Lufthansa Systems
Moving Your Business Ahead

The Art and Science of Marketshare Models:

How to forecast passenger demand in a competitive environment ?

Agenda

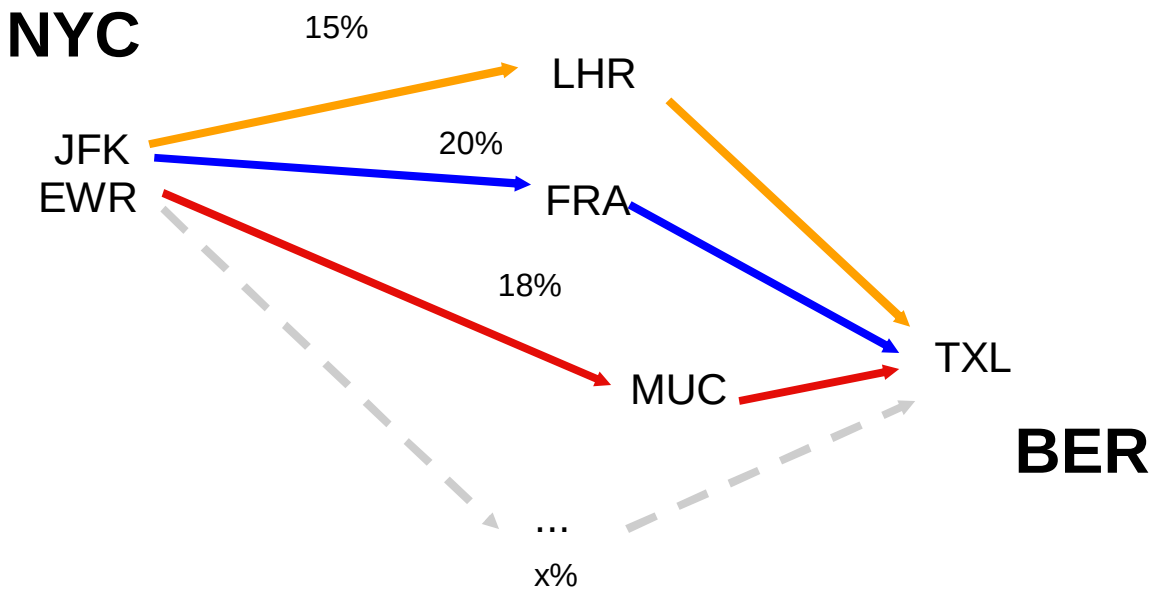
Marketshare Models for Travel Demand Forecasting

