

Considering Exogenous Capacity Changes in Airline Revenue Management



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Agenda

Revenue Management
& Capacity

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graph TD; A[Revenue Management & Capacity] --> B[State of the Art & Distinction]; B --> C[Model & Outlook];
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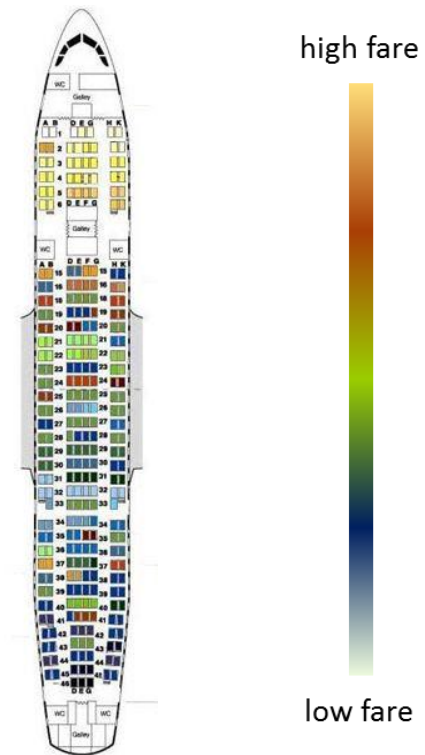
State of the Art
& Distinction

