and Izevbizua (2020) [2]. This work consider the available seats on an airplane, train, bus and car as non-regular inventories and derived a revenue function for transportation managers.

The total number of seats in an airplane, train, bus or a car are known and fixed. The seats are used to meet the demand of passengers moving from one point to another. Any seat not used to meet demand in a trip is considered outdated for that trip and when there are no seats available to meet a passengers demand, shortage occur, Chiu (1994) [3], Nahmias (1978) [4].

Next, we give a brief description of the different types of seats available on an airplane and a train.

Airplane: Every commercial airplane has four different types of seats or classes. These are economy class, premium economy class, business class and first class. The economy class also refer to as the main cabin is the most basic class. The seats are narrowest, ranging from 16inches to just over 19inches wide. The legroom ranges from 30inches to 34inches. It is the cheapest and always have more seats than the other classes. The premium economy class is mostly found on international flights and has slightly wider seats and more legroom when compared to the economy class. The business class is between the economy class and first class. The business class is also known as the executive class. The flight tickets are expensive, but much more affordable than first class seats. The business class have high quality accommodation and is intended mostly for business travels. First class service is typically the priciest of the classes. Passengers seating in the first class section have more comfortable seating and are often given extravagant services. It is most often occupied by celebrities and wealthy passengers. The first class seats are the most expensive, but most comfortable accommodations. (www.trainspred.com)

Trains: Like the airplane, the train have different types of seats or classes. The classes include; first class (FC). The first class have 4 berths in a lockable compartment. Sheets and blankets are often provided to passengers at extra cost. The chain class (AC), the seats here are arranged as 3+2 seats across the carriage. Sleeper class (SL), here you can bring a sleeping sheet and blankets because they are not provided. It is suitable for travelers on a tight budget. Second class (2S), one of the cheapest classes on the train. The second class often have two rows of three passengers each. Lastly, the unreserved/ general class (2S), is the cheapest class on the train. Seats are reserved or designated. Its always over crowded, noisy and smelly. Some passengers without seats, seats on the floor. (www.trianspread.com)

Buses and Cars: the seat in most buses and cars are uniform. Since they are uniform, their prices are the same and they offer the same comfort.

Description of the model

The available seats on an aeroplane, train, bus or car are considered as an inventory, used to meet the demand of travelling passengers. The total number of available seats is fixed and may be uniform (for buses and cars) or subdivided into classes (for trains and aeroplanes). Where the seats are uniform the price per seat is the same for all seats and the price per seat varies from class to class, when the number of available seats are subdivided in classes. The total revenue is the sum of revenue from each subclasses.

2. Assumptions of the model

1. The number of available seats is fixed.
2. The seats are either all of the same class or they are subdivided into subclasses.
3. Where the seats are all of the same class the price per seat is uniform and when there are subdivided into classes, the price per seat varies from class to class.
4. The total revenue per trip is the amount paid for all the seats (if they are uniform) or the sum of revenues from each subclass.
5. Any seat not used during a trip outdates at the end of the trip and an amount is charged against the transport manager for every seat that outdates.
6. If a passenger cannot get a seat because all available seats are taken, a shortage occurs.

Notation of the model

$N = total\ \ number\ \ of\ \ seats$

$n_i,\ i = 1,\ 2, \ldots = subclasses\ \ of\ \ \ seats$

$p = number\ of\ \ seats\ \ used\ \ to\ \ meet\ \ demand\ \ on\ \ a\ \ trip$

$q = number\ \ of\ \ seats\ \ not\ used\ \ to\ \ meet\ \ demand\ \ a\ \ trip$

$x = price\ \ per\ \ seat\ \ \ for\ uniform\ seats$

$x_i,\ i = 1, 2, \ldots\ price\ \ per\ \ seat\ \ in\ class\ n_i,\ i = 1,\ 2, \ldots$

$\theta = outdate\ \mathrm{cost}\ \ \ per\ \ outdated\ \ seat$

$\lambda = shortage\ \ \mathrm{cost}$

$Q = \ fixed\ \ setup\ \ \mathrm{cost}$

Deriving the revenue function

The components of the revenue function are the generating function, the outdate cost, the shortage cost and the setup cost.

The generating function

The generating function is used to compute the revenue generated on a trip. We derived a function similar Izevbizua and Olowu (2023), for the case where the seats are uniform and the case where the seats are subdivided into classes.