Correlations: Red and Blue Busses

A Practical Example

Summary and Outlook

Marketshare models: Forecasting marketshares

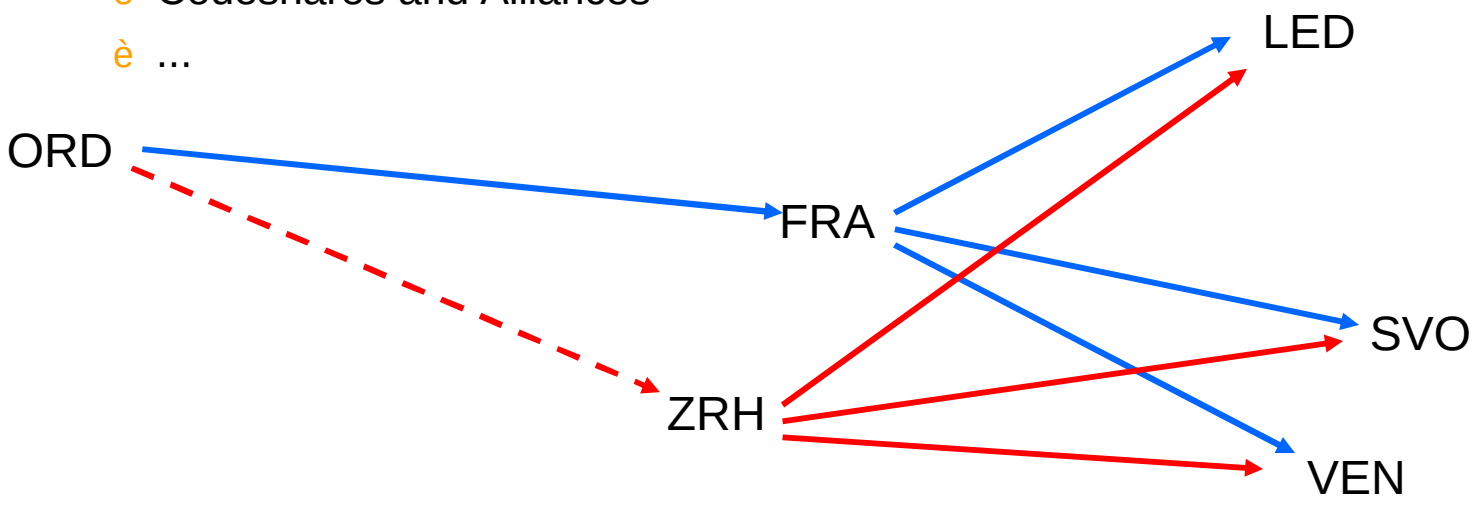


Marketshare Models – Why ?

- **Support for Scheduling and Network Decisions** in its own right

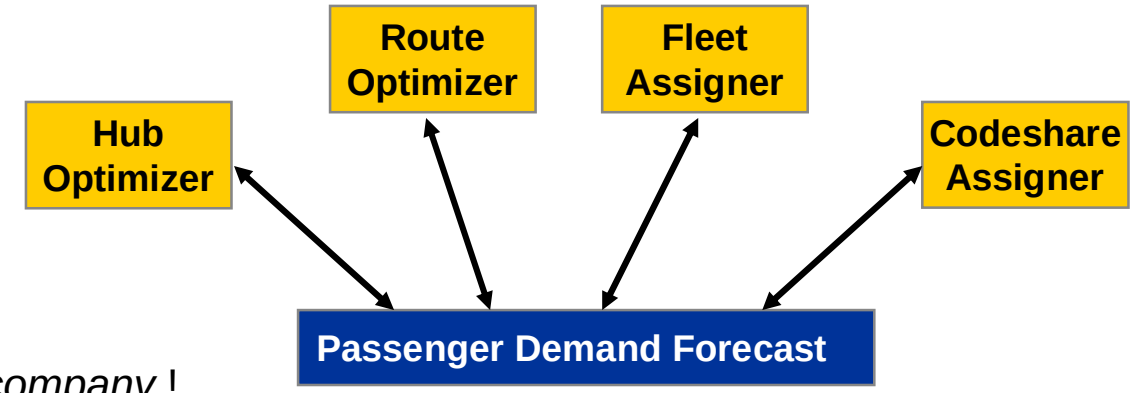
  Scenario studies for

  - è Re-timings
  - è Frequency changes
  - è Equipment changes
  - è Codeshares and Alliances
  - è ...



Marketshare Models in Scheduling and Strategic Planning

- **Goal function for Optimizers**, such as ...
  - ... Timing Optimization
  - ... Fleet Assignment
  - ... Codeshare Assignment



- **Why:**
  - *One model throughout the company* !
  - Consistent evaluation for e.g., re-fleeting and and re-timing scenarios !
  - Save calibration and data preparation efforts

Requirements

- **Reliability**
  - è Accuracy of Forecasts
  - è Taking into account all relevant effects appropriately

- **Scenario capability**
  - è account for all relevant business cases
    (re-timings, equipment changes, codeshares, ...)