Model
& Outlook

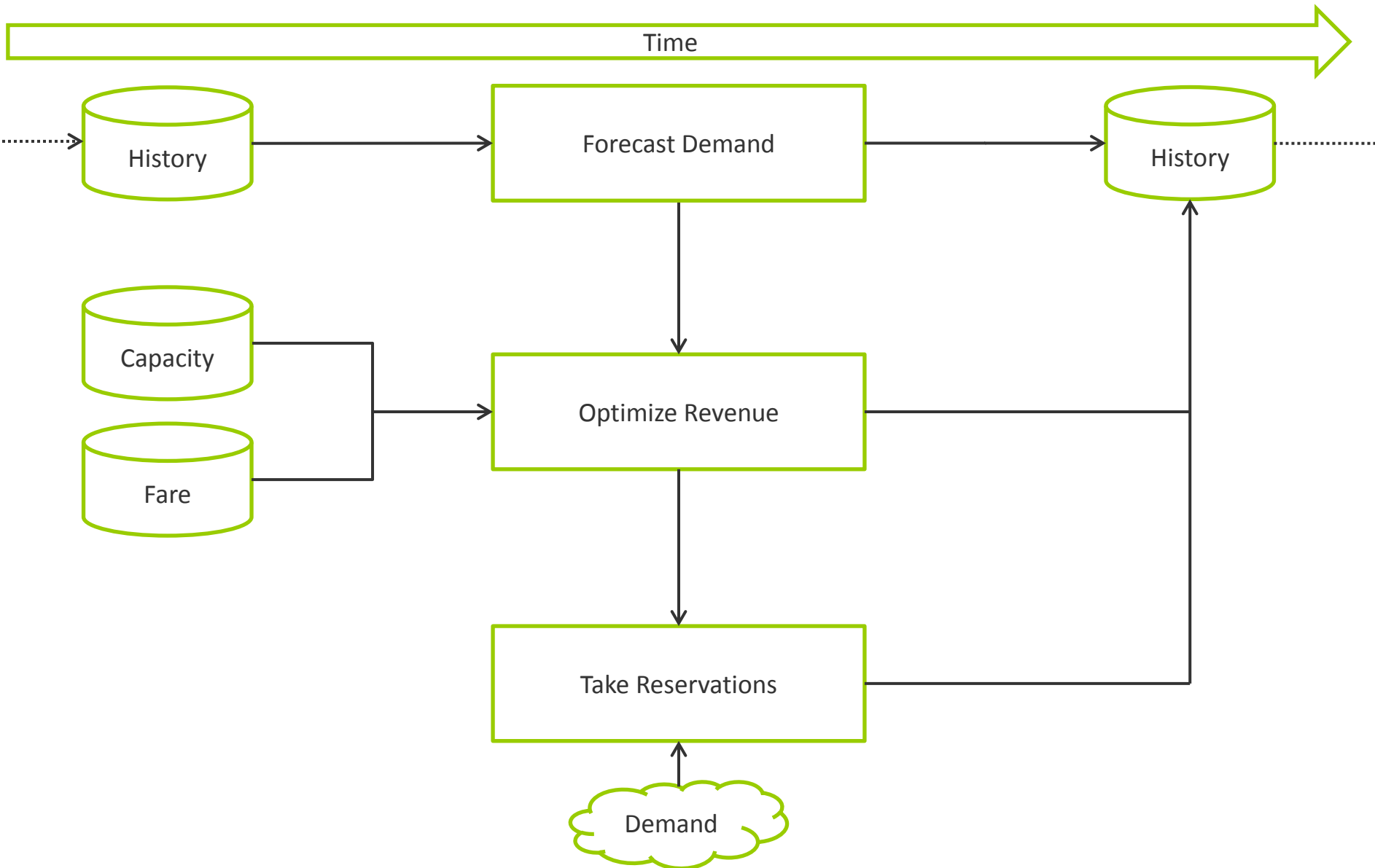
Revenue Management Introduction

Revenue Management (RM) ensures that companies will sell the right product to the right customer at the right time for the right price.

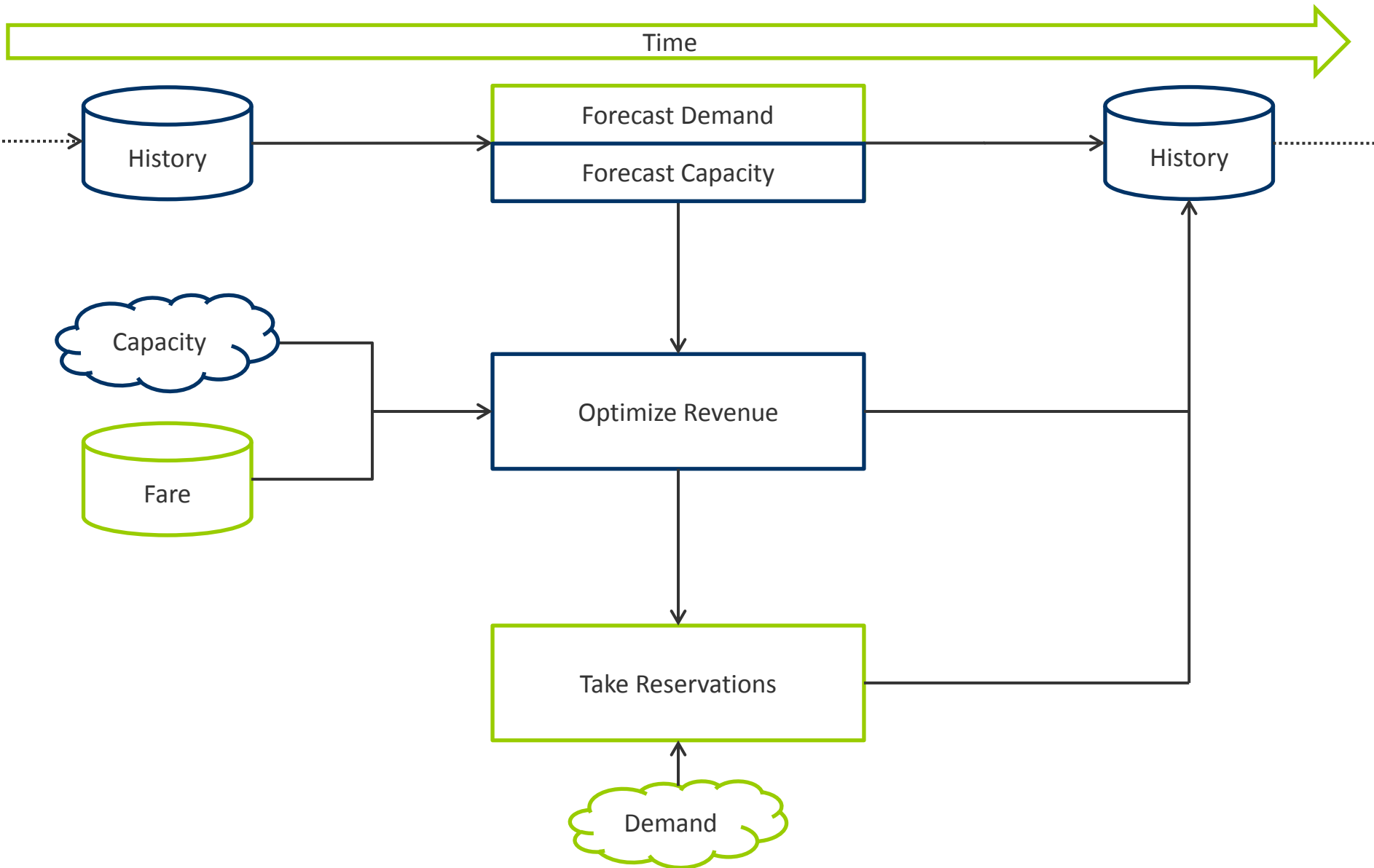
Cross R. (1997). Revenue Management: Hard-Core Tactics for Market Domination. New York, NY: Broadway Books.



