Revenue Management in the Airline Passenger Industry

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Airline Passenger Revenue Management

- Process of maximizing seat revenue through :
  - pricing
    - market segmentation
    - “different products at different prices”
  - inventory control
    - limit the number of seats available to specific segments
    - anticipate on future cancellations and no-shows

Example

- Paramaribo - Amsterdam
- Departure date: 23 January
- Booking date: 17 January

Availability PBM – AMS / 23 JAN

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23JAN TUE 0001-0300* PBM AMS

01 PBM AMS 2005 0900*  KL 714 J3C3I2Z1S9B4M0
   744   0  855
02 PBM AMS 1645 0825*  MP 663 C2Z2S0B0M0H0Q0O0
   767   1 1140
```

Fares PBM – AMS / 23 JAN

PBM-AMS TUE-23JAN07/KL - TAXES/FEES NOT INCLUDED

	CX	FARE	BASIS	C	AP	MIN / MAX
1	KL	449.00R	VLSX3NL	V	#	7 / 1M
2	KL	549.00R	QLSX3NL	Q	#	7 / 1M
3	KL	649.00R	HLPX3NL	H	#	7 / 3M
4	KL	749.00R	KLPX3NL	K	#	6 / 4M
5	KL	849.00R	MLPX3NL	M	#	5 / 6M
6	KL	1184.00R	BRT3NL	B		
7	KL	1750.00R	SRT3NL	S		
8	KL	1956.00R	ZSX3NL	Z		7 / 1M
9	KL	2863.00R	IRT3NL	I		
10	KL	3279.00R	CRT3NL	C		
11	KL	5252.00R	JRT3NL	J		

Flight KL 714 / 23JAN

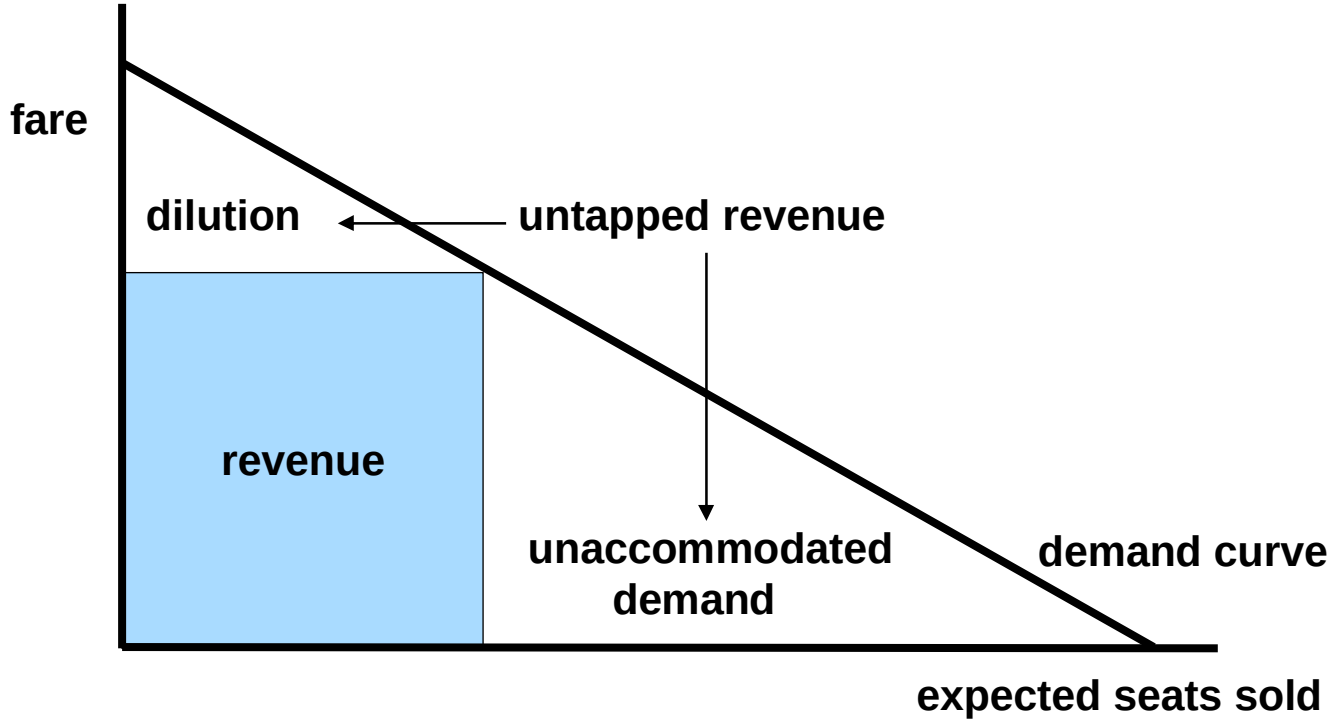
```
FLIGHT:  KL714  23JAN07 TUE 20:05
         LAST BID/BKT UPD:16JAN/2309Z PBM-AMS