Case 1: No subclasses. This is a situation where there is only one type of seat on the means of transportation and the price is uniform for all the seats, eg the bus or car. Since the total number of seat is N and the price per seat is x then revenue generated per trip will be

$$\mathrm{Re}\,venue = Nx \quad (when\ all\ seats\ are\ used\ to\ meet\ \ demand)$$

$$\mathrm{Re}\,venue = px \quad (p\ is\ number\ \ of\ \ seat\ \ used\ \ on\ the\ trip)$$

Case 2: Subclasses exists. This is when there are different classes of seat on the means of transportation, examples airplanes and trains. The total number of seats N is subdivided into $N_1,\ N_2,\ N_3, \ldots N_n$ and the prices of seats in each subclass are $x_1, x_2,\ x_3, \ldots x_n$. The number of seats from each subclass used to meet passengers demand on a trip are $p_1,\ p_2,\ p_3, \ldots, p_n$ while the number of seats not used to meet passengers demand on a trip are $q_1, q_2,\ q_3, \ldots q_n$. This would imply that $p = p_1 + p_2 + p_3 + \ldots + p_n\ \ and\ \ q = q_1 + q_2 + q_3 + \ldots + q_n$ and $N_1 = p_1 + q_1,\ N_2 = p_2 + q_2, \ldots N_n = p_n + q_n$. when all of the seats in a subclass is used to meet passengers demand, we have $N_i = p_i$, when non of the seats in a subclass is used to meet passengers demand, we have $N_i = q_i$ and when some of the seats are used to meet demand, we have $p_i = N_i - q_i$. Therefore the revenue generated from subclasses for a trip is

$$\mathrm{Re}\,venue = p_1x_1 + p_2x_2 + p_3x_3 + \ldots + p_nx_n$$

Outdate cost

When the demand for seats is less than the number of available seats, outdate occur. That is any seat not used to meet passengers demand outdate at the end of a trip and an outdate cost per seat is charged against the transport manager. For the no subclass case the outdate quantity is $q = N - p$ and the outdate cost is $outdate\ \mathrm{cost} = \theta q$, where θ is outdate cost per seat.

For the subclass case, the outdate quantity is $q = q_1 + q_2 + q_3 + \ldots + q_n$ and the outdate cost is $outdate\ \mathrm{cost} = \theta(q_1 + q_2 + q_3 + \ldots + q_n)$

Shortage cost

Whenever passengers demand is higher than the number of available seats to meet the demand, shortage is said to occur. That is $D > N$ and the shortage quantity will be $\int_N^\infty (D - N) f(D) dD$. With a shortage cost of λ per shortage, the shortage cost will be

$$shortage\ \ \mathrm{cost} = \lambda \int_N^\infty (D - N) f(D) dD$$

Finally, there is a fixed setup cost Q for the model.

Therefore, the revenue function for the case where there are no subclasses is

$$R(N, x) = Q + Nx - \theta q - \lambda \int_N^\infty (D - N) f(D) dD \tag{1}$$

And for the case with subclasses

$$R(p,x)=Q+(p_1x_1+p_2x_2+...+p_nx_n)-\theta(q_1+q_2+...+q_n)-\lambda\int_N^\infty (D-N)f(D)dD \qquad (2)$$

Numerical Examples

Next we implement equations (1) and (2). Mathematical 8 was used in computing our results.

Example 1

Table 1 shows the revenue generated by a 36 seater bus for a period of seven days. Note that this the case where subclasses dose not exits and price is uniform.

Table 1: Revenue from a 36 seater bus for a period of seven days.

Day	N	p	q	x	px
Day 1	36	28	8	4500	126,000
Day 2	36	36	0	4500	162,000
Day 3	36	30	6	4500	135,000
Day 4	36	36	0	4500	162,000
Day 5	36	29	7	4500	130,500
Day 6	36	34	2	4500	153,000
Day 7	36	35	1	4500	157,000
Total		229	24		1,026,000

The total number of seats on the bus is 36, the number of seats used over the seven days period is 229 and the number of seats not used over the period is 24. After seven days, the bus which operates one trip a day makes a total of one million and twenty-six thousand naira (N1,026,000).

Example 2

The next example is an airplane with a total of 260 seats subdivided into; economy class = 150 seats, premium class = 60 seats, business class = 30 seats and first class = 20 seats. We assume the airplane makes one trip a day and analyzed its operations for a period of seven days. The results are shown in Table 2

Table 2: Revenue from an airplane with 260 seats for a period of seven days.

