Update on Passenger Delay Analysis

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FAA Total Delay Impact project

- Published estimates of costs of delays to airlines and passengers vary from $14 billion to $31 billion
- Indirect costs to the U.S. economy are even harder to quantify
- Have NEXTOR apply a rigorous methodological approach to calculate costs of delays
  - For airlines, passengers, and the U.S. economy

Published passenger delay cost estimates

- Air Transportation Association estimates the costs of passenger delays at $4 billion for 2008
  - $37.18 per hour times flight delays
- U.S. Congress Joint Economic Committee estimates the costs at $12 billion for 2007
  - $37.60 per hour (including schedule padding)
- Who is right?

Passenger flow data

- Planned flight schedules
  - ASQP on-time performance data
- Flight seating capacities
  - Schedule B-43 airline inventory, ETMS ICAO aircraft codes, T-100 monthly segment demands
- Aggregate passenger demand data
  - T-100 monthly segment demands, DB1B quarterly 10% coupon samples (one-way itinerary routes)
- Proprietary ticketing / booking data
  - Two major carriers, one quarter each

Passenger delay calculation

1. Determine ASQP flight seating capacities
2. Generate potential passenger itineraries based on planned ASQP flights
   - Non-stop and one-stop (over 95% of passengers)
3. Allocate passengers to generated itineraries
   - *This is where most of our work has been…*
4. Determine disrupted passengers based on ASQP flight delays and cancellations
5. Re-accommodate disrupted passengers

Flight seating capacities

1. Match ASQP flights against Schedule B-43 airline inventories
2. Use average T-100 seating capacities when the variation is small
3. Determine ICAO aircraft code from ETMS and flight offering data
   - Lookup seating capacities in Schedule B-43s
4. For remaining 1.5% of flights, default to T-100

Generated itineraries

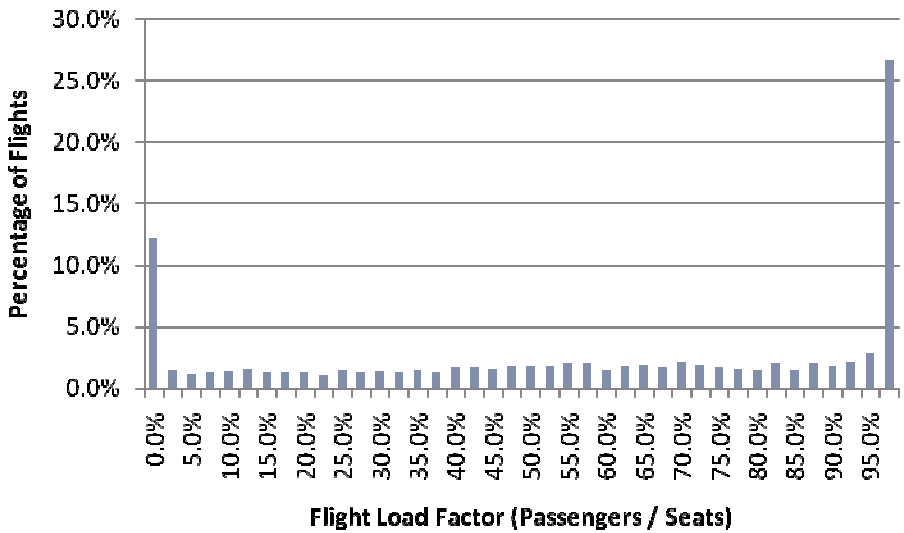
- Match ASQP flights against ASQP flights
- Filter carrier routes based on DB1B
  - DB1B contains multi-carrier routes, so we do not explicitly consider code shares
- Allow 30 minute to 3 hour connection times
  - Longer connections are less likely to be disrupted

Passenger allocation approaches

1. Deterministic optimization allocation
   - Linear program assigns passengers to itineraries to minimize deviation from aggregate demand statistics
2. Sampled discrete choice allocation
   - Calibrate parameters of discrete choice itinerary shares model using proprietary data
   - Sample passenger allocations from calibrated model to disaggregate passenger demand

Problems with optimization based assignment

- Difficult to incorporate secondary factors
  - E.g., connection time and short vs. long haul
- Too many degrees of freedom
  - Basic feasible solutions tend to the extremes