Traditional Revenue Management Process



Modified Revenue Management Process



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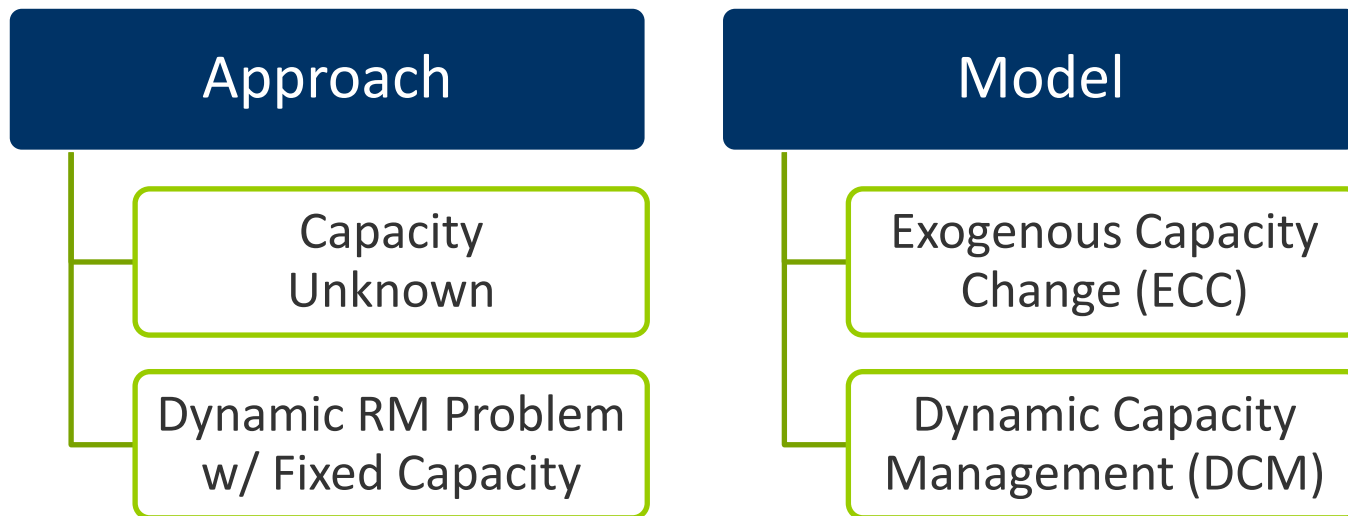
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State of the Art
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Preliminary Work

- Exogenous capacity changes (ECC) are highly motivated by practice, however almost completely neglected in theory
- First attempt by [Wang & Regan \(2006\)](#):
 - Two cockpit compatible aircrafts
 - Paired by fleet assignment
 - Different capacities



Wang X., Regan A. (2006). Dynamic yield management when aircraft assignments are subject to swap. *Transportation Research Part B: Methodological*, 40(7), pp. 563–576.

