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Impact des contraintes de capacité sur les horraires des compagnies aériennes

Mark Hansen, Mike Ball,
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Impact of Airport Capacity Constraints on Airline Schedules

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Background/Motivation

- FAA must perform investment analyses for major projects
- Analyses often require valuations of increased capacity
- Valuation traditionally based on delay reduction

"20 minute Rule"

- Large increases in traffic without commensurate increases in capacity result in huge delays
- FAA assumes that airlines would not allow these large delays to occur by
  - Reducing operations
  - Up-gauging
  - Rescheduling flights
- Average delays per operation are therefore truncated at 20 minutes for purposes of investment analysis

From "FAA Airport Benefit-Cost Analysis Guidance"

Airports experiencing severe delay due to congestion will not be able to accommodate rising demand for air service. Average delay per operation of 10 minutes or more may be considered severe. At 20 minutes average delay (approximately the highest recorded average delay per operation known to FAA at an airport in the U.S.), growth in operations at the airport will largely cease. Prior to reaching these levels, airlines would begin to use larger aircraft, adjust schedules, and cancel or consolidate flights during peak delay periods. Passengers would make use of alternative airports, seek other means of transportation (e.g., automobile or train), or simply avoid making some trips.[5]

"Thus, it would be unrealistic to conclude that an investment alternative would save more than 20-minutes of delay per operation relative to the base case."

Research Questions

- Do capacity constraints affect airline schedules?
- How should this effect be taken into account in investment analysis?

Forms of Adjustment

- Capacity reduction
  - Considered in NEXTGEN CBA's
  - Monetized using consumer surplus
- Up-gauging
  - Little evidence that this occurs
  - LGA average gauge appears lower than that in comparable non-LGA segments
- Schedule de-peaking (our focus)

Schedule De-peaking

- Well-known phenomenon
- Post-9/11 cost control strategy for legacy airlines at their hubs
- Less understood
  - De-peaking as a response to capacity constraints
  - Macro as opposed to micro de-peaking

Hypotheses

- Airport capacity constraints cause schedule de-peaking at macro level
- The higher the capacity utilization, the more de-peaked the schedule (all else equal)

Schedule Peaking Metric

- Measures unevenness of flight schedule throughout the day
- Coefficient of variation of number of flights scheduled in quarter hour

Schedule Peaking Metric

Define:

N(t)--Number of arrivals/departures/operations scheduled in quarter hour t at an airport on an "average day"

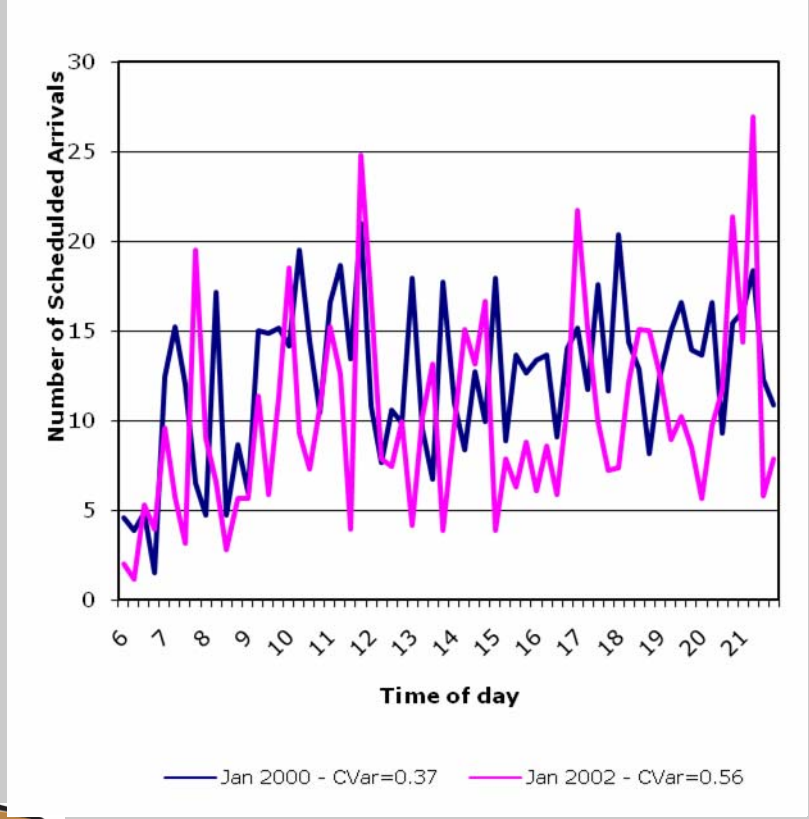
μ_N—The average of N(t) over the operating day

