Revenue Management under Customer Choice Behaviour with Cancellations and Overbooking[I]

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[I] This work is in collaboration with prof.dr. G.M Koole, prof.dr. R.D. van der Mei, dr. J.I. van der Rest, and prof.dr. B. Zwart.

http://informsrmp2014.org/en/Accommodation-and-Transfer.html

Hotel	Category	Distance to the Conference Venue	Single Room	Double Room
Hilton ParkSa	4 Star Superior	2 min walking	FULLY BOOKED	FULLY BOOKED
Suite Home Osmanbey	4 Star	10 min walking	USD 147	USD 168
ITU Macka Guest House*		1 min walking	USD 45	USD 70

One night: ($147 ≈ €105)

Booking.com

Besteprijsgarantie

Bedankt, Dirk! Uw reservering is nu bevestigd.

Istanbul Suite Home Osmanbey

Adres: Halaskargazi Caddesi No:80 Osmanbey Şişli, Şişli
Istanbul, 34371, Turkije

Telefoon: +90212 2315930

E-mail: osmanbey@istanbulsuite.com

Reisinformatie: Toon routebeschrijving

Uw reservering	2 nachten, 1 kamer Aanpassen
Inchecken	woensdag 4 juni 2014 (vanaf 13:00)
Uitchecken	vrijdag 6 juni 2014 (tot 12:30)
Totaalprijs	**€ 103,50**

Two nights: (€103.50 ≈ $147)

Availability

No booking or credit card fees!

Available rooms from **Wednesday 4 June 2014** to **Friday 6 June 2014**, for **2 nights** Change dates

Room type	Conditions	Max	Price for 2 nights	Nr. rooms	Reservation
Business Double or Twin Room Air Conditioning Free WiFi **Bed preference:** No preference	• Non-refundable		€ 168	0	Reserve Confirmation is immediate
	• Special conditions, pay when you stay • Breakfast included		€ 180	0	
	• Special conditions, pay when you stay • Breakfast included		€ 160	0	

We have 1 room left!