Distinction to Preliminary Work

	Wang & Regan (2006)	Kadatz (2014)
Demand	independent	dependent
Cockpit compatibility	yes	yes
Change time	variable	variable
RM policy	leg-based	leg-based/network
Number of ECC	1	1
Capacities	2	>2
Change risk	assumed to be known	forecasted probabilities

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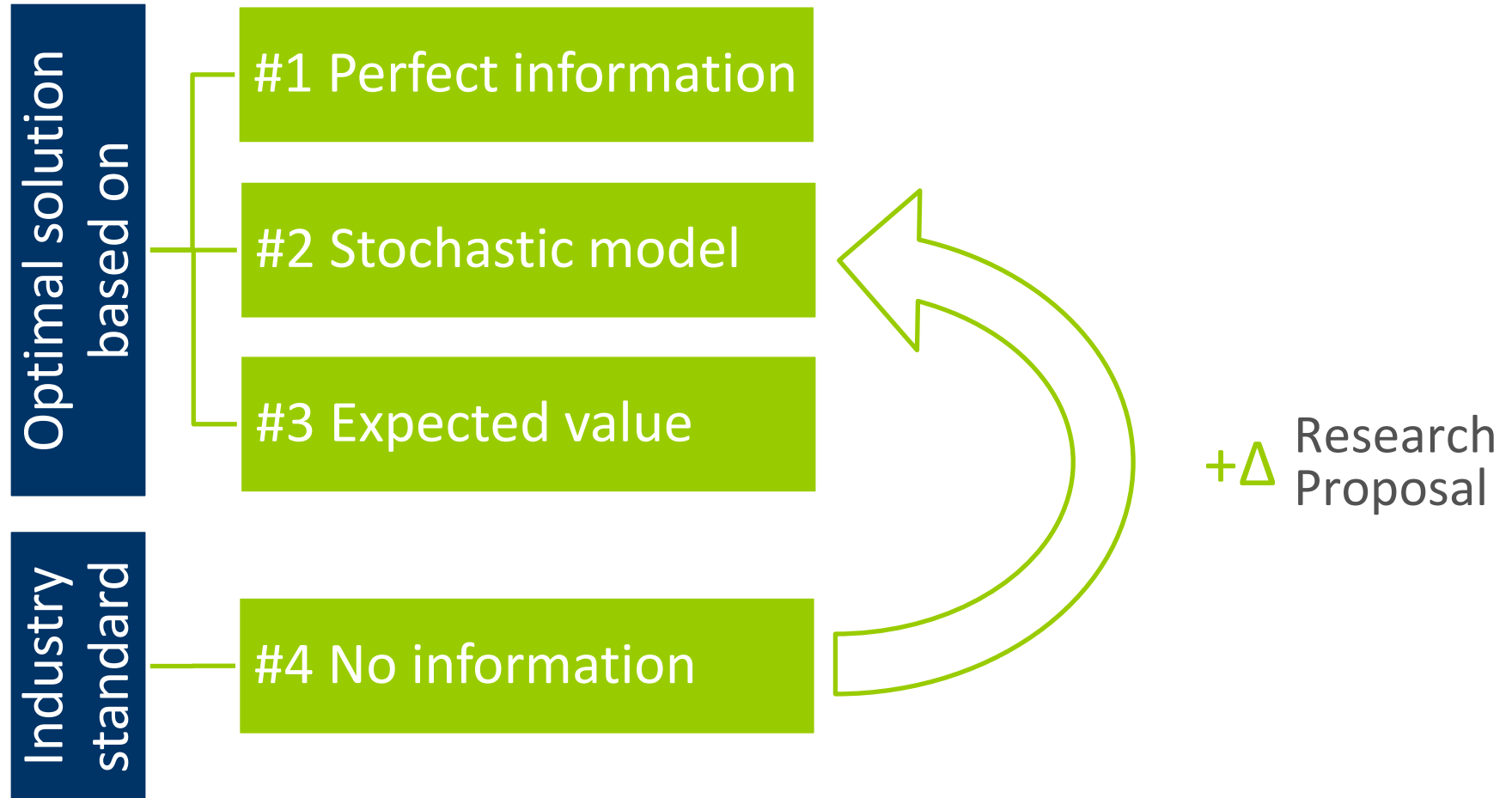