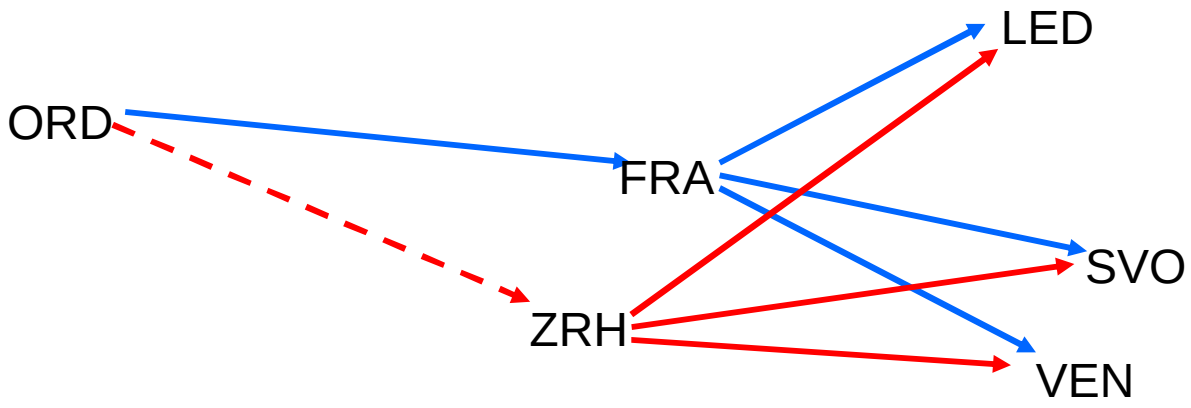
- **Speed**
  - è Optimizers require lots of evaluations
  - è Convenience for users
    (spend time on analysis rather than generating numbers)

Marketshare Models – How do they work ?

- Mathematical measure for itinerary quality, for example:

$$u(i) = \beta_{ConType} * x_{ConType} + \beta_{el.Time} * x_{el.time} + \beta_{Airline} * x_{AirlinePref} + \ldots$$

- Account for all relevant effects that have an impact on passengers‘ choice
  - è Departure/arrival time preference
  - è Airline preferences
  - è Connect type
  - è Elapsed time
  - è ...



QSI models

Mathematical measure for itinerary quality, for example:

$$u(i) = \beta_{ConType} * x_{ConType} + \beta_{el.Time} * x_{el.time} + \beta_{Airline} * x_{AirlinePref} + \ldots$$

Is related to marketshare for itinerary i:

$$share(i) = \frac{u(i)}{\sum_j u(j)}$$

Random utility theory – Logit and Probit

- **Utility maximisation theory**:

  Decisions are made such, that the utility for the decision-making individual is maximised .

- **How to measure utility ?**
  - non-rational/non-parametrisable influences
  - non-observable influence
  - taste variations
  - ...

$$V(i) = u(i) + \varepsilon(i)$$
$$= \beta_1 * x_1(i) + \beta_2 * x_2(i) + \ldots + \varepsilon(i)$$

Parametrisation of the stochastic term

- **Logit:**

$$\varepsilon(i) \sim \exp[-\exp(-\varepsilon(i))] * \exp(-\varepsilon(i))$$

  - è Gumbel distribution
  - è Independent alternatives
  - è Analytical integration possible