Prices are per room for 2 nights

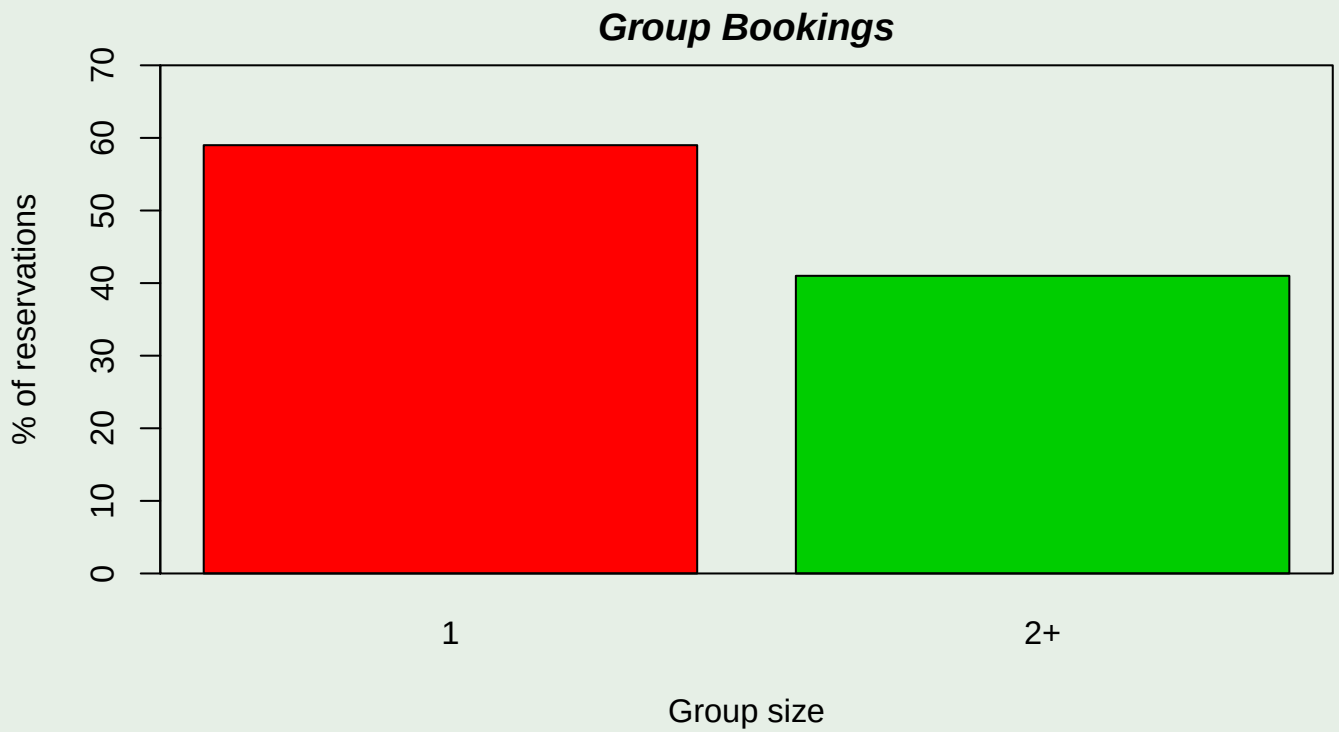
Included: 8 % VAT

Two nights: (€160 ≈ $220)

Our Research

- Collaboration with 5 small independent hotels in the Netherlands
- Research motivated by real hotel data