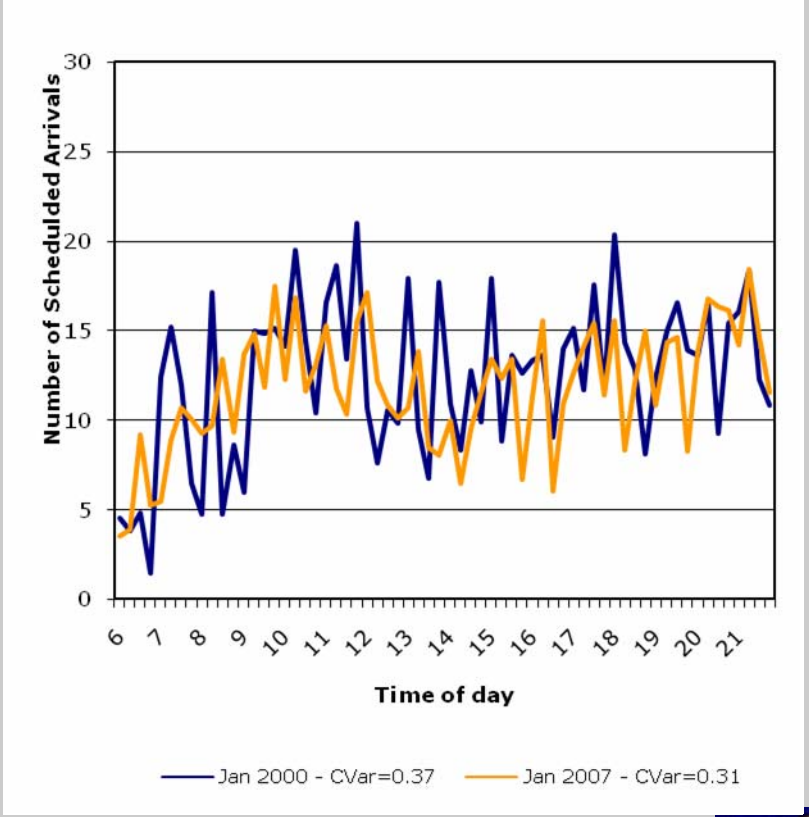
σ_N—The standard deviation of N(t) over the operating day

Proposed peaking metric is coefficient of variation for N:

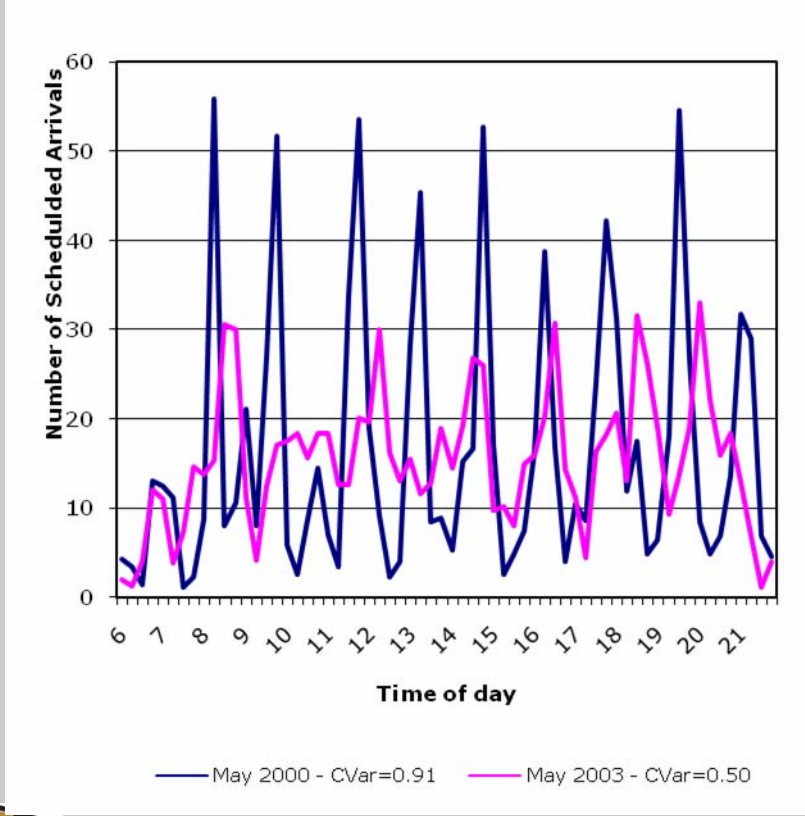
$$CV_N = \frac{\sigma_N}{\mu_N}$$

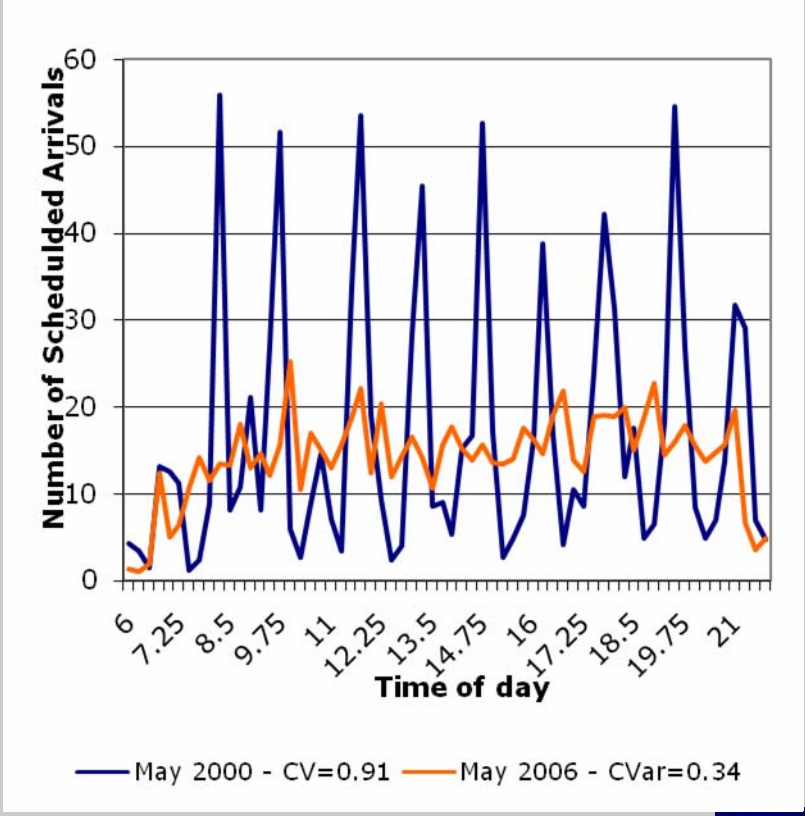
Examples: ATL Arrivals



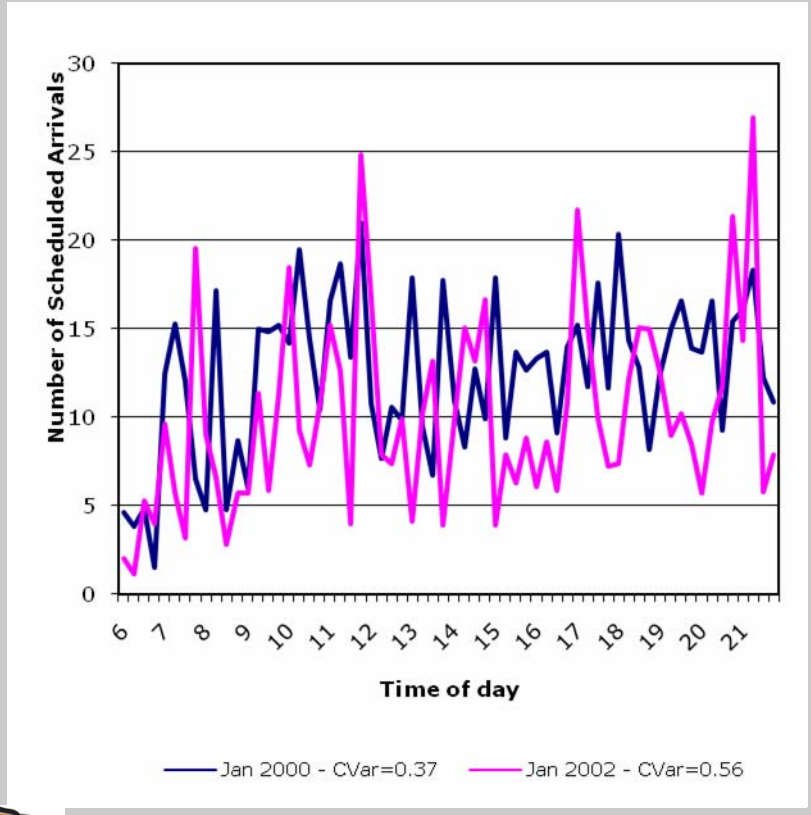


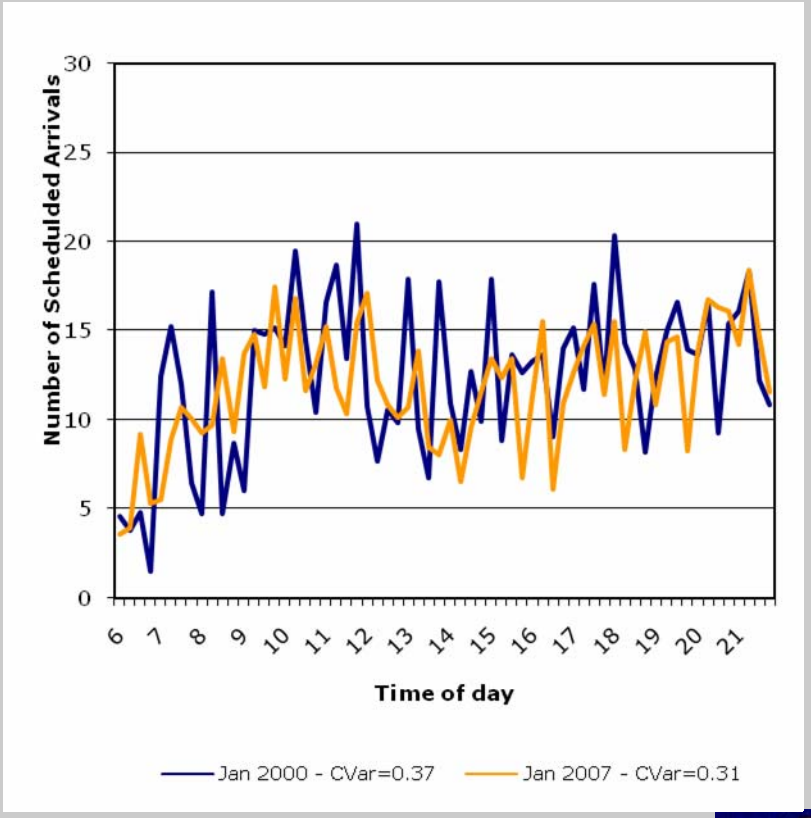
Examples: DFW Arrivals