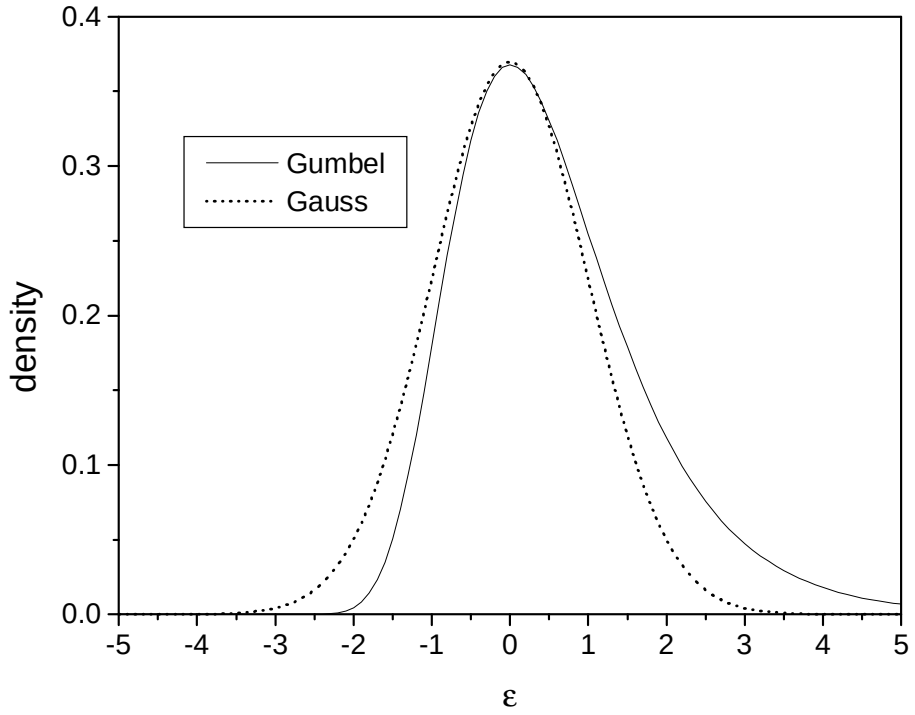
- **Probit:**

$$\varepsilon \sim \exp[-\varepsilon\, \Omega\, \varepsilon]$$

  - è Gauß distribution
  - è Correlated alternatives
  - è numerical solutions only à time consuming !

Stochastic contribution to the utility

$$V(i) = u(i) + \varepsilon(i)$$
$$= \beta_1 * x_1(i) + \beta_2 * x_2(i) + \ldots + \varepsilon(i)$$



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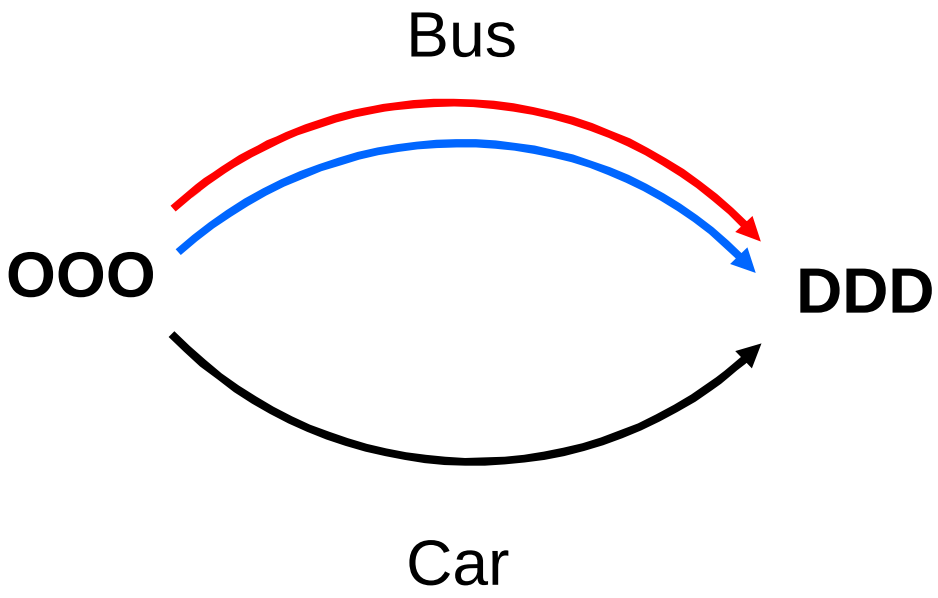
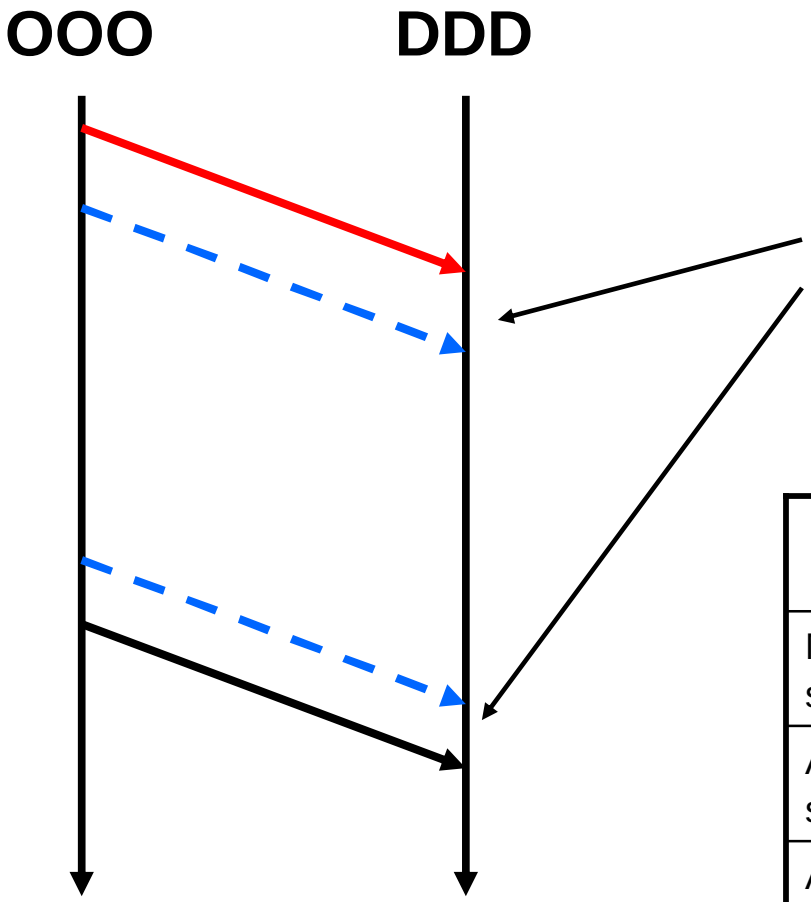
Correlation effects: Red Bus-Blue Bus paradox



