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Consequences of Feeder Delays for the Success of A380 Operations

A Case Study of Lufthansa at Frankfurt Airport

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Research Question

Will delays of feeder aircraft question the financial success of the A380?

Agenda

- Introduction
- The Role of Feeder Delays for the Success of Mega-Carrier Operations
- Data Sample and Model Layout
- Empirical Results
- Implications for Future Action
- Conclusion

Countdown for A380 Introduction

- A380 successfully completed maiden flight on April 27, 2005
- Introduction of A380 requires airlines to fill their planes with more passengers than ever
- Due to slot and capacity constraints airlines need to utilize larger feeder aircraft to feed their A380 operations at hub airports
- Critical delays of these larger aircraft would result in significant reduction of profitability as the load factor of an outgoing A380 decreases
- As traffic volume and congestion is likely to increase, the level of delays is expected to become larger as well

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The Capacity Issue

- Depending on the seating, an A380 provides up to 160 additional seats in a standard layout compared to the B747-400
- With a seating capacity of 550 seats (LH) and a common break-even load factor of 70%, 385 sets need to be filled in order to reach profitability
- Possible sources of additional passengers:
  - Utilization of larger feeder aircraft
  - Increased frequency of feeding traffic
  - Increased catchment area
- Due to several problems associated with the last two options, the paper assumes the deployment of larger feeder aircraft

Effects of Air Traffic Delays on Airline Profitability

- The average delay per movement (ADM) increased from 2003 to 2004 by 4.9% to 10.4 min. for arrivals and by 7.5% to 10.0 min. for departures in Europe
- Four sources of air traffic delays can be distinguished:
  - Capacity shortages and inefficient capacity management (ATC)
  - Lacking runway, apron or terminal capacity (airport)
  - Operational issues like baggage or aircraft handling (airline)
  - Extreme weather conditions
- Research reveals that hub airports experience an additional average arrival delay of 1.5 to 4.5 minutes per flight (Mayer & Sinai 2003)
- When applying a hub-and-spoke concept, delay of feeder aircraft obviously threatens the profitability of an airline

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The Data – Initial Setting

- Case Study of Lufthansa (LH) at Frankfurt airport (FRA)
- Expected first year of permanent A380 operations in 2008
- FRA one of the most slot constrained airports in Europe
- Current order volume for LH: 15 A380 to be operated on long-haul routes
- Demand Analysis: True O&D pairs for 2004 from global reservation systems
- Forecasted demand data for 2008 using IATA international passenger forecasts (applied on historic demand for a typical week)

Suggested Initial LH A380 Routes for 2008

- In-depth analysis of three routes (Beijing, Tokyo, Los Angeles)
- Analysis of possible operating patterns with forecasted demand compared to today‘s operations

	Beijing	Tokyo	Los Angeles
PAX per week	5214.7	5369.6	3142.8
Chosen operating pattern	12/7	12/7	7/7
Envisaged load factor	79.0 %	81.4 %	81.6 %
Connecting passengers	55.1 %	63.1 %	63.2 %
Total feeder PAX	239.29	282.22	283.72
Simulated feeder PAX	220.60	236.81	194.47
Time of departure	4.20 p.m.	11.45 a.m.	11.30 a.m.

Current Delay of Feeder Flights

- Analysis of historic delays at Frankfurt
- Average delay per flight in minutes:

Airport Classification	Beijing	Tokyo	Los Angeles	Total
Level 1 (non coordinated)	11.54	8.66	8.32	9.96
Level 2 (schedules facilitated)	8.53	9.64	9.52	9.32
Level 3 (fully coordinated)	10.56	13.11	12.67	12.13

- **Level 1** describes those airports whose capacities are adequate to meet the demands of users.
- **Level 2** describes airports where the demand is approaching capacity and a more formal level of co-operation is required to avoid reaching, if at all possible, an over-capacity situation.
- **Level 3** describes those airports where demand exceeds capacity during the relevant period and it is impossible to resolve the problem through voluntary co-operation between airlines and where, after consultation with all the parties involved, there are no possibilities of resolving the serious problems in the short term. In this scenario, formal procedures need to be implemented at the airport to allocate available capacity and coordinate schedules.

