The Impact of Block Time Reliability on Scheduled Block Time Setting

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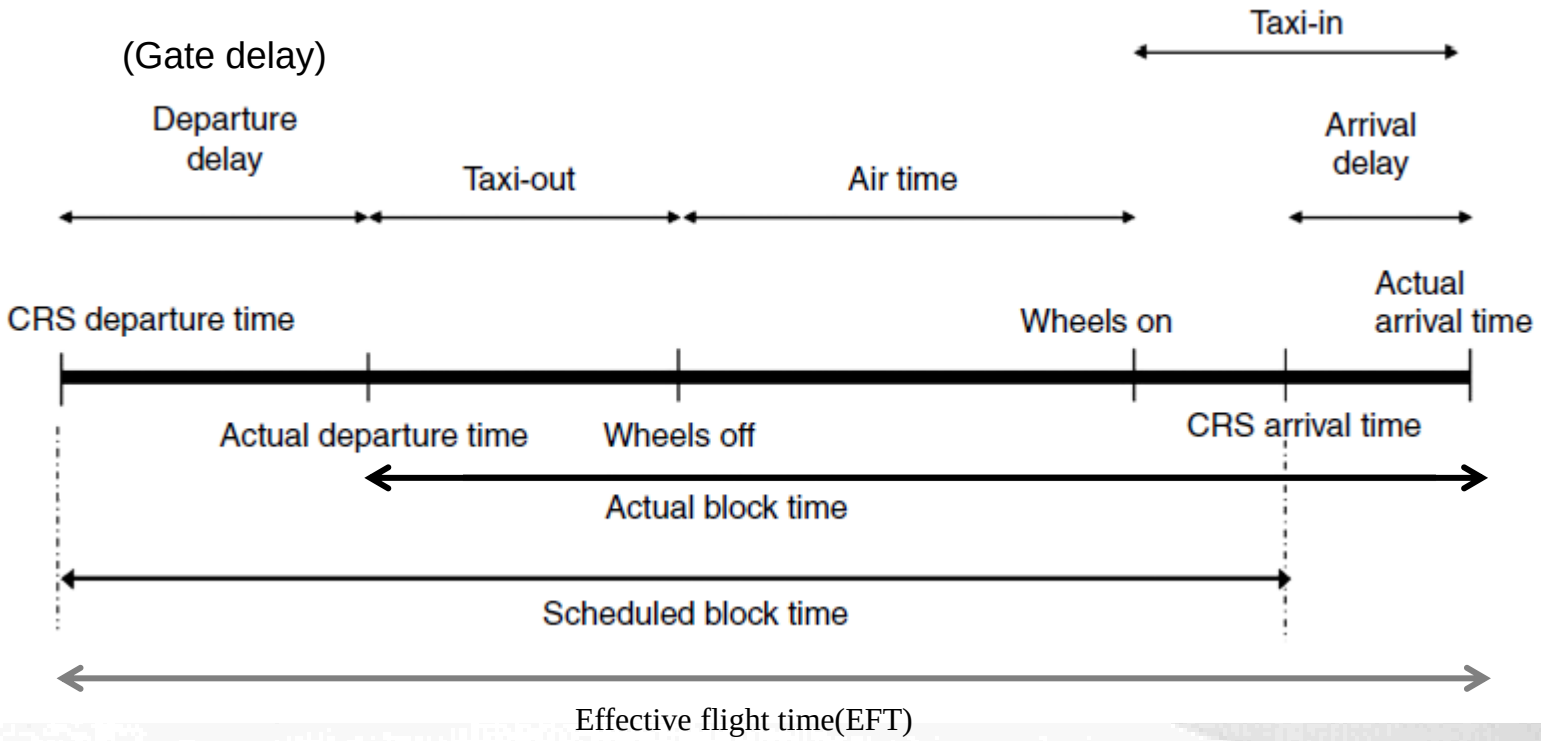
Outline

- Background and literature review
- Percentile model for SBT setting
- Impact Analysis
- Conclusion

Scheduled Block Time (SBT) Setting



Picture Source: Deshpande, V. and M. Arikan. The Impact of Airline Flight Schedules on Flight Delays. *Manufacturing & Service Operations Management*, Articles in Advance, pp. 1-18.

