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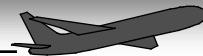## Airport Capacity, Airport Delay, and Airline Service Supply: The Case of DFW
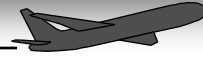
Faculty and Staff: D. Gillen, M. Hansen, A. Kanafani, J. Tsao

Visiting Scholar: G. Nero and

Students: S. A. Huang and W. Wei

Institute of Transportation Studies

University of California at Berkeley

1

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Presentation Outline

✈ **Background Study/Motivation**

✈ **Delay Changes**

✈ **Airline Adaptations to New Capacity**

✈ **Conclusions & Future Work**

2

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Background

✈ **10/96 Changes at DFW**
  - New runway (October 1)
  - Airspace redesign (October 10)

✈ **Expected Capacity Impacts**
  - VFR: from 102 to 146 operations/hr
  - IFR: from 66 to 108 operations/hr

✈ **Expected Benefit**
  - "75% increase in regional capacity; 15-25% nationwide"

✈ **Research Questions**
  - How did delay change?
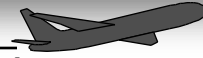 - How did airlines adapt?

3

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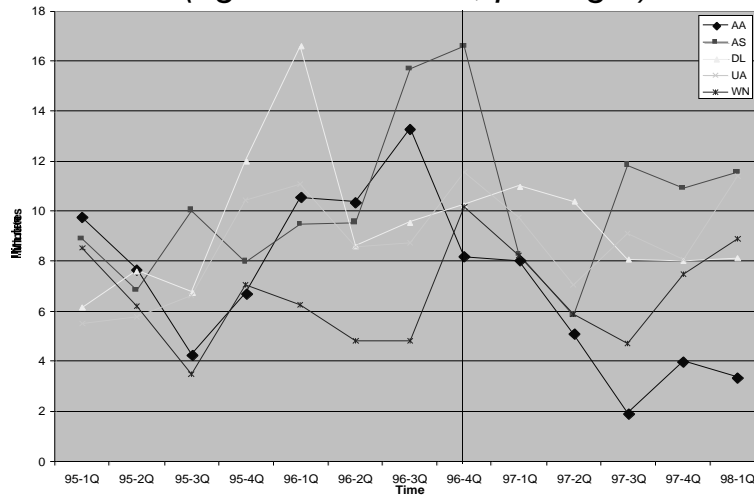## *Airport Average Arrival Delay*
(against schedule, per flight)
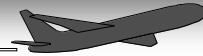
Average Flight Delay
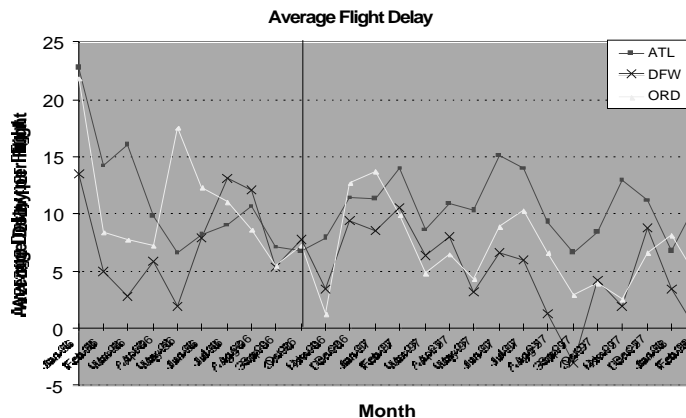
4

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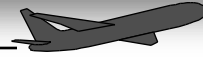## Airline System Arrival Delay
(against schedule, per flight)

5

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Schedule Padding

✈ **Compare AA scheduled flight (gate to gate) time between DFW and 20 largest airports in January 96 and January 98**

✈ **Find AA scheduled flight times increased by 4 minutes**

- On - time performance initiative
- Accounts for DFW and AA delay changes

6

3

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Effective Flight Time

✈ Effective Flight Time (EFT) is the time between <u>scheduled departure</u> and <u>actual arrival</u> of a flight.