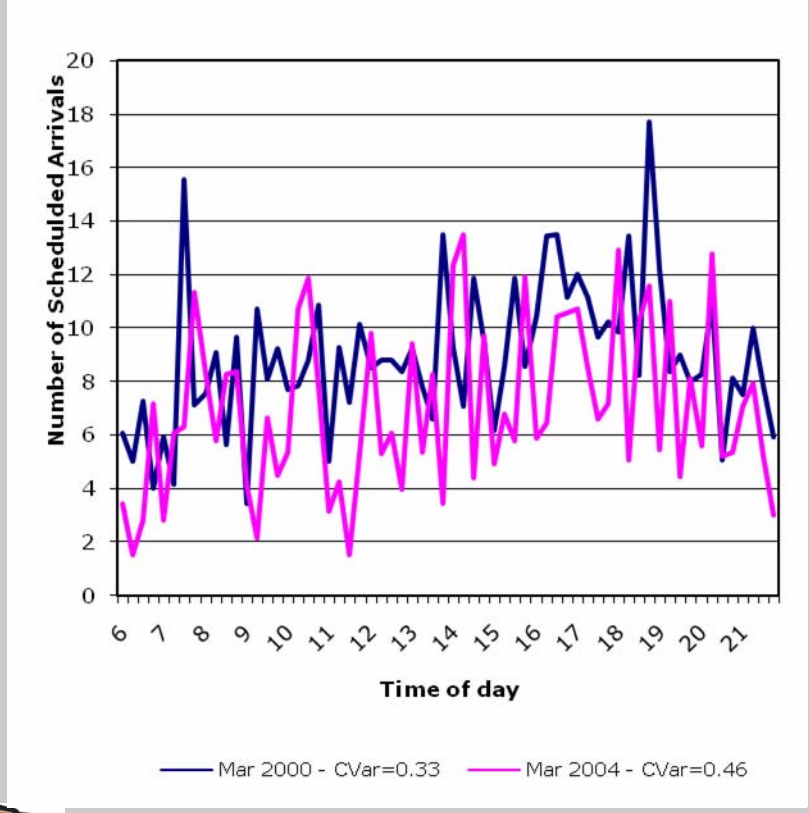


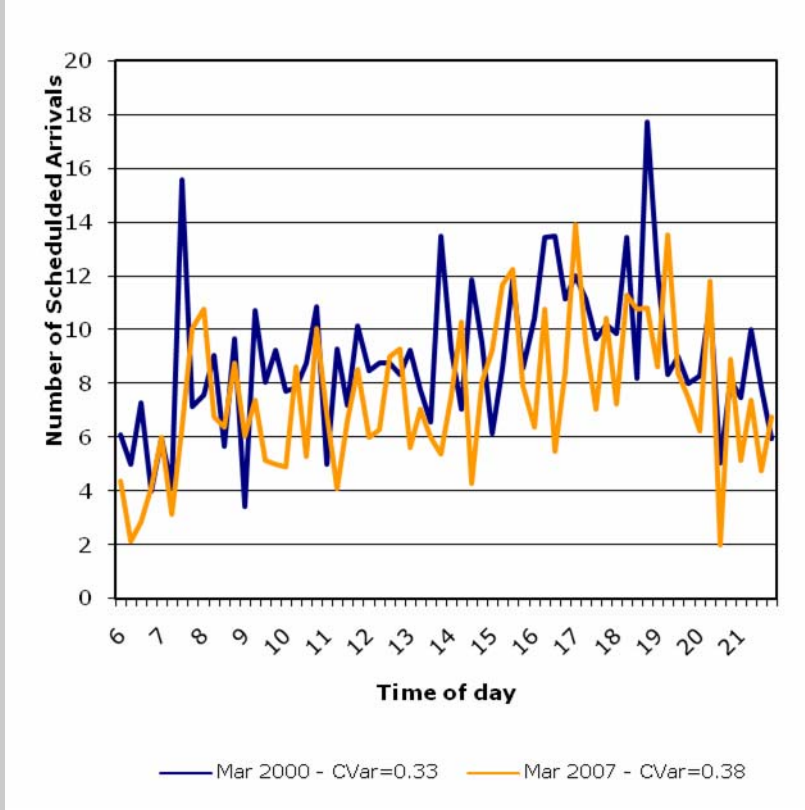
Examples: LAX Arrivals





Examples: BOS Arrivals





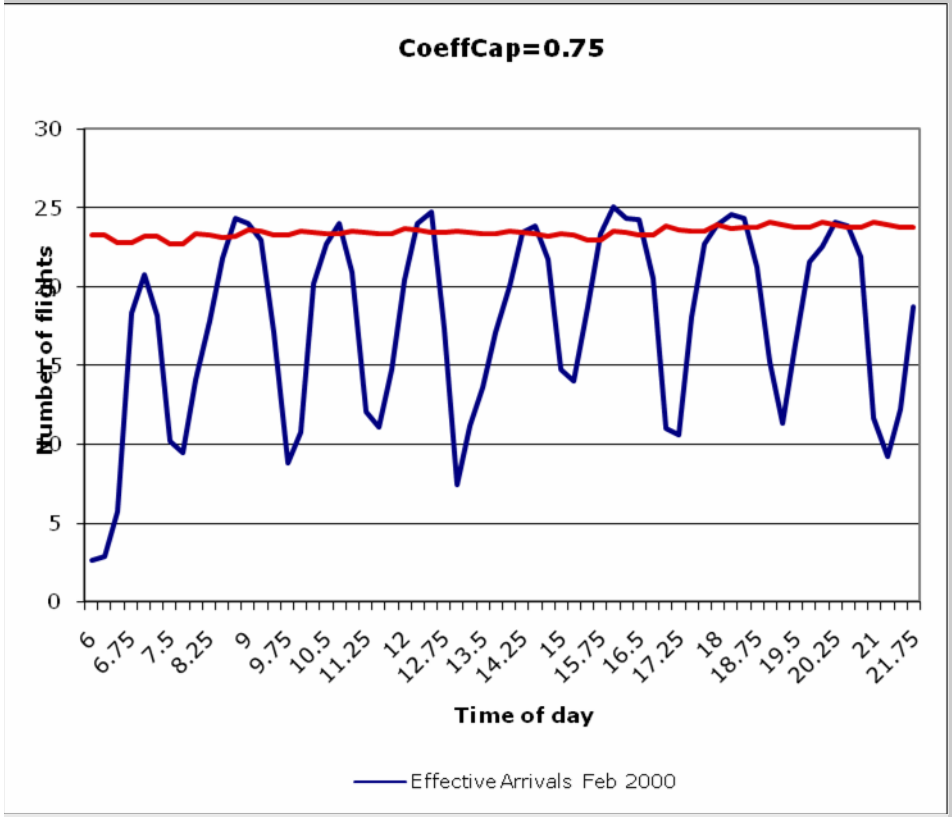
Capacity Utilization Metric

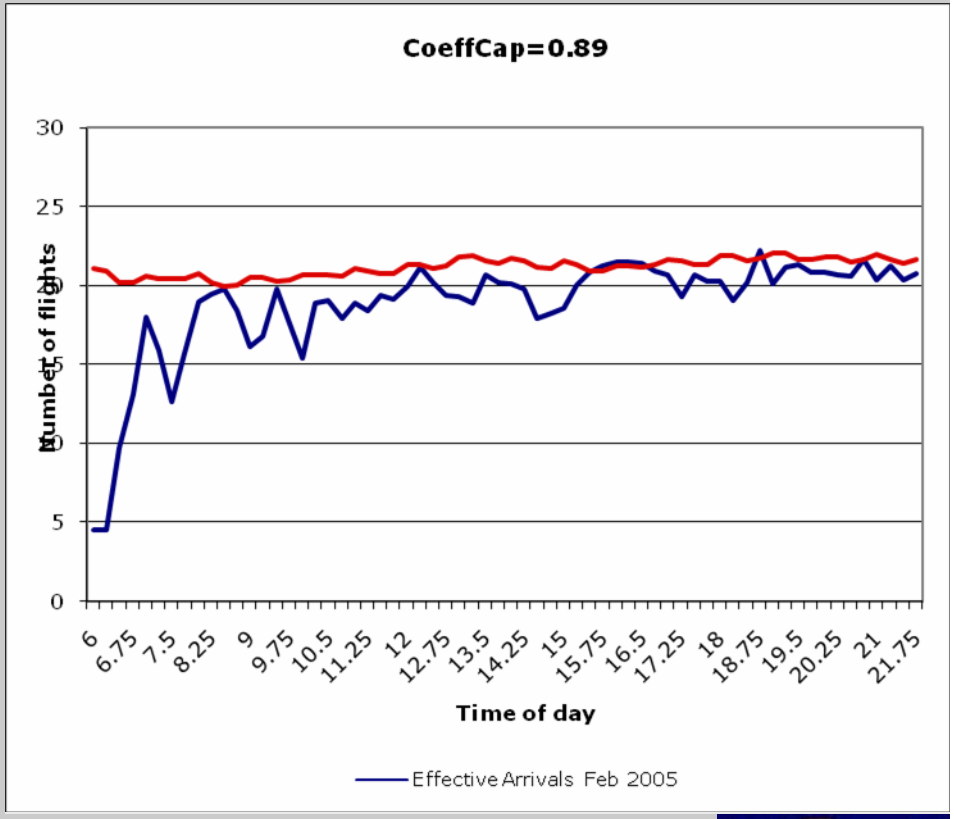
Define:
Q(t)--Number of arrivals/departures/operations that occur in quarter hour t at an airport on an "average day"
C(t)—The arrival/departure/operations capacity at time t for an airport on an "average day"

Proposed capacity utilization metric is capacity utilization ratio:

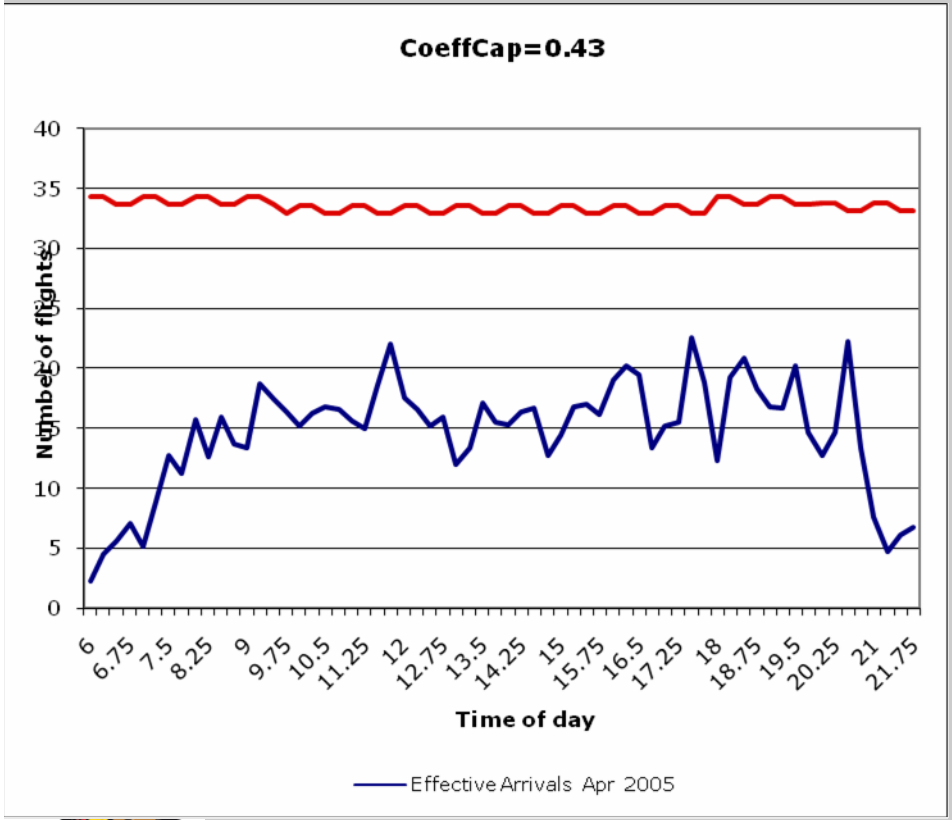
$$CUR = \frac{\sum_t Q_t}{\sum_t C_t}$$

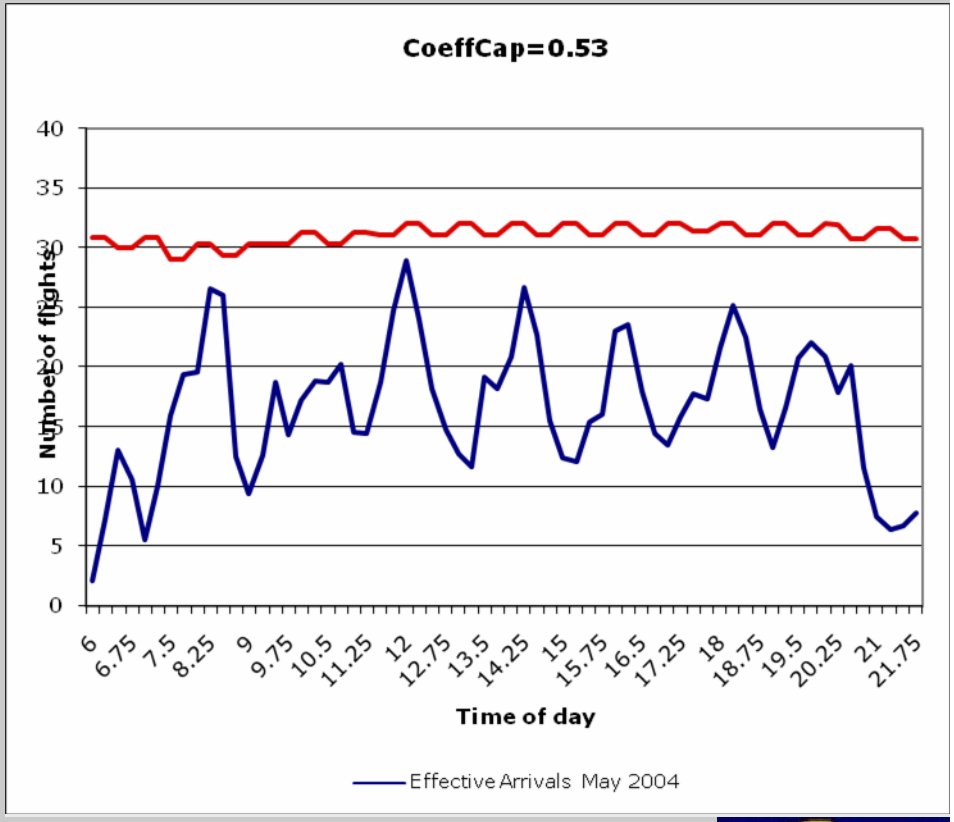
Examples: ATL



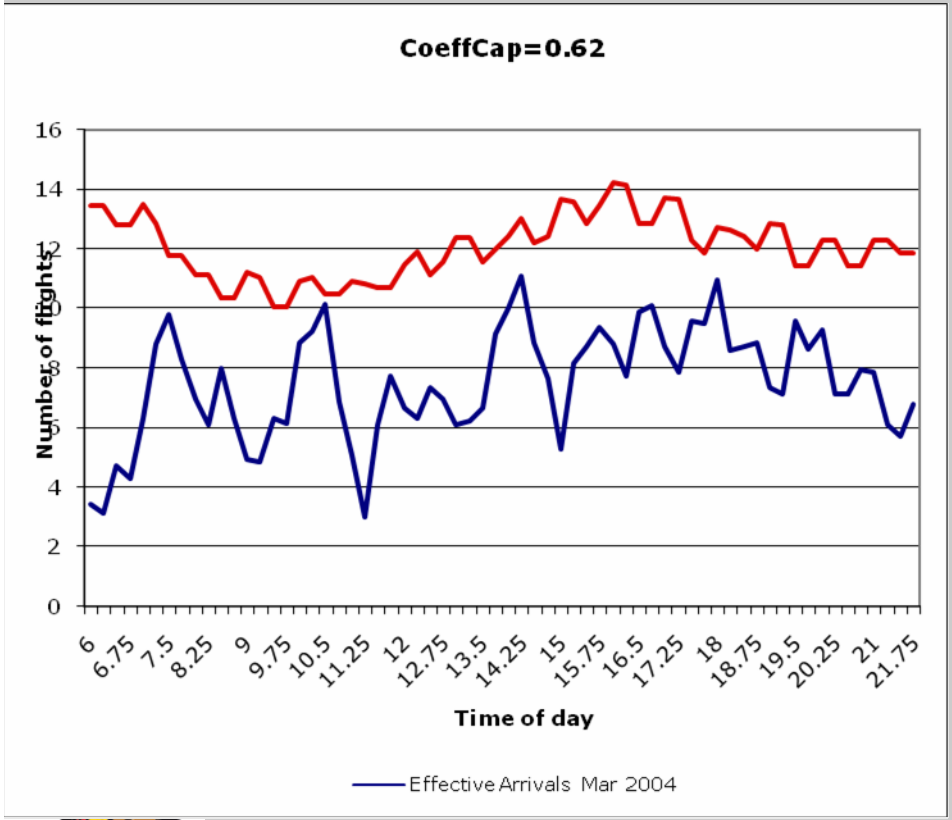


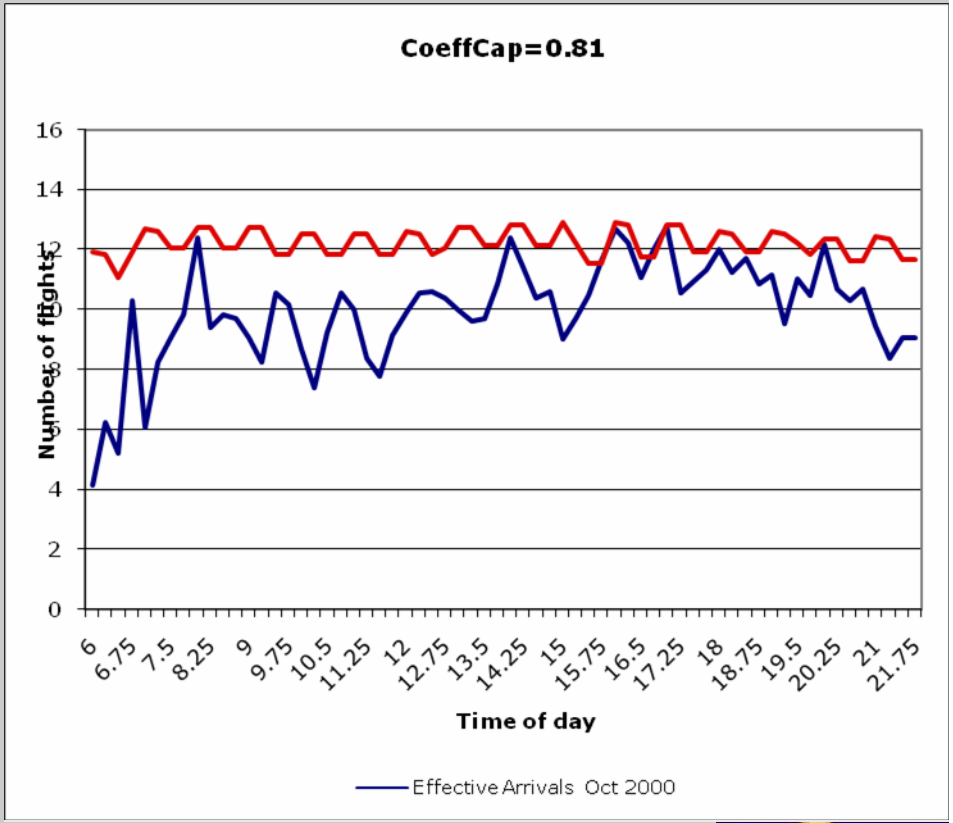
Examples: DFW





Examples: BOS





Relation between Peaking and Capacity Utilization

- Multivariate models
  - Monthly data for 14 airports from 2000 to 2007
  - Dependent variable: peaking metric
  - Independent variables
    - ✓ Capacity utilization metric
    - ✓ Airport concentration based on airline traffic shares
    - ✓ Time period and airport fixed effects
- Panel models and single airport models
- Arrival, departure, and total operations models

Estimation Results (Preliminary)

- Support hypothesis that increased capacity utilization results in reduced peaking
- Effect is highly statistically significant in pooled model
- Effect varies across airports and is significant in ½ of them