Assumptions

- Minimum connecting time (MCT): 45 minutes
- Average day of operations
- Existing wave and bank patterns will be kept
- Break-even load factor: 70 %
- Passenger demand is deterministic, whereas delays are stochastic
- Independent delays
- Attribution of passengers into feeder flights with 50% into the last feeder of respective airport, remaining passengers equally distributed into earlier flights
- Congestion scenarios:

Scenario	Status Quo	Most Likely	Worst Case
Level 1	Current status	Current status	+ 2 minutes per flight
Level 2	Current status	+ 2 minutes per flight	+ 4 minutes per flight
Level 3	Current status	+ 4 minutes per flight	+ 8 minutes per flight

The Simulation Model (1)

(1) $t_i = (H_{A380} - 45) - h_i$ **Individual cut off times for each feeder**

with $i = 1,\ldots,N$ Set of feeder flights

$j = 1,\ldots,M$ Set of simulation runs

H_{A380} Departure time A380

h_i Scheduled arrival feeder flight i

(2) $\tilde{F}_i(\tilde{d}_i)$ **Observed empirical distributions for each feeder i**

with $\tilde{d}_i$ Observed historical delay for feeder i

(3) $y_{i,j} = \begin{cases} 1 & d_{i,j} \le t_i \\ 0 & d_{i,j} > t_i \end{cases}$ **Index variable**

with $d_{i,j}$ Delay in minutes for feeder i at run j

$d_{i,j} \in \mathrm{N}_0$

The Simulation Model (2)
Monte Carlo Simulation

(4) $u_{i=1,j=1},\ldots\ldots,u_{i=N,j=M} \leftarrow U_{[0,1]}$ **Random number from a uniformally distributed population**

(5) $\tilde{F}_i^{-1}(u_{i,j}) = \hat{d}_{i,j}$ **Simulated delay in minutes for feeder i at run j**

(6) $\hat{p}_j^{A380} = \sum_{i=1}^{N}(p_i \cdot y_{i,j})$ **Simulated number of passengers for A380 at run j**

(7) $(\hat{p}_1^{A380},\ldots\ldots,\hat{p}_{5000}^{A380}) \sim \hat{F}^{Sim}(p^{A380}) \approx F(p^{A380})$ **Simulated A380 occupation**