Background

- SBT is crucial in airline scheduling
- Airlines' trade-off in setting SBT
  - Shorter SBT
    - SBTs are expensive: crew cost, fuel cost
    - Aircraft utilization
    - More competitive in the market
  - Longer SBT
    - Better on-time performance
    - Less propagated delay

Literature Review

- Travel time reliability in ground transportation
- Analogy between ground and air

Concept	Ground transportation	Air transportation
Decision	Departure time	Block-time
Scheduled travel time	Preferred arrival time – Selected departure time	Scheduled block-time
Actual travel time	Actual arrival time – Selected departure time	Actual block-time
Prior knowledge	Historical travel times	Historical block-times
Cost of earliness/excessive SBTs	Lost utility from reduced time at origin	Excess labor expense, reduced aircraft utilization
Costs of lateness/insufficient SBTs	Late penalty, work constraints	Degraded on-time performance, traveler inconvenience, delay propagation

Background: Travel Time Reliability

- Widespread interest in travel time reliability in ground transportation
  - Measurement and valuation of travel time reliability
  - Departure time scheduling with uncertain travel time (Vickrey,1973; Small, 1982; Jenelius, et.al., 2011; Fosgerau, 2010)

- New concept and metric for flight predictability
  - Delay and capacity used to be the only metrics for measuring customer service
  - Reliability metrics have not been considered in SBT setting analysis (Coy, 2006; Mayer,2003; Chiraphadhanakul, 2011)

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Capturing Predictability?

- Past experience: variance
  - Counter-intuitive estimation results
  - Outliers pull up measured predictability too much
- Learn from industry practice: capturing the distribution of block time