Introducing Blue Bus with identical attributes as Red Bus

à *model forecast*: decreasing marketshare for Car

Correlation effects: Timings



Introducing blue service affects marketshare of red service differently depending on timing !

	No add. service	Add. morning service	Add. afternoon service
Morning service	50 %	25 %	50%
Afternoon service	50 %	50 %	25%
Add. service	0%	25%	25%

How to deal with this ?

In the standard *Logit* and the *QSI* theory no accouting for correlation/coupling effects !

Have a look at the *Probit* approach:

$$V(i) = u(i) + \varepsilon(i)$$

$$\varepsilon(i) \sim \exp\left[-\omega_{ii}\,\varepsilon_i^2\right] * \exp\left[-\sum_j \varepsilon_i\,\omega_{ij}\,\varepsilon_j\right]$$

Bi-linear term à accounting for correlations

Extended Logit approach

Include bi-linear terms into the *Logit* approach:

$$V(i) = u(i) + \varepsilon(i)$$

$$\varepsilon(i) \sim \exp[-\exp(-\varepsilon(i))] * \exp(-\varepsilon(i)) * \Phi(\varepsilon_i, \varepsilon_j, \varepsilon_k, \ldots)$$

Define a suitable expression to account for coupling between alternatives

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Example

European regional market

- Short haul, high frequency market

- Mainly nonstop services of different airlines
  - *Elapsed time* and *connect type* no relevant choice parameter !

- Choice parameters are
  - Arrival/departure timing
  - *Timing competition*
  - *Airline competition/correlation*

Nr.	Dep. Time	Blocktime	Airline	Stops
1	06:50	75	2	0
2	07:45	65	3	0
3	08:15	70	1	0
4	09:55	75	2	0
5	10:00	70	1	0
6	10:30	65	3	0
7	14:40	65	3	0
8	17:15	70	1	0
9	18:40	65	3	0
10	20:20	65	3	0