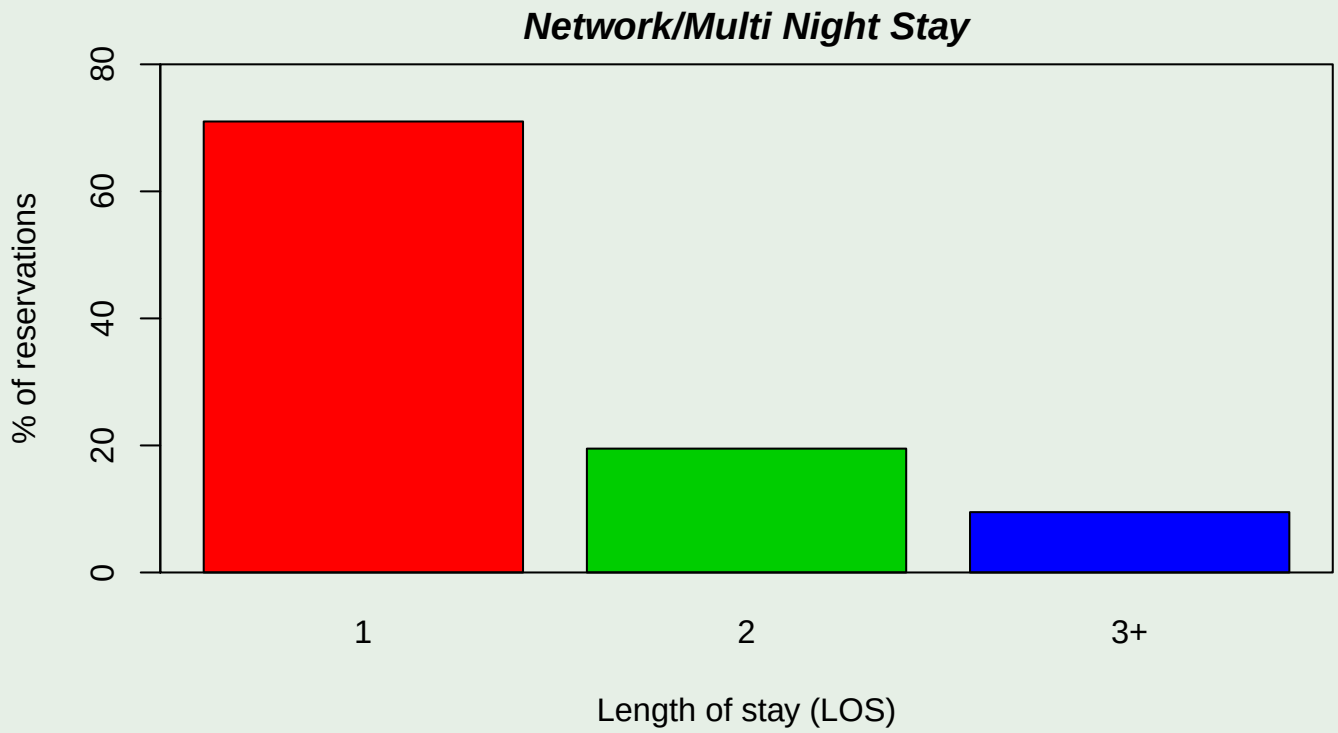
Group Bookings



Observation

Large part (41%) of all bookings are group bookings

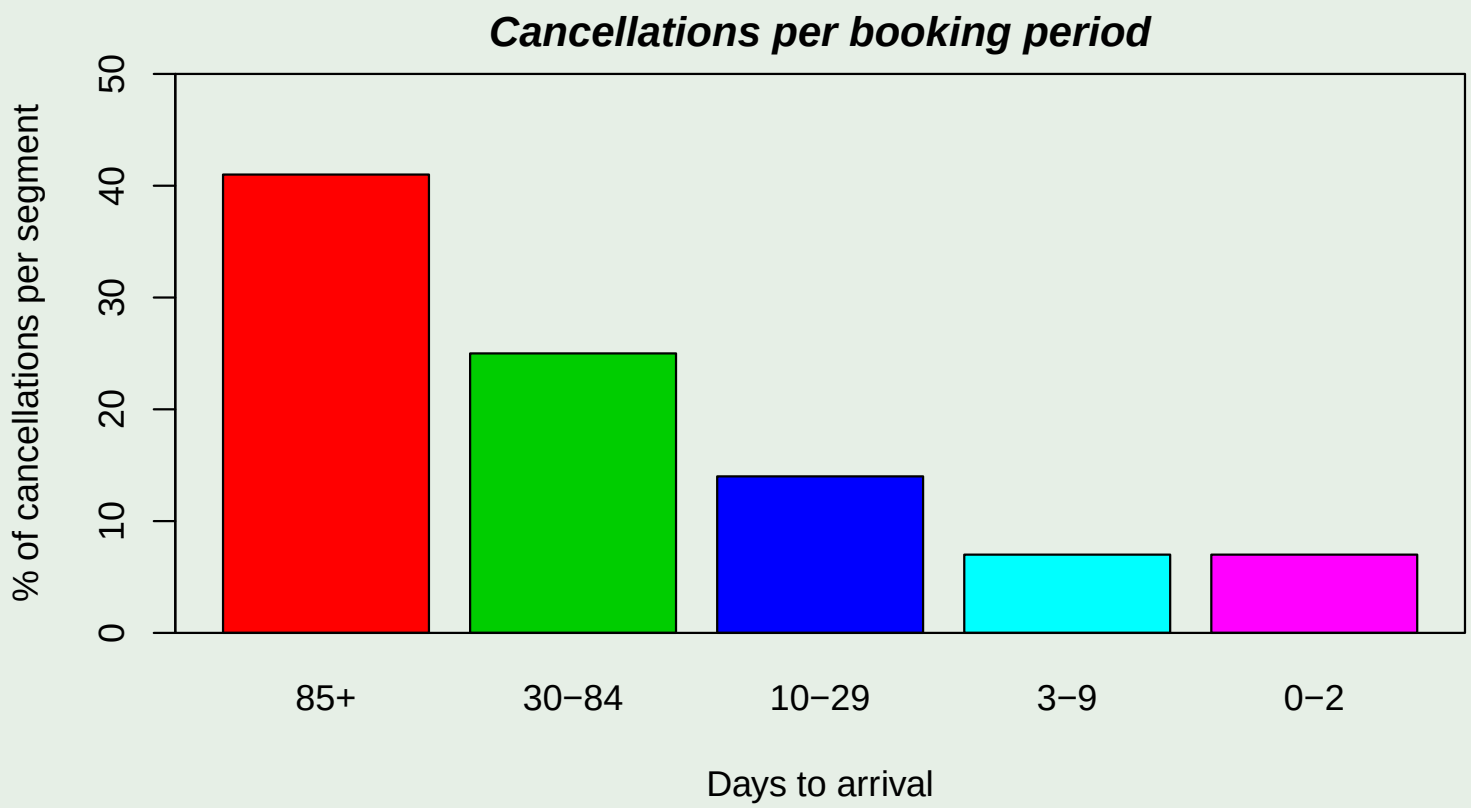
Networks/Multiple Night Stays



Observation

Big part (29%) stays more than one night

Cancellations



Observations

- 22% of all bookings are cancelled
- Early booking $\Longrightarrow$ high cancellation probability