✈ EFT is unaffected by changes in scheduled flight time.

✈ EFT can be decomposed into departure delay, taxi time, and airborne time.
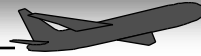
7

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Aggregation to Daily Level

✈ **Daily Average Flight Time (DAFT) is the mean daily EFT of all arrivals from a particular origin.**

✈ **Daily Flight Time Index (DFTI) is a weighted average of the DAFT for a fixed "market basket" of origins.**

✈ **Like EFT, DAFT and DFTI can be decomposed into departure delay, taxi time, and airborne time.**
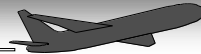
8

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DFTI Before and After Capacity Expansion
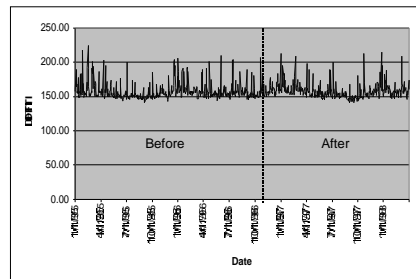
- ✈ **No obvious impact for good days.**
- ✈ **Some indication of decrease in bad days.**
- ✈ **Some very bad days both before and after.**

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Daily Level DFTI Model

- ✈ Statistical model estimated on daily observations of DFTI at DFW and explanatory variables.
- ✈ Explanatory variables include:
  - • **Demand**
  - • **Weather**
  - • **Delay at Origin Airports**
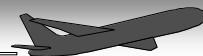 - • **Expansion**

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Metrics for Explanatory Variables

| Explanator	Metric
Demand	Hypothetical deterministic delay based on scheduled arrival times and nominal capacity.
Weather	Four weather factors resulting from performing factor analysis on 15 weather variables. Factors correspond to temperature, wind, precipitation, and visibility.
Origin airport delay	Average departure delay for flights not going to DFW region from origin airports included in "market basket."
Capacity Expansion	"Dummy" variable =0 prior to 10/1/96 and 1 after 10/31/96.

11

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Predicted vs Actual DFTI
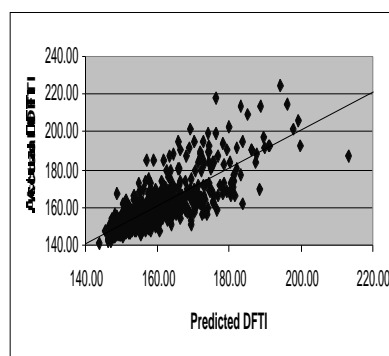
✈ **Model accounts for most variation in DFTI.**

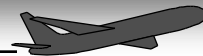✈ **Pronounced heteroskedasticity poses estimation problems.**
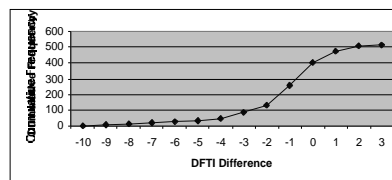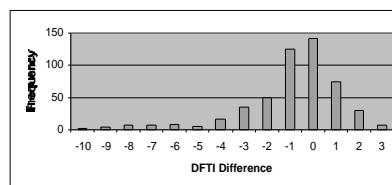
12

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Effect of Capacity Expansion on DFTI

✈ Strong interaction with visibility factor.

✈ After expansion, impact of low visibility on DFTI is essentially eliminated.

✈ No other significant effects.