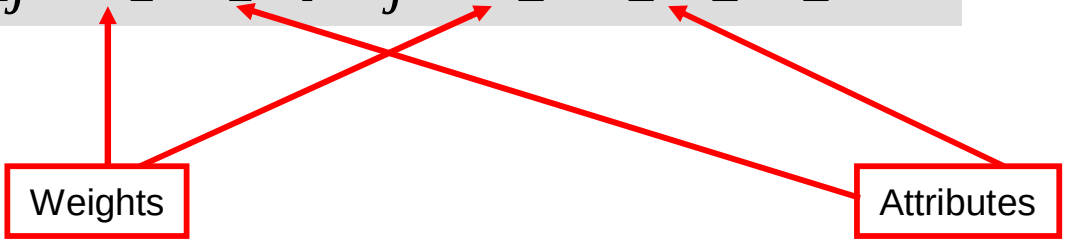
Influence of Correlation/Coupling

- *Example: Correlation of departure times:*
  - è competitive coupling
  - è leading to decrease in marketshare

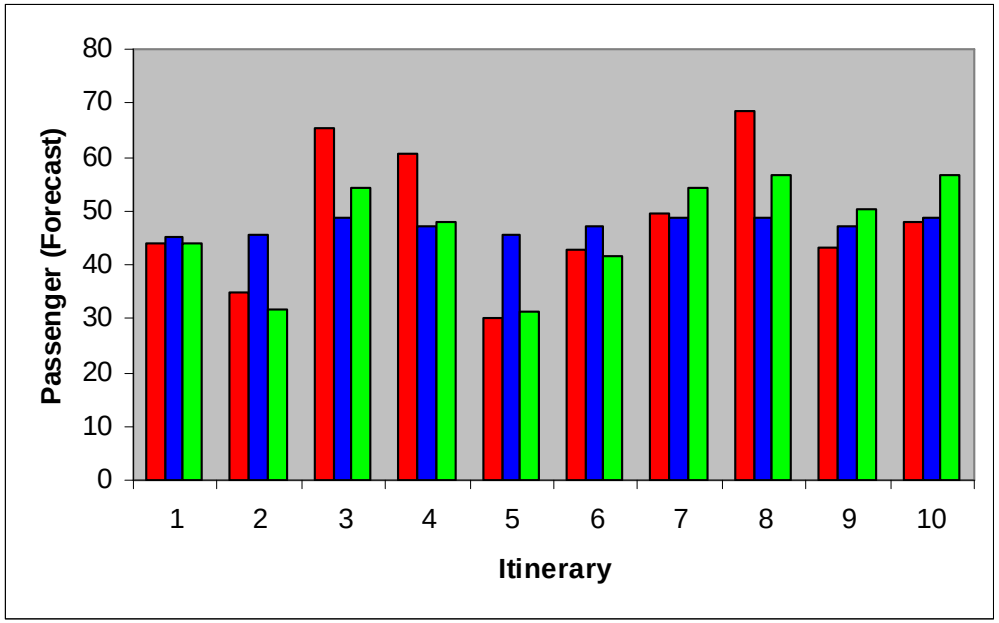
- *Example: Correlation of operating/marketing airline of schedule alternatives*:
  - è competitive coupling (‚I want to fly with airlines xyz !‘)
  - è synergistic coupling due to better overall service

Determine overall coupling parameter for two alternatives:

$$B_{ij} = \gamma_1 * z_1(x_i, x_j) + \gamma_2 * z_2(x_2, x_2) + \ldots$$



Results - I



Legend:
- Observed bookings
- Standard Logit forecast
- Extended Logit forecast

- *Extended Logit*
  - Good correlation
  - Peaks and valleys adequately represented

- *Standard Logit*
  - Essential properties of market not represented adequately

Results – II

Values of Coefficients:

- *Timing Correlation*: negative contribution parameter (γ_{TC} = - 0.976)
  - è Significant competition present between trip alternatives
  - è Itineraries close in departure time compete for the same passengers

- *Airline Correlation*: positive contribution parameter (γ_{AC} = + 0.102)
  - è Synergistic effect outweighs competition
  - è High marketpresence gives competitive advantage

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Summary + Outlook

- More sophisticated model leads to higher accuracy of forecasts
  - è Getting around pitfalls of previous models
  - è A better understanding of highly competitive O&D‘s
- Suitable for scenario studies
- Combine speed of Logit with accuracy of Probit
  - è Fast evaluation
  - è Also suitable as goal function for optimization

All requirements for a good model fulfilled