  BDG   SA   SS TSFS   AU CNCLD BID
C PBM    3   13   16   42      6 590
M PBM   11  426  437  386   1187 590

CAB   BKT   BA    BND      CAB   BKT   BA    BND
  C     1    3   2014        M    1    11    558
        2    3   1009             2    10    515
        3    2    803             3     9    254
        4    1    361             4     6    173
        5    0      0             5     5     84
                                   6     4      0
```

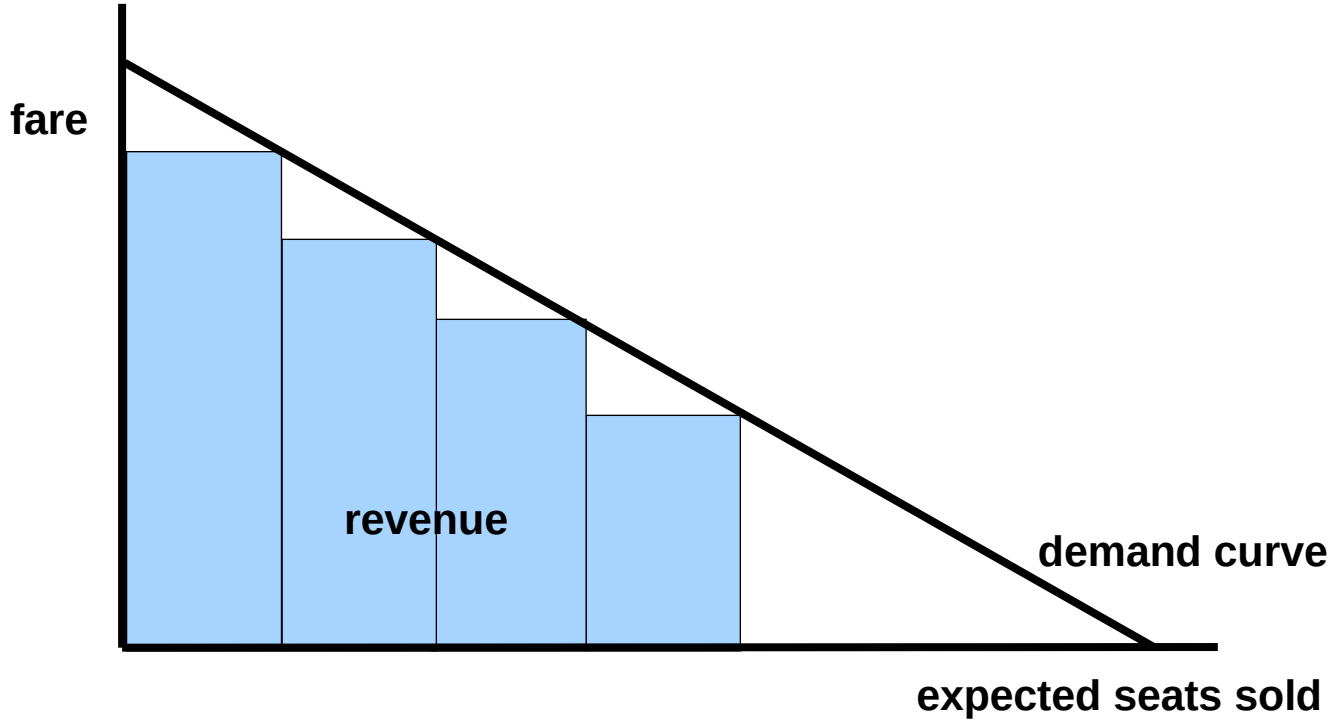
Pricing (1)

- Market segmentation
  - Single fare class



Pricing (2)

- Market segmentation
  - multiple fare classes with different restrictions



Inventory Control

- Maximize total revenue
  - compute the “optimal” passenger mix
    - number of passengers / route / fare
  - allow (limited) overbooking
    - number of denied boardings (close to) zero

Input (1)

- Schedule and capacity
  - flight departure and arrival times
  - cabin capacities
  - sales restrictions
  - 0 to 360 days before departure

Input (2)

- Demand and cancellation forecast
  - based on observed bookings in the past
  - low level :
    - route (origin / destination / flight list)
    - point of sale
    - passenger type
    - day of week / season
    - fare class
  - overrules for specific departure dates

Models

- Notations
  - ***OD*** : dated route (origin, destination, flight list) / fare class / point of sale / passenger type
  - for each ***OD***
    - X_{OD} : number of passengers to accept (booking limit)
    - D_{OD} : probabilistic demand
    - F_{OD} : fare
  - for each ***flight j***
    - C_j : remaining capacity (= capacity - actual seats sold) (single cabin flights only)

Stochastic Model

- Maximize

$$E\left(\sum_{OD} F_{OD} \cdot \min\{X_{OD}, D_{OD}\}\right)$$

- Subject to

$$\sum_{OD \supseteq \text{flight } j} X_{OD} \leq C_j \qquad \text{(for all } \textit{flights } j\text{)}$$

$$X_{OD} \geq 0 \text{ and integer} \qquad \text{(for all } \textit{OD's}\text{)}$$

Deterministic Model (1)

- Approximation of stochastic model
- Maximize

$$\sum_{OD} F_{OD} \cdot x_{OD}$$

- Subject to

$$\sum_{OD \supseteq flight\ j} x_{OD} \leq C_j \qquad \textbf{(for all flights } j\textbf{)}$$

$$0 \leq x_{OD} \leq ED_{OD} \qquad \textbf{(for all } OD\textbf{'s)}$$

Deterministic Model (2)

- Advantages
  - simple (linear programming)
  - well solvable (large instances)
  - easily extendable to multi-cabin flights

- Disadvantages
  - fractional solutions
  - deterministic (average demand)

    $\rightarrow$ how to handle unexpected booking behavior?

Dual Formulation (1)

- Decision variables
  - for each ***OD*** : W_{OD} **(≥ 0)**
  - for each dated ***flight j*** : B_j **(≥ 0)**

- Minimize

$$\sum_{OD} D_{OD} \cdot W_{OD} + \sum_j C_j \cdot B_j$$

- Subject to