Observations from the Data

- Group bookings (41%)
- Networks (multiple night stays) (29%)
- **Cancellations** (22%)

Customer Choice Cancellation Model

Properties:

- Customer choice behaviour
- Cancellations
- Overbooking

Related work:

- Subramanian et alii (1999): Cancellations
- Talluri and Van Ryzin (2004): Customer choice behaviour
- Newman et alii (2010): Parameter estimation

Other Application Areas

Applying the Cancellation Model in Practice

- Modelling cancellations and customer choice behaviour
- Tractable and well-performing solution methods
- Efficient parameter estimation method

Example (Talluri & van Ryzin, 2004)

Hotel with

- $C = 20$ rooms
- $n = 3$ products with prices

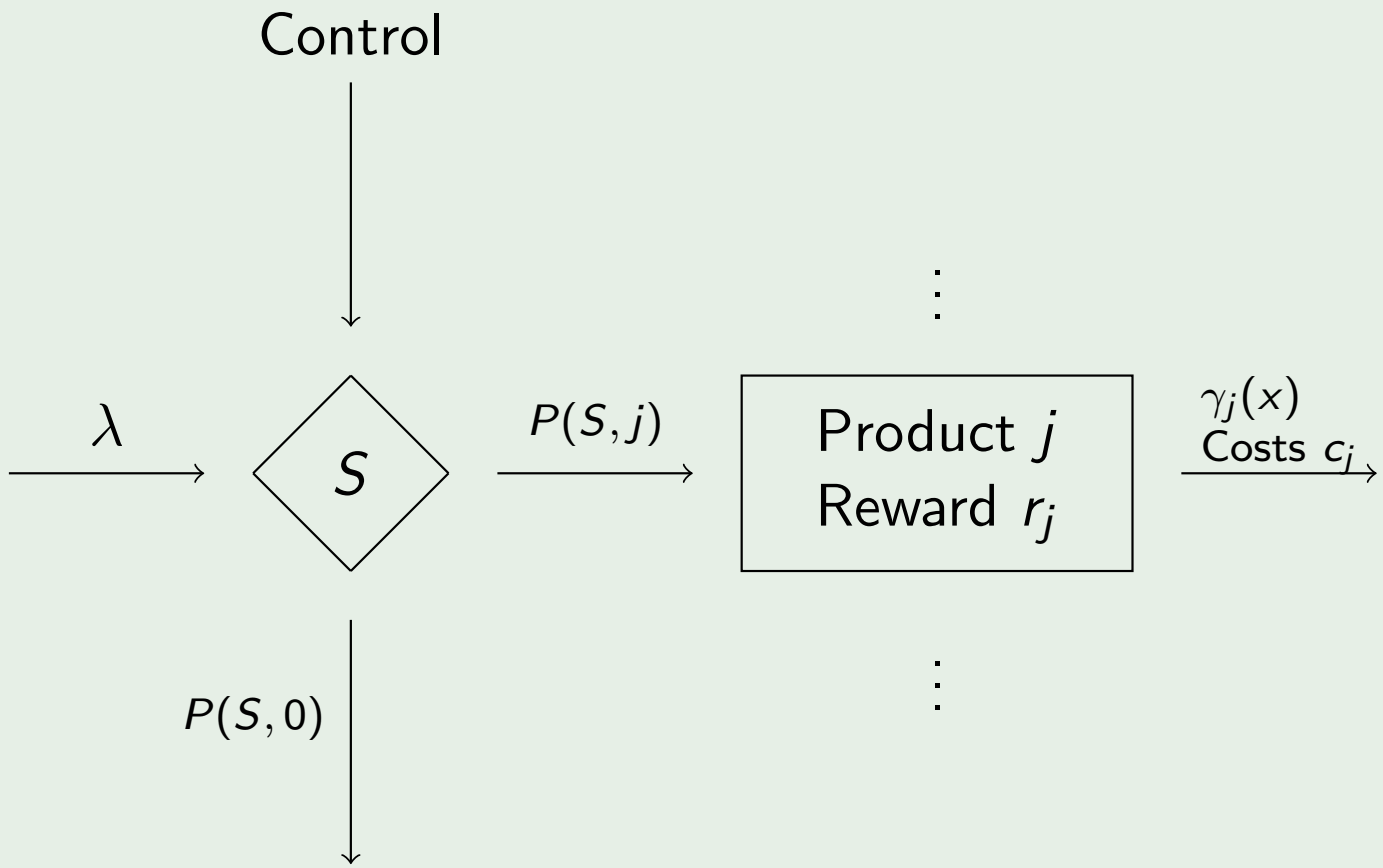
$$r_1 = 160 \qquad r_2 = 100 \qquad r_3 = 90$$