13

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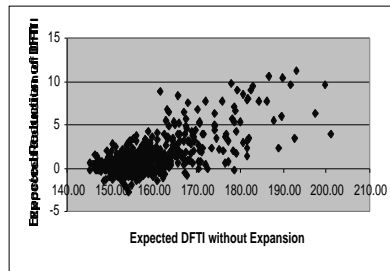## *Day-to-Day Variation in Impact*

✈ **Less than 1 minute reduction on 60 percent of days.**

✈ **Greater than 4 minute reduction on 10 percent of days.**

✈ **Largest reductions of 10 minutes.**

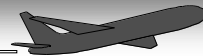✈ **Slight increase on about 25 percent of days.**
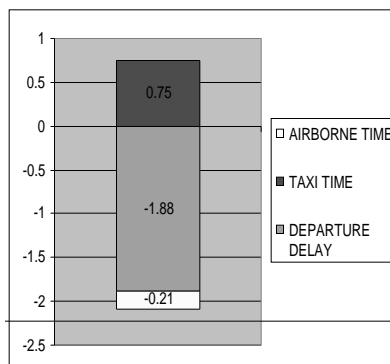
14

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DFTI Impact vs DFTI Value

- ✈ Greatest estimated reductions on days with greatest estimated delays.
- ✈ Implies increase in reliability.
- ✈ May also have masked benefit since "bad" days are still "bad."

15

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Effect of Capacity Expansion on DFTI Components

- ✈ **Sizable reduction in departure delay due to reduced ground holding.**
- ✈ **Increase in taxi time due to distance of runway from terminal.**
- ✈ **Small reduction in airborne time.**

16

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Sources and Components of DFTI Change from Before to After Expansion

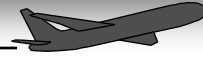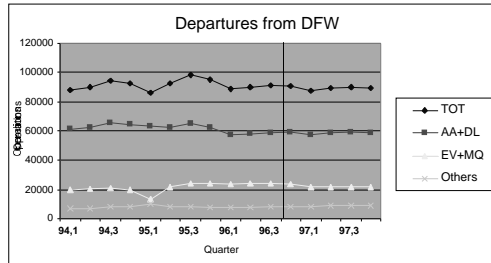| Source	Departure Delay	Taxi Time	Airborne Time	TOTAL CONTRIBUTION
Demand	0.0771	0.3679	3.4032	3.8482
Origin Airport Delay	0.0317	0.0043	-0.1437	-0.1077
Total Weather	0.1672	-0.1188	-0.2805	-0.2321
Origin Airport Delay-Weather Interactions	0.2028	0.0827	0.0341	0.3196
Capacity Expansion	-1.8810	0.7549	-0.2091	-1.3353
TOTAL CHANGE	-1.4022	1.0910	2.8040	2.4927

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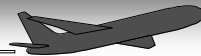
Airline Adaptation Metrics

✈ Number of Operations

✈ Peaking

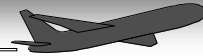✈ Concentration

✈ Scheduled Layover Times
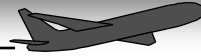
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Airline Departures from DFW

Departures from DFW

[Chart showing Operations (y-axis: 0 to 120000) vs Quarter (x-axis: 94,1 to 97,3) with series: TOT, AA+DL, EV+MQ, Others]

✈ **No significant increase after expansion.**

✈ **Remains 10 percent below pre-expansion highs.**

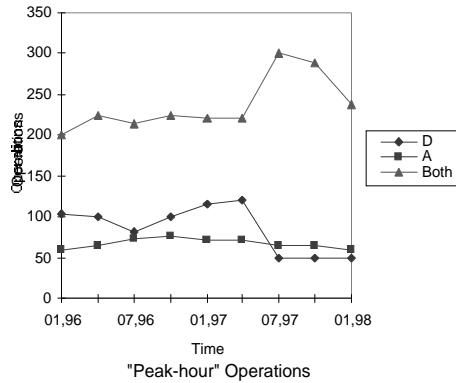✈ **No change in AA/DL dominance.**

19

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Schedule Peaking

✈ **Find shortest time interval in which given number of operations are scheduled (50 operations in this case).**

✈ **Convert to equivalent operations per hour.**
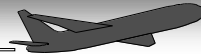
✈ **Performed for arrivals, departures and both.**