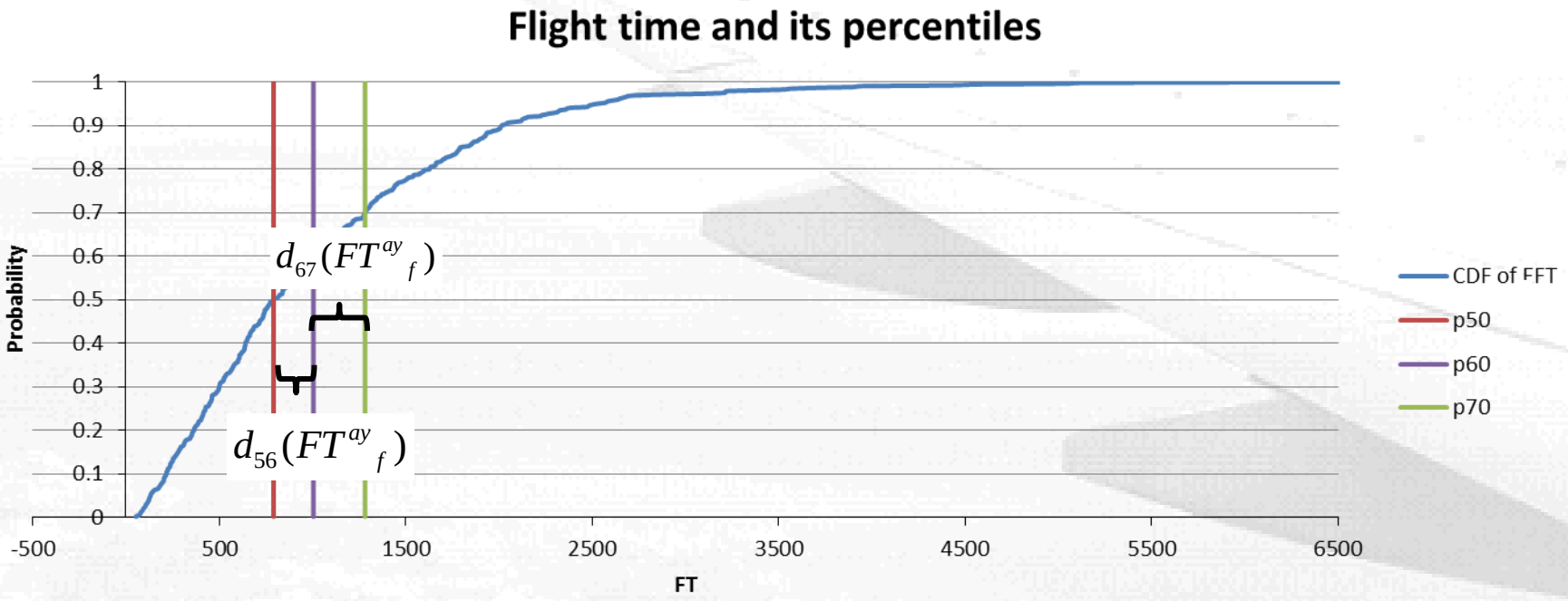
Percentile Model for SBT Setting

- Relate SBT to historical block time
- Treat different segment of block time distribution differently
- Allow for investigating the potential benefit from improved predictability

Percentile Model:

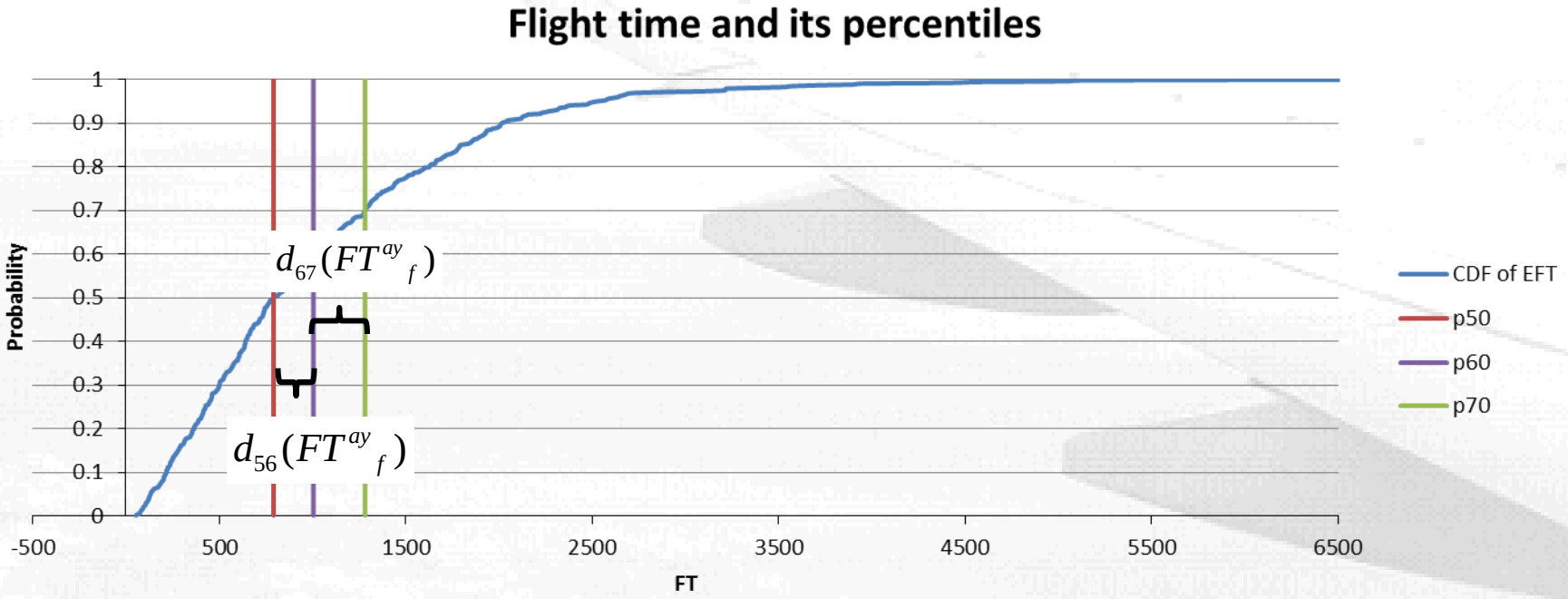
- Capture the distribution with piece-wise approximation
- 50^{th} to 100^{th} percentile of FT distribution
- Median and the difference every 10^{th} percentiles:

$$d_{56}(FT^{ay}{}_f) = p_{60}(FT^{ay}{}_f) - p_{50}(FT^{ay}{}_f)$$



Percentile Model

- Capture the distribution with piece-wise approximation
- 50^{th} to 100^{th} percentile of BT distribution
- Median and the difference every 10^{th} percentiles:
- Distinguish different component of block time: taxi-out time, non taxi-out time; gate delay



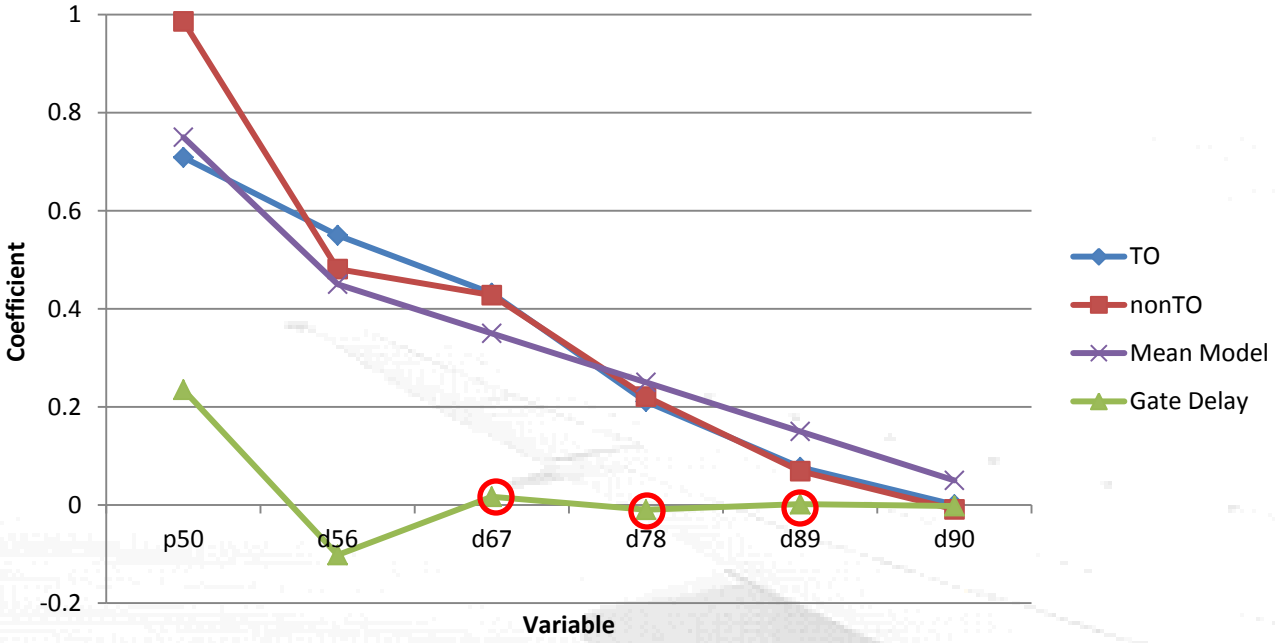
Variables – OD level

- Flight distance
- Competitiveness of the OD pair: Herfindahl index (HHI)
- Load factor
- Flight fare
- Airport characteristic
  - OEP 35 airports
  - Airline operating hubs

Percentile Model: Data Aggregation

- Scheduled block-time (SBT)
  - Uniform for each individual flight over a quarter
  - Median SBT
- Data from three consecutive years
  - SBT: year 2011
  - Historical flight data: aggregated from year 2009 and 2010
- Individual flight defined by OD pair, departure time window (30 min), aircraft type, carrier and quarter, e.g., ATL BOS 20 B757 DL 1 (airline practice)