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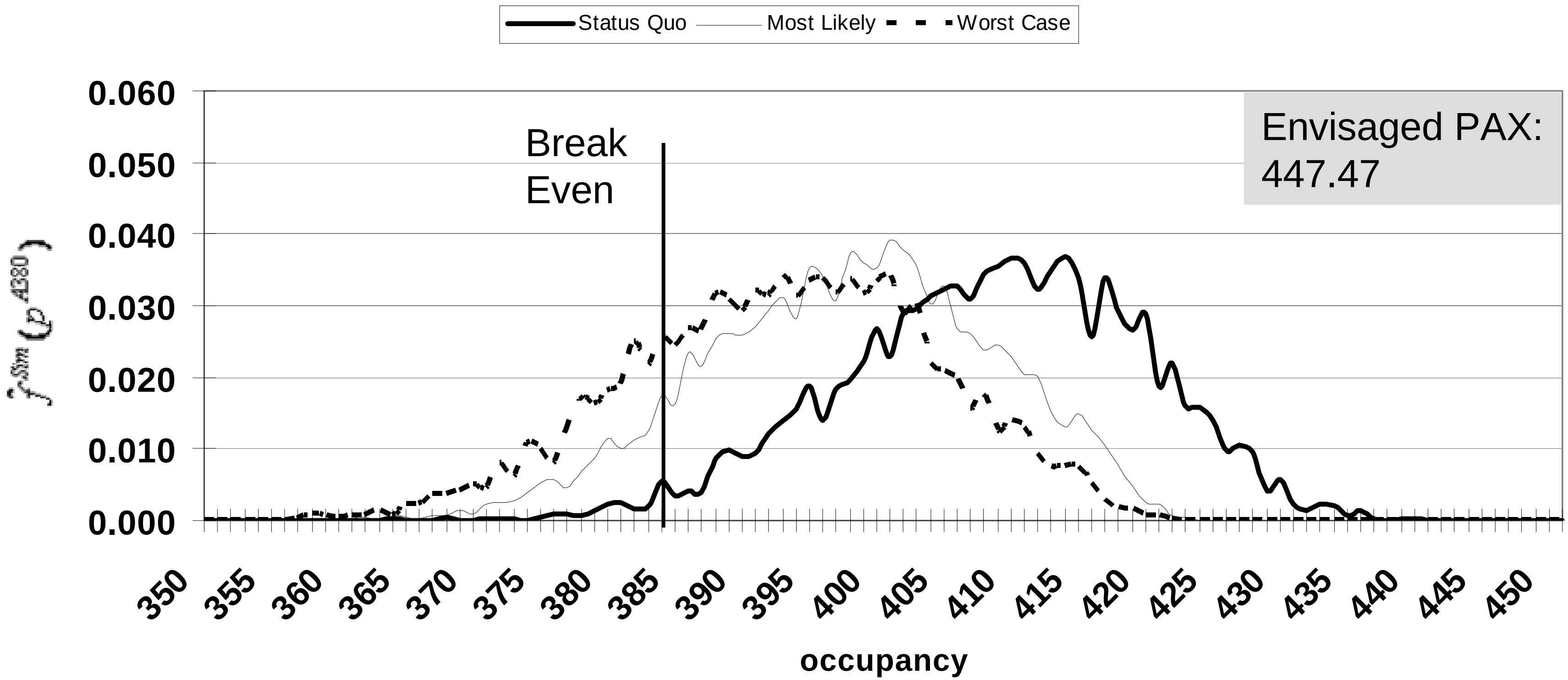
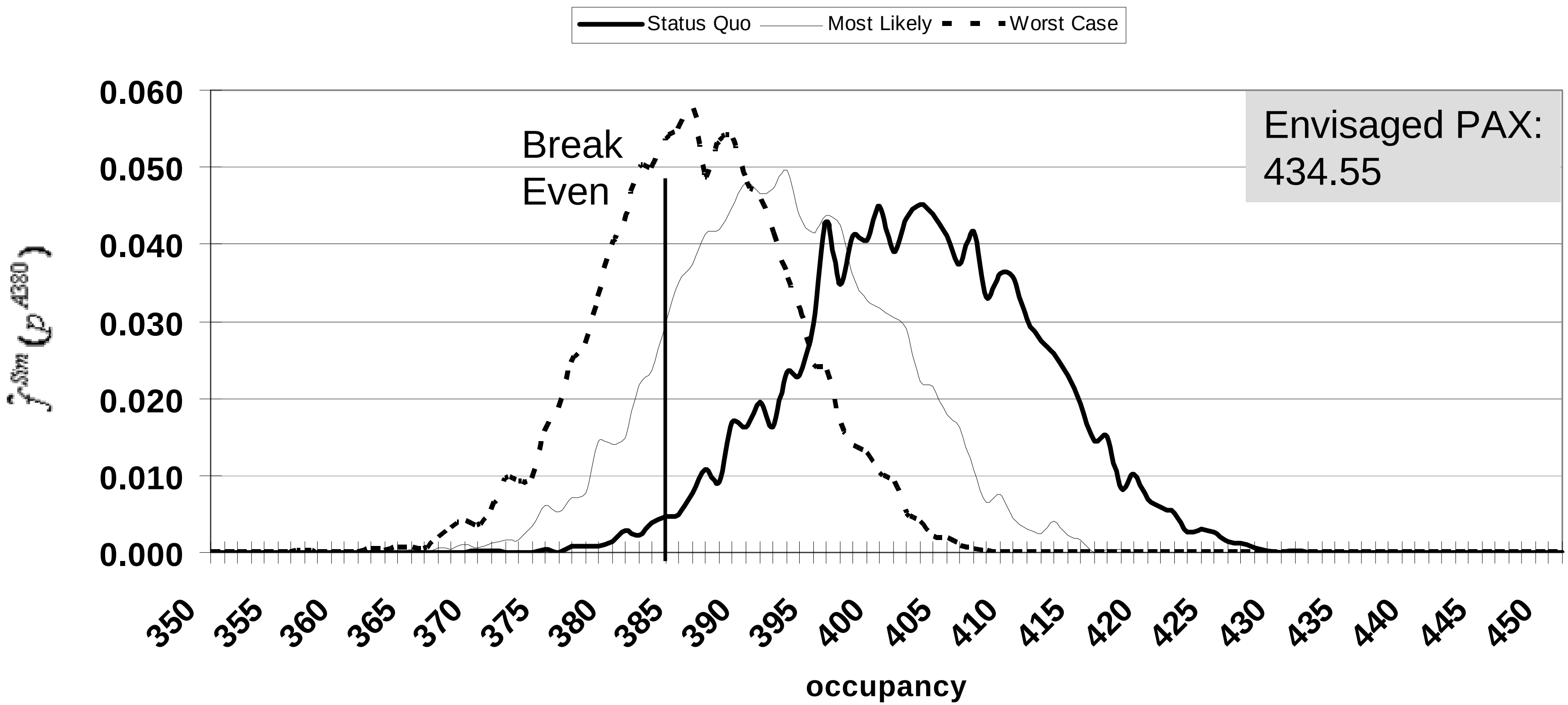
Empirical Results (1) Frankfurt – Tokyo