Discrete choice sampling

- Train discrete choice itinerary shares model using proprietary airline bookings data
  - Initial features include time of day, day of week, and connection time
- Sample passenger counts for generated itineraries based on estimated proportions:

$$P(i) = \frac{e^{\beta X_i}}{\sum_i e^{\beta X_i}}$$

Discrete choice allocation examples

Example #1

Day of Week	Departure	Connection	Weight	Proportion
Monday	7:00 AM	Non-stop	1.00	**21%**
Monday	10:00 AM	Non-stop	1.01	**22%**
Monday	2:00 PM	Non-stop	0.94	**20%**
Monday	6:00 PM	Non-stop	0.88	**19%**
Tuesday	7:00 AM	Non-stop	0.83	**18%**

Example #2

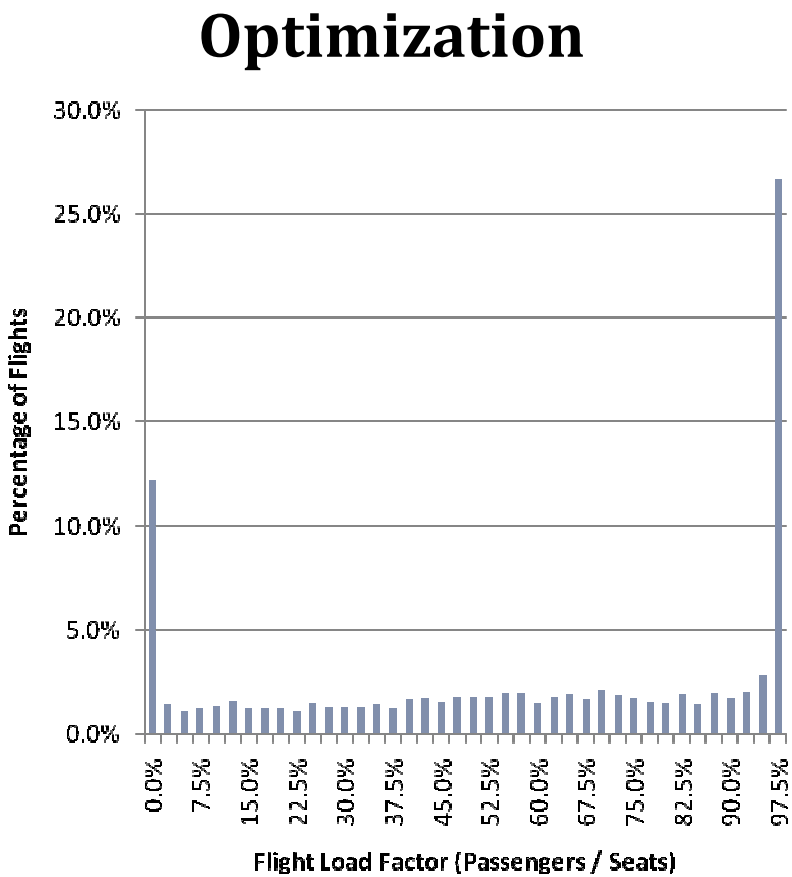
Day of Week	Departure	Connection	Weight	Proportion
Monday	7:00 AM	30 min.	1.11	**24%**
Monday	7:00 AM	1 hour	1.35	**29%**
Monday	7:00 AM	2 hour	1.18	**25%**
Monday	7:00 AM	3 hour	1.04	**22%**