Summary of Capacity Utilization Regression Coefficients

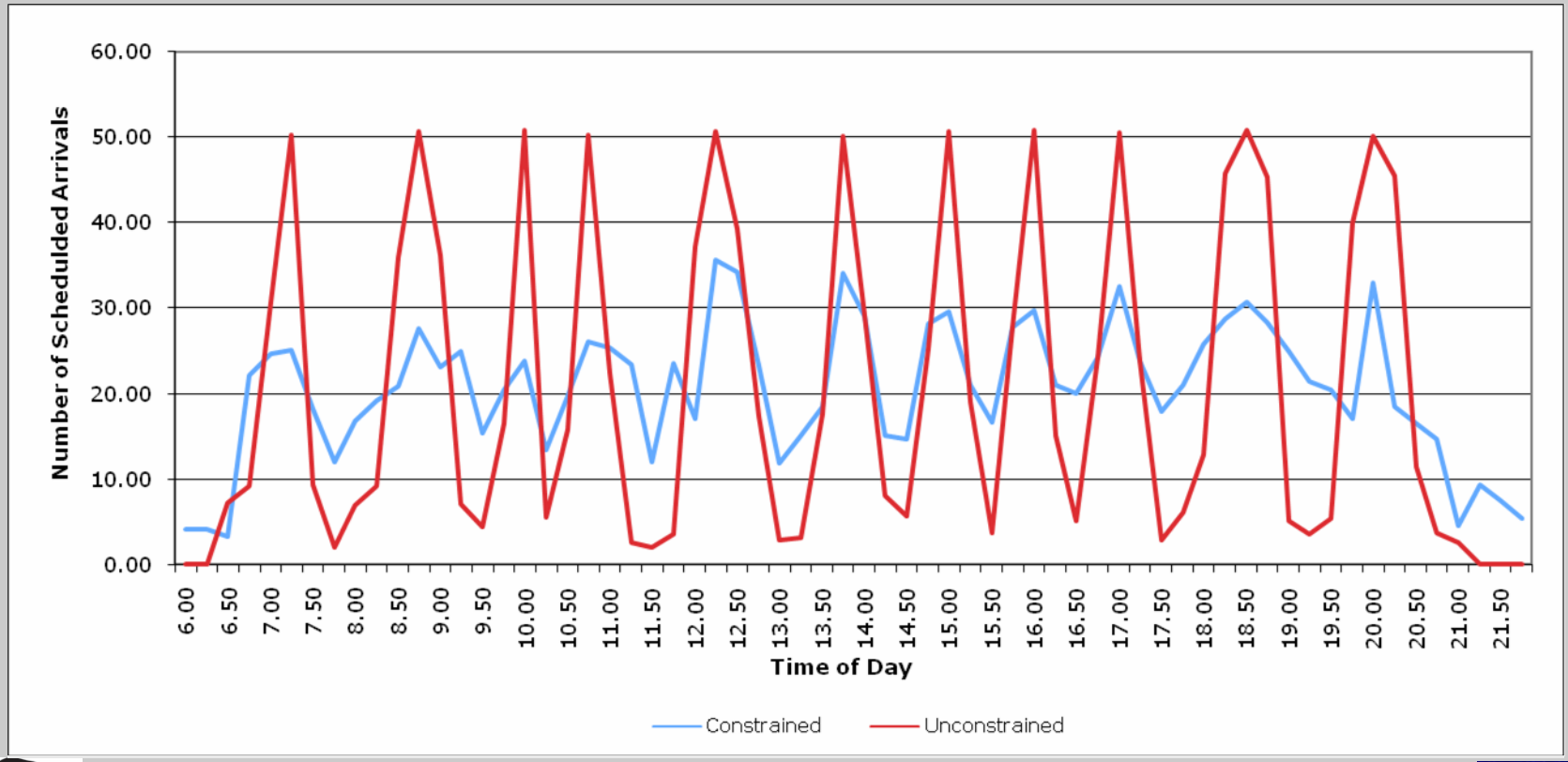
Airport	Arrivals	Departures
ATL	-0.0255	-0.0454
BOS	**-0.1615**	**-0.354**
DEN	-0.3947	-0.1631
DFW	-0.0306	0.3054
DTW	0.0851	-0.1099
EWR	**-0.3006**	**-0.3149**
IAH	**-0.3025**	**-0.2152**
JFK	**-0.1784**	**-0.3256**
LAX	**-0.1594**	**-0.2765**
ORD	**-0.5925**	**-0.5116**
PHL	**-0.4132**	**-0.6418**
PHX	0.0156	0.0011
SEA	-0.0346	-0.0829
SFO	-0.0815	-0.3532
Pooled	**-0.1174**	**-0.1439**

Bold values are significant at 0.05 level.

Capacity Unconstrained Schedule

- What the schedule “wants to be”
- Predict coefficient of variation if capacity were infinite (so capacity utilization is zero)
- Move flights in capacity constrained schedule so as to match target COV

Example, ORD in April 2004



COV=0.38 COV=0.91

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Next Steps

- Refine statistical models
- Formalize algorithm for constructing unconstrained schedule from constrained one
- Develop method to monetize difference between two schedules
- Consider gate constraints

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