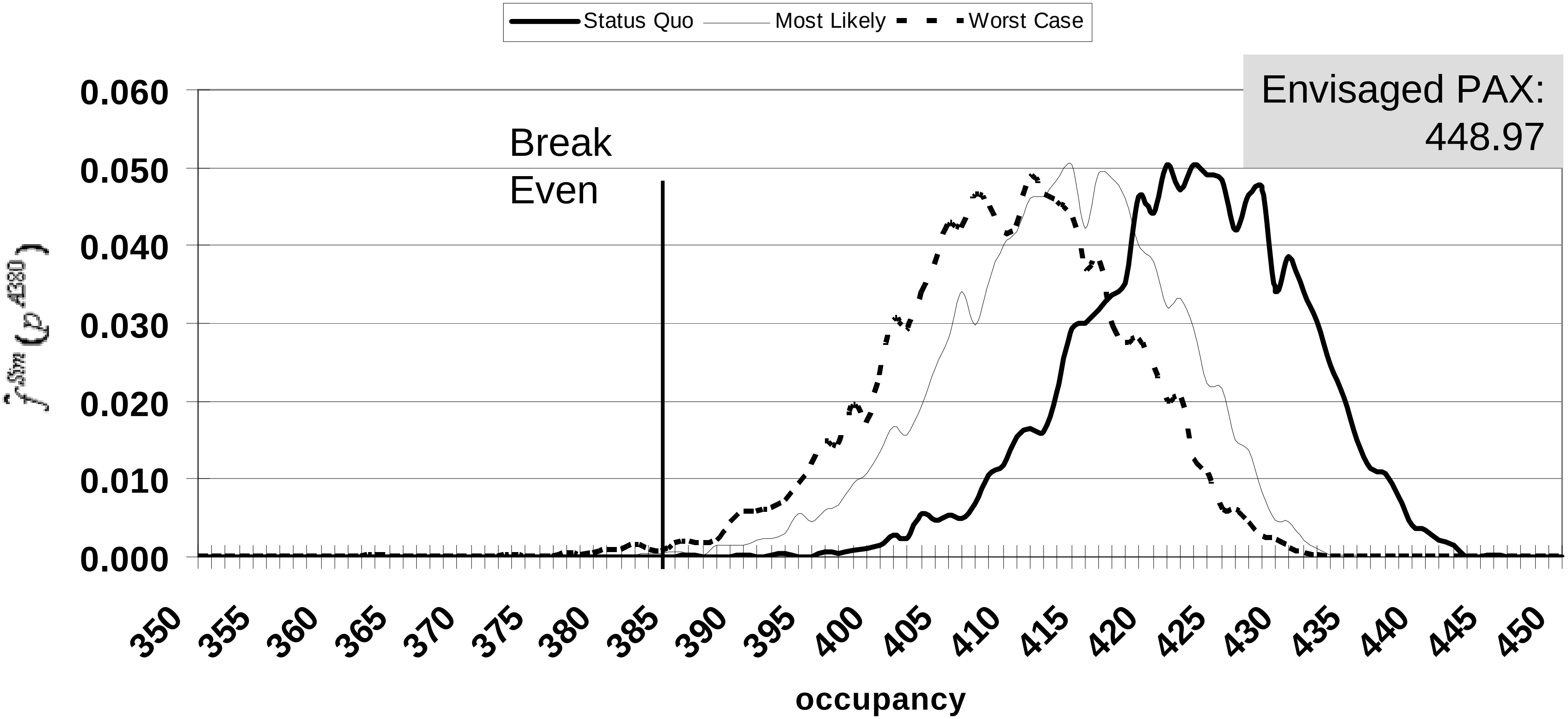
	Status Quo	Most Likely	Worst Case
Mean	408.13	397.36	392.65
Unprofitable	2.30%	12.78%	25.38%
Missed Connection	13.94%	17.68%	19.42%