$$W_{OD} \geq F_{OD} - \sum_{OD \supseteq flight\ j} B_j \quad \textbf{(for all } OD\textbf{'s)}$$

Dual Formulation (2)

- W_{ODFP} & B_j
  - marginal values w.r.t. demand and capacity

- **Terminology**
  - B_j : *bid price* of *flight j*
  - $F_{OD} - \sum_{OD \supseteq vlucht\ j} B_j$: ***OD*** *(customer) contribution*

    $\rightarrow$ notation : $CuCo_{OD}$

Unexpected Booking Behavior

- Acceptance strategy for passengers willing to fly a certain ***OD***

  - accept the passengers if

$$CuCo_{OD} = F_{OD} - \sum_{OD \supseteq flight\ j} B_j > 0$$

  - refuse the passengers if

$$CuCo_{OD} = F_{OD} - \sum_{OD \supseteq flight\ j} B_j < 0$$

  - conditionally accept the passengers if

$$CuCo_{OD} = F_{OD} - \sum_{OD \supseteq flight\ j} B_j = 0$$

Optimization Frequency

- Best strategy
  - after each accepted booking
  - if expected bookings fail to happen

  $\rightarrow$ practically infeasible

- Second best strategy
  - at regular time intervals : daily, weekly, …
  - on demand : heavy booking activity, schedule changes, …

  $\rightarrow$ how to avoid loss of revenue?

Expected Marginal Seat Revenue (1)

- Simple & fast revenue management heuristic
  - several variants
  - Belobaba 1989
- Idea : reserve seats for higher valued demand
- Flight based
  - flights are assumed to be independent of each other
- Works remarkably well with any reasonable (flight based) stochastic demand/fare forecast

Expected Marginal Seat Revenue (2)

- Used by
  - many airlines as main tool (Transavia, AirFrance, …)
  - network carriers as secondary tool (Lufthansa, KLM, …)
    - forecast based on customer contribution

- Steering mechanism
  - bucket : set of fares / customer values
  - bucket protection : number of seats reserved for passengers paying at least a fare associated with that bucket

- Availability : for each fare return the least availability of all flights in the itinerary

Issues (1)

- Cancellations and no-shows

  → flights leave with empty seats

  → overbooking of flights
    → limit expected number of denied boardings
    → limit denied boarding costs

  → minor changes in the model

Issues (2)

- Buy-down
  - model assumes that
    passengers willing to pay a specific fare
    will actually buy a ticket at that fare
  - used to be valid due to fare restrictions, such as
    - minimum / maximum stay
    - refundability
    - ...
  - fare restrictions disappear gradually …

- flights that are expected to leave with empty seats have bidprice zero

→ passengers may **and will** buy cheapest ticket in the market
  → direct loss of revenue
  → lower demand forecast for higher fares
    → indirect loss of revenue in the future (spiral down)

- new *choice* / *sell-up* models incorporate *customer behavior*
  - mixed integer / nonlinear

→ airlines will not always offer low fare tickets in order to fill up their empty flights