20

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Schedule Peaking Results (AA Only)

"Peak-hour" Operations
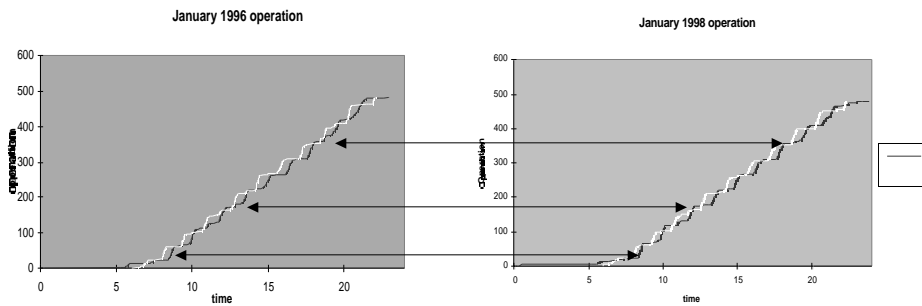
✈ Arrival peaking stable.

✈ Departure peaking decreases.

✈ Combined peaking increases.

✈ Reduced gap between departure and subsequent arrival banks.

21
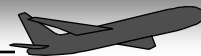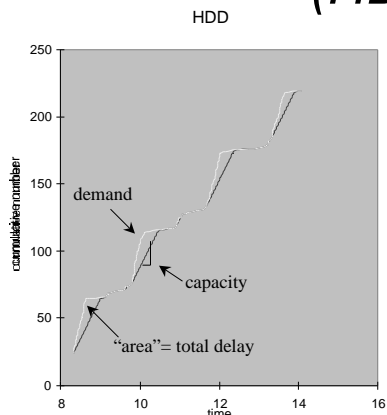
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AA Cumulative Arrival and Departures--Jan' 96 and Jan' 98

January 1996 operation
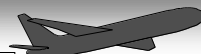
January 1998 operation

22

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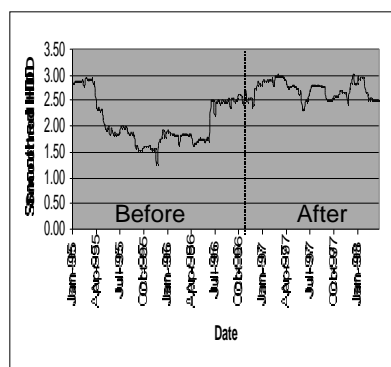## Hypothetical Deterministic Delay (HDD)

HDD

- ✈ Combined measure of banking intensity and duration
- ✈ Based on *hypothetical* delay as a function of
  - flight schedule
  - assumed capacity level (90 operations per hour in this case)
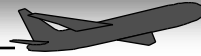- ✈ Delay calculated from input-output diagram

23

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Trends in HDD

- ✈ **Sharp jump in summer 1996.**
- ✈ **Further increase after expansion.**
- ✈ **Impact of expansion is uncertain**
  - Large values in early 1995.
  - Fluctuations after expansion.
 - Role of confounding factors (pilots union).

24

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Total Impact of Expansion on Fight Time

Assumed Impact on Demand	Direct DFTI Impact	Indirect DFTI Impact	Total Impact
None	-1.39	0	-1.39
Comparison with July-Sep,1996	-1.39	0.51	-0.88
Comparison with April-June,1996	-1.39	1.78	0.39

✈ **Direct delay reduction offset by "Induced" change in demand (HDD).**

✈ **Degree of induced change uncertain.**

✈ **Under most plausible assumption, airlines "traded in" about 40 percent of direct reduction for schedule modifications.**

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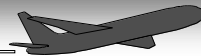
Conclusion

✈ **Expansion reduced delay, all else equal, about 1.3 min/flight.**

✈ **Most reduction on bad weather days.**

✈ **Some (~40 percent) of delay reduction apparently traded for schedule changes.**

✈ **Adaptations may have increased or decreased benefit.**