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State of the Art
& Distinction

Model
& Outlook

Stochastic Programming Approach



Stochastic Model

Given:

f	fare class $f \in F$	s	scenario $s \in S$, defining time slot of capacity change t_θ^s and final capacity c^s
t	time slot $t \in [\hat{t}, \dots, 0]$	p^s	probability that scenario s takes place
r_f	revenue of fare class f	c^s	final capacity of scenario s
b	penalty cost per denied boarding	t_θ^s	time slot of capacity change $t \in [\hat{t}, \dots, 0]$ in scenario s
D_{ft}	net demand of fare class f in time slot t	$\bar{D}_{ft_\theta}^s$	cumulative net demand of fare class f in time slot t till 0

Variables:

x_{ft}	strategy variable: under uncertainty, sell x_{ft} tickets of fare class f in time t	$y_{f<}^s$	# of tickets of sales x_{ft} in scenario s , before t_θ^s	} $\forall \geq 0$
α^s	denied boardings	$y_{f>}^s$	# of tickets sold in fare class f , after t_θ^s	

$$\max \sum_{s \in S} p^s \left(\sum_{f \in F} r_f (y_{f<}^s + y_{f>}^s) - b \cdot \alpha^s \right)$$

s.t.

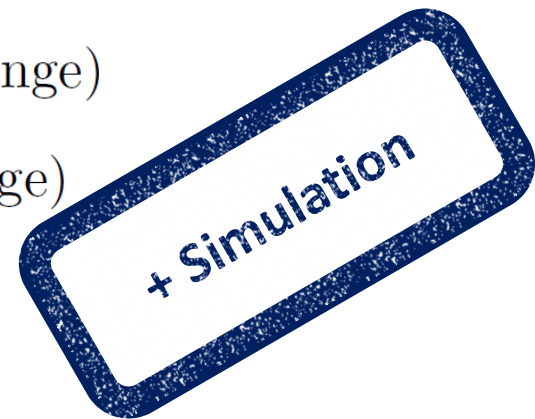
$$y_{f<}^s + y_{f>}^s \leq c^s \quad (\text{capacity})$$

$$y_{f<}^s \leq \sum_{t=\hat{t}}^{t_\theta^s} x_{ft} \quad (\text{utilization before change})$$

$$y_{f>}^s \leq \bar{D}_{ft_\theta}^s \quad (\text{utilization after change})$$

$$x_{ft} \leq D_{ft} \quad (\text{demand})$$

$$\sum_{f \in F} \sum_{t=\hat{t}}^{t_\theta^s} x_{ft} - \sum_{f \in F} y_{f<}^s \leq \alpha^s \quad (\text{denied boardings})$$



Planned Numerical Analyses

Different characteristics of ECC must be analyzed:

- Probability
- Distribution
- Number of ECC within one booking horizon
- Point of time
- Gap between initial and final capacity
- Number of different available capacities



Sensitivity
analyses

- Network effects
- Economic evaluation

Outlook: Data and Industries

- Analyzing empirical airline data for more realistic patterns in different markets:
 - Real extent of capacity differences
 - Frequency of ECC appearance and point of time
 - Distribution pattern of ECC appearance
- Discussing applicability of considering ECC in other industries:
 - Car rental
 - Hotels
 - Energy
 - Advertisement
 - Parking space
 - ...