Day	N	p	q	x	$p_i x_i$
Day 1	$N_1=150$	$p_1=120$	$q_1=30$	$x_1=50{,}000$	6,000,000
	$N_2=60$	$p_2=51$	$q_2=9$	$x_2=70{,}000$	3,570,000
	$N_3=30$	$p_3=24$	$q_3=6$	$x_3=100{,}000$	2,400,000
	$N_4=20$	$p_4=16$	$q_4=4$	$x_4=180{,}000$	2,880,000
Total		211	49		14,850,000
Day 2	$N_1=150$	$p_1=140$	$q_1=10$	$x_1=50{,}000$	7,000,000
	$N_2=60$	$p_2=55$	$q_2=5$	$x_2=70{,}000$	3,850,000
	$N_3=30$	$p_3=30$	$q_3=0$	$x_3=100{,}000$	3,000,000
	$N_4=20$	$p_4=18$	$q_4=2$	$x_4=180{,}000$	3,240,000
Total		243	17		17,090,000
Day 3	$N_1=150$	$p_1=150$	$q_1=0$	$x_1=50{,}000$	7,500,000
	$N_2=60$	$p_2=60$	$q_2=0$	$x_2=70{,}000$	4,200,000
	$N_3=30$	$p_3=20$	$q_3=10$	$x_3=100{,}000$	2,000,000
	$N_4=20$	$p_4=15$	$q_4=5$	$x_4=180{,}000$	2,700,000
Total		245	15		16,400,000
Day 4	$N_1=150$	$p_1=145$	$q_1=5$	$x_1=50{,}000$	7,250,000
	$N_2=60$	$p_2=48$	$q_2=12$	$x_2=70{,}000$	3,360,000
	$N_3=30$	$p_3=25$	$q_3=5$	$x_3=100{,}000$	2,500,000
	$N_4=20$	$p_4=20$	$q_4=0$	$x_4=180{,}000$	3,600,000
Total		238	22		16,710,000
Day 5	$N_1=150$	$p_1=140$	$q_1=10$	$x_1=50{,}000$	7,000,000
	$N_2=60$	$p_2=50$	$q_2=10$	$x_2=70{,}000$	3,500,000
	$N_3=30$	$p_3=29$	$q_3=1$	$x_3=100{,}000$	2,900,000

	$N_4 = 20$	$p_4 = 12$	$q_4 = 8$	$x_4 = 180,000$	2,160,000
$Total$		231	29		15,560,000
Day 6	$N_1 = 150$	$p_1 = 150$	$q_1 = 0$	$x_1 = 50,000$	7,500,000
	$N_2 = 60$	$p_2 = 40$	$q_2 = 20$	$x_2 = 70,000$	2,800,000
	$N_3 = 30$	$p_3 = 28$	$q_3 = 2$	$x_3 = 100,000$	2,800,000
	$N_4 = 20$	$p_4 = 16$	$q_4 = 4$	$x_4 = 180,000$	2,880,000
$Total$		234	26		15,980,000
Day 7	$N_1 = 150$	$p_1 = 150$	$q_1 = 0$	$x_1 = 50,000$	7,500,000
	$N_2 = 60$	$p_2 = 54$	$q_2 = 6$	$x_2 = 70,000$	3,780,000
	$N_3 = 30$	$p_3 = 26$	$q_3 = 4$	$x_3 = 100,000$	2,600,000
	$N_4 = 20$	$p_4 = 19$	$q_4 = 1$	$x_4 = 180,000$	3,420,000
$Total$		249	11		17,300,000

Table 2 shows the revenue generated by a 260 seater airplane, while Table 3 gives a summary of the operations of the airplane for the seven days.

Table 3: Summary of the airplane seven days operations.

Day	N	p	q	Revenue
Day 1	260	211	49	14,850,000
Day 2	260	243	17	17,090,000
Day 3	260	245	15	16,400,000
Day 4	260	238	22	16,710,000
Day 5	260	231	29	15,560,000
Day 6	260	234	26	15,980,000
Day 7	260	249	11	17,300,000
Total		1651	169	113,890,000

From Table 3, a total of 1651 seats was used to meet demand over a period of seven days and 169 seats was not used to meet passengers demand. A total of one hundred and thirteen million and eight hundred and ninety thousand naira (N113,890,000) was generated.

3. Conclusion

The model obtained in this work considers the seats on a given means of transportation as non-regular fixed lifetime inventory and derived a revenue generating function for the means of transportation. The seats in any means of transportation can either be uniform or classify into subclasses. Numerical examples shows that the total number of seats (passengers) used to meet demand and those not used to meet demand over a period of time is easily determined. Also, the model computes the revenue generated by the transportation company over any period of time. Transportation companies will find the model interesting and easy to use.

4. References

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