Estimation Results



- Effect of historical BT:
  - Median(left tail): strong
  - The "inner right tail": moderate — airline's BTR target
  - Additional flight time above the 70th percentile: not strong
- Effect of gate delay: negligible, insignificant

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Impact Analysis

- Percentile model confirms that different segments of the distribution have varying impacts on SBT setting
  - Left tail (median)
  - Inner right tail

- Is this happening in real life?
  - Observe the changes in block time distribution over a time period
  - Its contribution to SBT, schedule adherence metrics

Impact Analysis

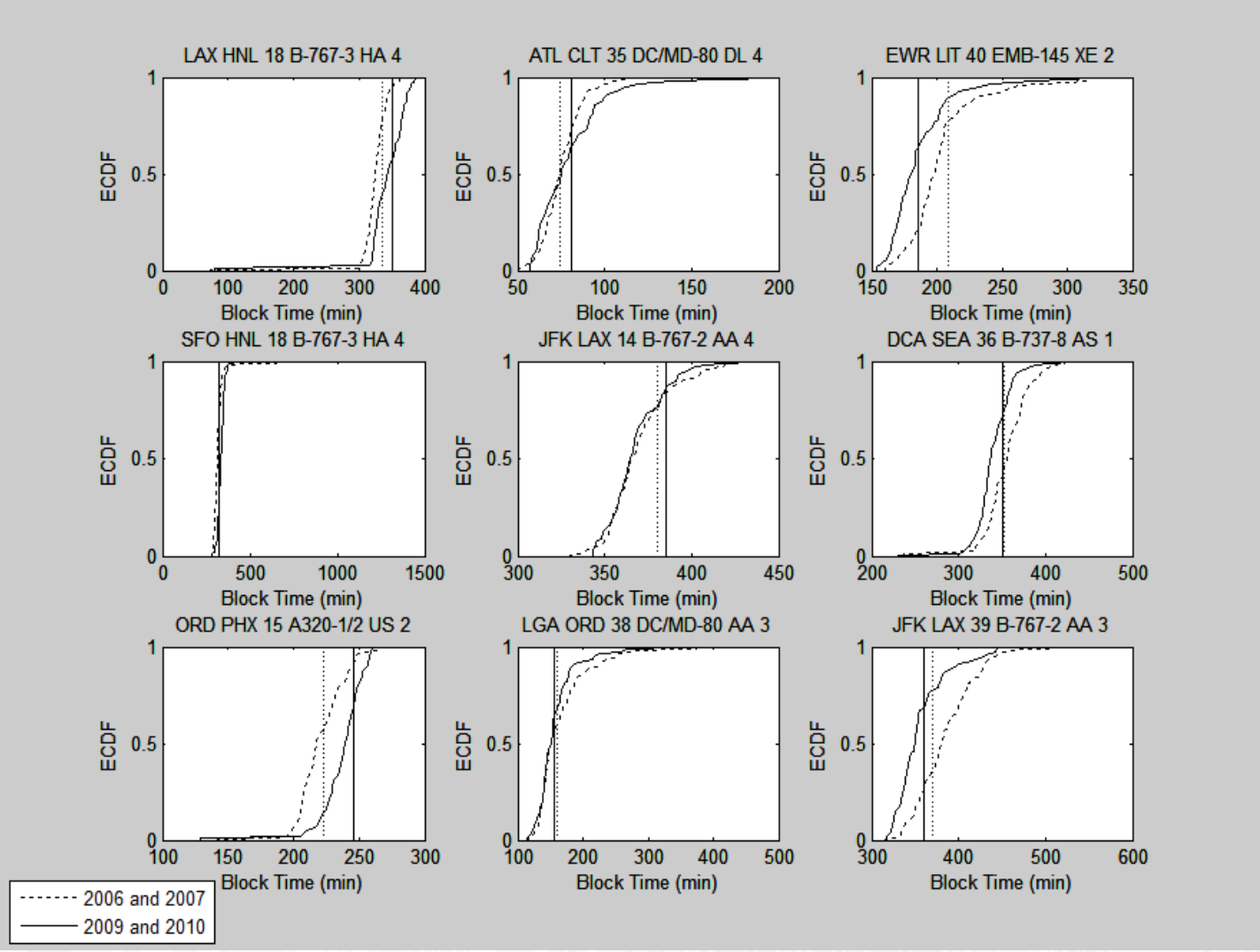
- Two groups of data: 2006&2007; 2009&2010
- Two variables we control: median block time; inner right tail (75th percentile – median)
- Three "scenarios" for each variable: increase, decrease, remain the same