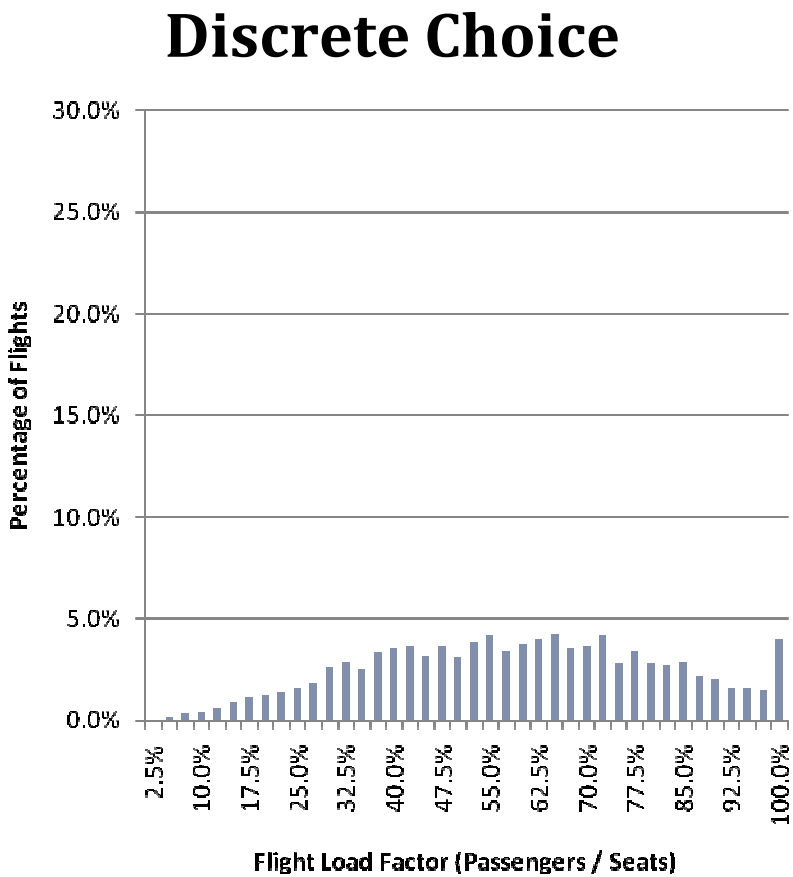
Evaluating the two approaches

- Evaluate by assigning aggregate passengers and comparing to proprietary data
  - Sum absolute deviation between passenger counts for matching itineraries
  - Report as % of allocated demand

	Optimization	Discrete Choice
Error %	61.2%	25.5%

Comparing flight load factors





Measuring passenger delays

- Recover disrupted passengers for each airline
  - Using Bratu & Barnhart Passenger Delay Calculator
  - Greedy re-accommodation of passengers based on scheduled arrival time
- Example results for Continental and JetBlue for the week of October 21st – 27th

Continental passenger delay estimates

	10/21	10/22	10/23	10/24	10/25	10/26	10/27
Num. passengers	**79,204**	**79,324**	**68,232**	**75,007**	**81,529**	**82,903**	**58,461**
Delay > 15 min.	13%	34%	26%	31%	24%	24%	16%
Num. disrupted	**175**	**797**	**792**	**1217**	**528**	**776**	**237**
Cancellations	0%	16%	57%	70%	42%	53%	0%
Misconnections	100%	84%	43%	30%	58%	47%	100%
Avg. delay min.	**7**	**23**	**18**	**24**	**19**	**22**	**13**
Cancellations	0%	2%	14%	12%	1%	3%	0%
Misconnections	9%	11%	5%	6%	3%	5%	8%

JetBlue passenger delay estimates

	10/21	10/22	10/23	10/24	10/25	10/26	10/27
Num. passengers	**47,694**	**43,954**	**38,429**	**40,460**	**45,817**	**46,535**	**41,077**
Delay > 15 min.	11%	5%	20%	50%	26%	43%	43%
Num. disrupted	**84**	**125**	**508**	**267**	**157**	**529**	**222**
Cancellations	0%	69%	87%	0%	0%	39%	0%
Misconnections	100%	31%	13%	100%	100%	61%	100%
Avg. delay min.	**7**	**4**	**16**	**42**	**18**	**44**	**27**
Cancellations	0%	19%	33%	0%	0%	6%	0%
Misconnections	6%	7%	3%	6%	8%	8%	6%

Next steps

- Consider other factors, such as short vs. long haul
- Complete estimates for all ASQP carriers for 2007
- Perform multiple iterations to test sensitivity to sampling of passenger allocations
- Analyze results to look for patterns in passenger delays (e.g. scheduling, network structure, etc.)
- Develop airline disruption response simulator to evaluate passenger impacts of Traffic Flow Management

Conclusion

- Described two approaches for simulating historical passenger itinerary flows
- Demonstrated that discrete choice sampling outperforms the optimization approach
- Provided sample delay results for two airlines
- Discussed next steps and ongoing research plans