Empirical Results (2)
Frankfurt – Beijing



	Status Quo	Most Likely	Worst Case
Mean	402.44	392.22	385.77
Unprofitable	2.28%	19.04%	45.92%
Missed Connection	13.42%	17.82%	20.41%

Empirical Results (3)
Frankfurt – Los Angeles



	Status Quo	Most Likely	Worst Case
Mean	422.05	412.57	408.53
Unprofitable	0.00%	0.20%	0.78%
Missed Connection	9.49%	12.90%	14.25%

Empirical Findings

- Large discrepancy between envisaged demand and simulated transferring passengers in each scenario (large loss in profitability)
- Status-Quo-Scenario shows overall profitable operations for all flights, thus airline might not consider situation sufficiently threatening to make any structural wave changes
- Large percentage of unprofitable flights with applied congestions scenarios
- Feeders show very different delay distributions depending on origin and time of day

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Reduction of the Delay Issue (1)

- (1) Make the schedule more robust against delays by spreading (i.e. re-scheduling) the feeder traffic
- (2) Slot swap: shift those flights to earlier slots which are both important and mostly affected by delays
- Problem: Total travel time for preferred flights increases and slots at origin airports might not be available for swapping the affected flights

- Postpone the departure of the A380
- Problem: Application for new slots at hub airports will be mostly infeasible or impossible due to limited slot availability

Reduction of the Delay Issue (2)

- Relocate hub activities to less congested airports
- Example: Lufthansa established Munich as secondary hub to Frankfurt
- Problem: Less transfer passengers from other airlines

- Shift feeding traffic to alternative modes of transportation
- Example: AirRail approach from Lufthansa between Frankfurt and Cologne and Stuttgart
- Problem: The realization of this particular measure depends on the railway network and the willingness of passengers to use rail-transport

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- Delays cause a significant downside to profitable operations of A380
- Status-Quo-scenarios might not be experienced as harmful at the moment – therefore delays might not be on top of the agenda for carriers
- A further tightening of the situation would result in very questionable financial success (high percentage of A380 flights below break-even)
- Different empirical delay distributions observable – thus monitoring of individual feeders seems appropriate
- Suggestion of different "second best"-solutions to counteract delays

- Results and implications applicable to other routes / airports?