- T days before arrival
- $\lambda = 1/4$ probability that a customer arrives
- x_j number of reservations for product j ($x = (x_1, x_2, x_3)$)
- $\gamma(x_j) = x_j/100$ probability that product j is cancelled
- $c_j = r_j$ costs if product j is cancelled

Example (continued)

- $P(S, j)$ probability that customer buys product j if $S \subset \{1, 2, 3\}$ is offered
- $P(S, 0)$ probability that customer buys nothing
- E.g. $S = \{1, 2\}$ and

$$P(S, 1) = 0.1$$
$$P(S, 2) = 0.6$$
$$P(S, 3) = 0$$
$$P(S, 0) = 0.3$$


Control
λ
S
$P(S,j)$
Product j
Reward r_j
$\gamma_j(x)$
Costs c_j
$P(S,0)$

Objective

Which rooms in combination with price and conditions to offer?

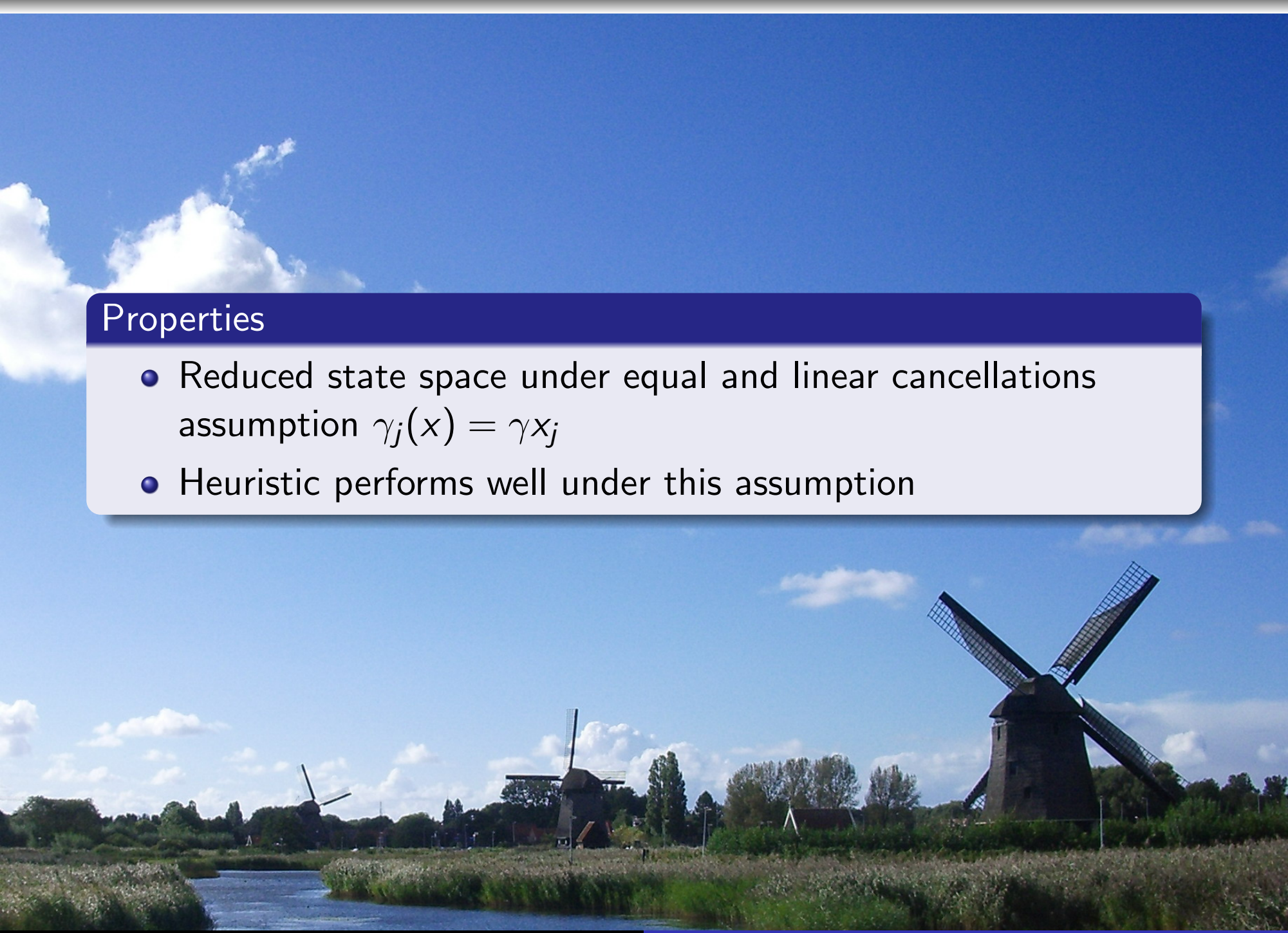
Solution

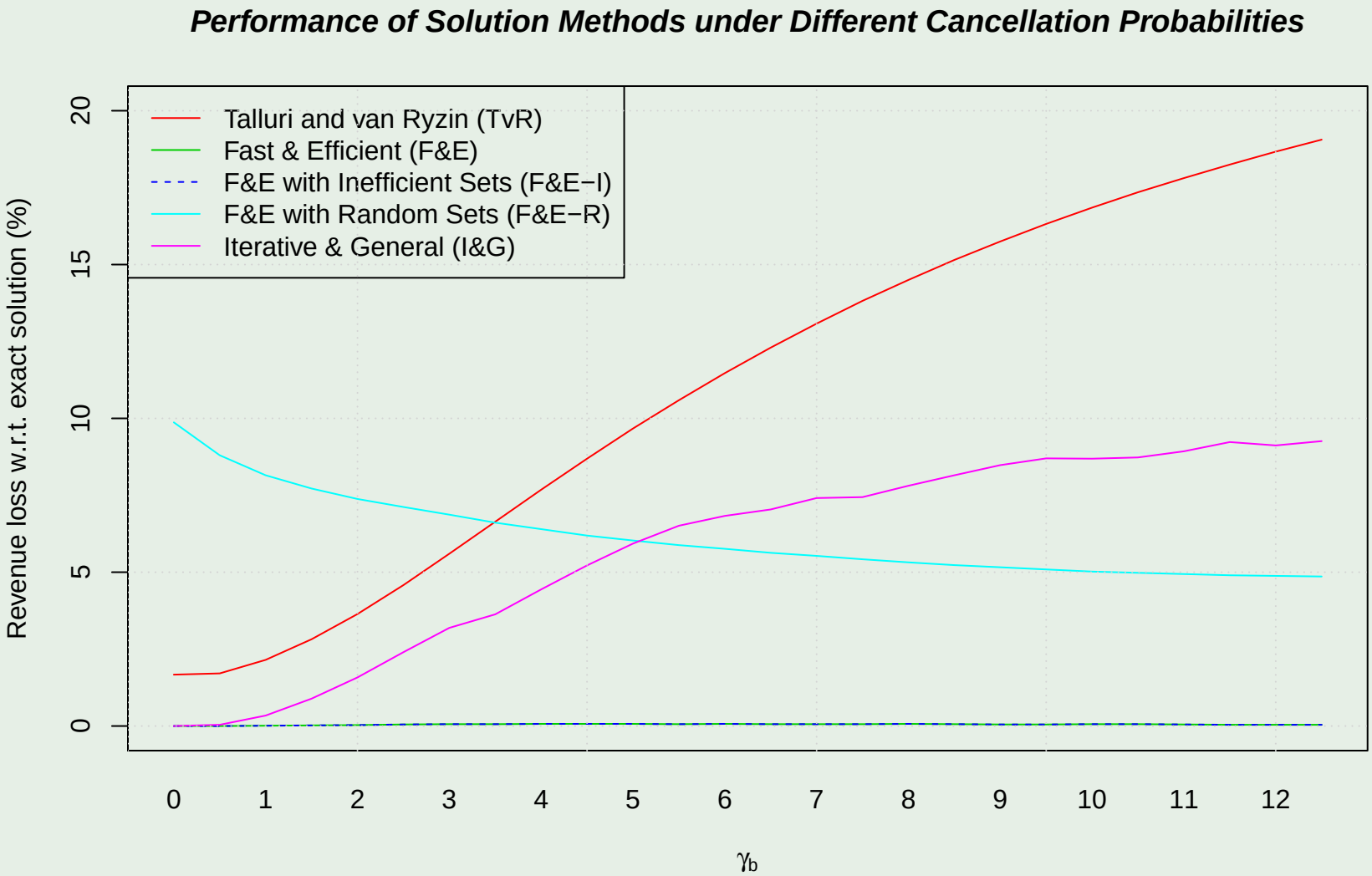
Model as Markov decision process and solve with dynamic programming:

$$V(x,t) = \max_{S \subset N} \Bigg\{ \lambda \sum_{j \in S} P(S,j)\big(r_j + V(x+e_j, t-1)\big) + \sum_{j=1}^{n} \gamma_j(x)\big(-c_j(t) + V(x-e_j, t-1)\big) + \left(1 - \lambda \sum_{j \in S} P(S,j) - \sum_{j=1}^{n} \gamma_j(x)\right) V(x, t-1) \Bigg\}.$$

Properties

- Reduced state space under equal and linear cancellations assumption $\gamma_j(x) = \gamma x_j$
- Heuristic performs well under this assumption



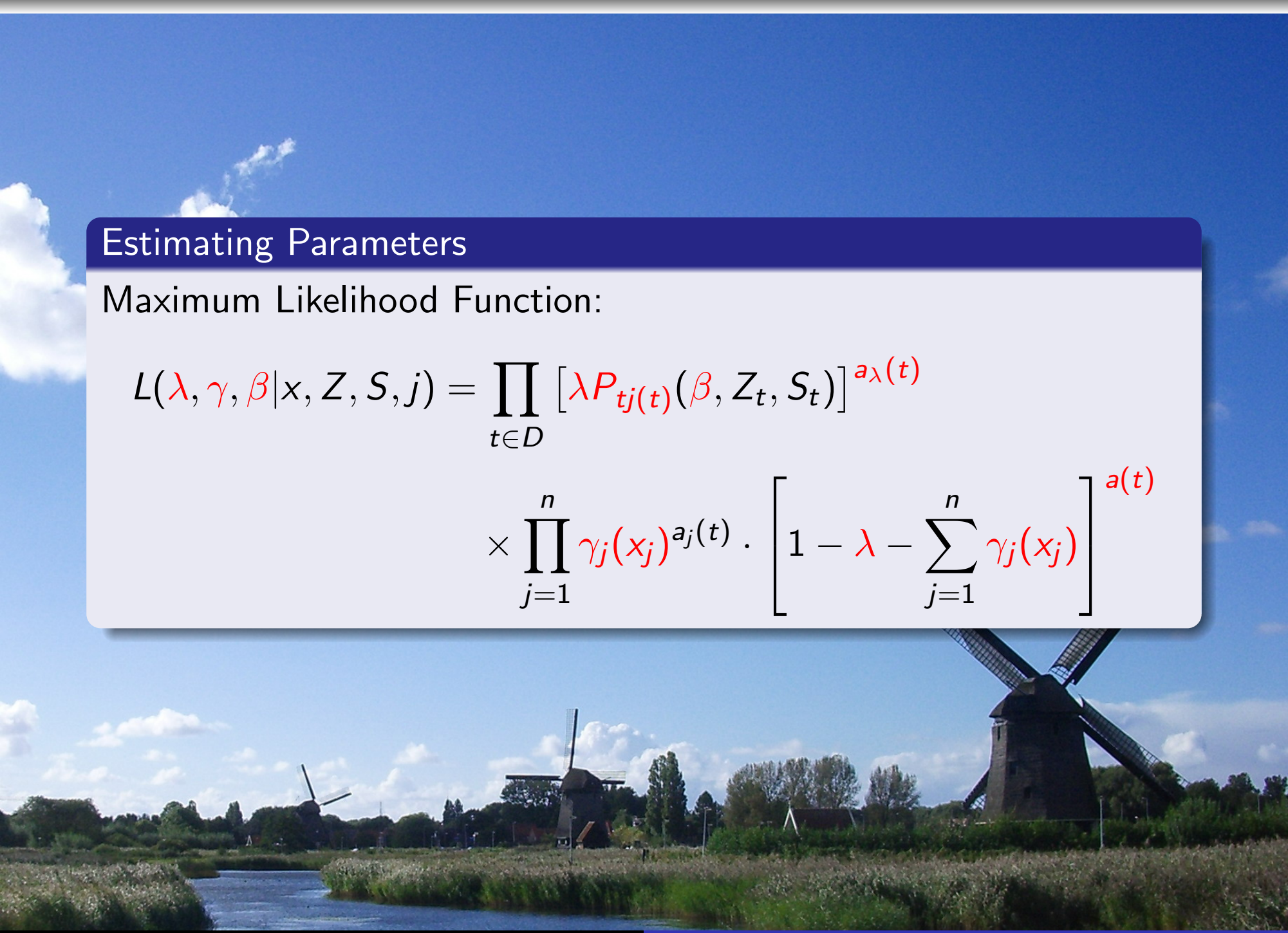

Performance of Solution Methods under Different Cancellation Probabilities
Talluri and van Ryzin (TvR)
Fast & Efficient (F&E)
F&E with Inefficient Sets (F&E−I)
F&E with Random Sets (F&E−R)
Iterative & General (I&G)
Revenue loss w.r.t. exact solution (%)
0
5
10
15
20
0
1
2
3
4
5
6
7
8
9
10
11
12
γb

Estimating Parameters

Maximum Likelihood Function:

$$L(\lambda, \gamma, \beta | x, Z, S, j) = \prod_{t \in D} \left[\lambda P_{tj(t)}(\beta, Z_t, S_t) \right]^{a_\lambda(t)}$$

$$\times \prod_{j=1}^{n} \gamma_j(x_j)^{a_j(t)} \cdot \left[1 - \lambda - \sum_{j=1}^{n} \gamma_j(x_j) \right]^{a(t)}$$



New Parameter Estimation Algorithm

Based on Newman et alii (2010).

1. Estimate $\hat{\gamma}$ (cancellations)
2. Estimate $\hat{\beta}$ (customer choice behaviour)
3. Estimate $\hat{\alpha}$ and $\hat{\lambda}$ using $\hat{\beta}$ (market demand)

Upside: Fast; accurate; consistent
Downside: Data collection difficult for independent hotels

Example: customer choice behaviour estimate

.

	Family	Double	Twin	Single	Price	Competition
β	9.43	0.36	-0.38	-10.43	-0.57	1.32

Observations:

- Price elasticity: higher price $\Longrightarrow$ lower demand
- Competition price higher $\Longrightarrow$ higher demand
- Family room attractive, compensated by price.
- Single room less attractive, compensated by lower price.

Current Research: Applying the Cancallation Model

- Pilot starting soon in several Dutch hotels
- Hotels currently do not use RM system

Collaborating hotels

Aankomstdata

Van 06/06/2014 tot 06/06/2014 OK

Huidige pickup

	Kamertype 1	Kamertype 2	Seizoen	Prijs concurrent
Vr 6 jun 2014	4	11	Hoog	€ 80

Prijsadvies

	Kamertype 1		Kamertype 2	
	Refundable	*Non-refundable*	*Refundable*	*Non-refundable*
Vr 6 jun 2014	€ 84.64	€ 74.04	€ 85.36	€ 75.02

Conclusion

- Cancellations have big impact on revenue
- The heuristic approximates the optimal solution well
- The new parameter estimation method performs well
- Cancellation model is suitable for practitioners

Further Research

- Application to Dutch hotels
- Expand with group bookings and networks/multiple night stays