		Median BT			
		Increase	Average	Decrease	Total
Inner Right Tail of BT	Increase	226 (0.027)	598 (0.072)	142 (0.017)	966 (0.116)
	Average	657 (0.079	5125 (0.614)	733 (0.088	6515 (0.781)
	Decrease	88 (0.011)	521 (0.062)	263 (0.031)	872 (0.104)
	Total	971 (0.117)	6244 (0.748)	1138 (0.136)	8353 (1.00)

The Outcome

- Performance in the year after: 2008; 2011
  - Change in SBT
  - On-time performance: A0, A14
  - Block time deviation from schedule: positive, negative
- How changes in SBT affect schedule adherence metrics
  - Hypothetical scenario for 2011
  - SBT stays the same as in 2008

Results: Representative Flight for Each Scenario



Results: Change in SBT

		SBT (min)	Change
Scenario	Scenario Description	mean	s.t.d
1	Med +, IRTail +	5.834	6.323
2	Med same, IRTail +	1.273	6.429
3	Med –, IRTail +	-4.109	7.968
4	Med +, IRTail same	3.638	6.513
5	Med same, IRTail same	-0.348	5.113
6	Med –, IRTail same	-4.909	6.637
7	Med +, IRTail –	2.267	7.995
8	Med same, IRTail –	-2.050	6.733
9	Med –, IRTail –	-7.348	8.024

- Greatest change of SBT happens when both measures change in the same direction: 1&9

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- Inner right tail: around 3.3 minute difference when median changes in the same direction

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- Median: 9 minutes

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- Inner right tail: around 3.3 minute difference when median changes in the same direction
- Median: 9 minutes

Results: Change in Schedule Adherence Metrics

		SBT (min)		A0			A14		
Scenario	Scenario Description	2008	2011	2008	2011	2011’	2008	2011	2011’
1	Med +, IRTail +	150.6	156.4	0.53	0.68	0.56	0.76	0.84	0.80
9	Med –, IRTail –	184.3	177.0	0.49	0.51	0.62	0.67	0.71	0.76
		SBT (min)	Change	ND (min)			PD (min)		
Scenario	Scenario Description	mean	s.t.d	2008	2011	2011’	2008	2011	2011’
1	Med +, IRTail +	5.8	6.3	4.9	8.9	5.4	6.4	3.6	5.9
9	Med –, IRTail –	-7.3	8.0	9.4	7.6	13.2	5.8	5.0	3.3

Results: Change in Schedule Adherence Metrics

- Overall improvement from 2008 to 2011: resulted from combined effect of SBT change and operational performance change

- Isolating the effect of SBT (2011'): sizable impact
  - 1: improvement is due to 6 minute increase in SBT
  - 9: no substantial improvement because the reduction in SBT
  - Comparing magnitude: the impact of changes in SBT is at same level as the underlying operational performance changes

Conclusion

- SBT setting behavior
  - Segmenting the distribution is crucial in understanding how block time reliability affects SBT
  - Left and inner right tail has larger impacts on SBT setting
  - The far right tail of the distribution has small impacts
- Impact analysis
  - Significant adjustments in SBTs happen when there are changes in block time distribution
  - SBT has impacts on schedule adherence other than underlying operational performance
- Average block time is not enough information to understand the impacts on SBT, on-time performance, or deviation from schedule

Thank you!