MIT International Center for Air Transportation

FLIGHT TIME COMPONENTS AND THEIR DELAYS ON US DOMESTIC ROUTES

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Database

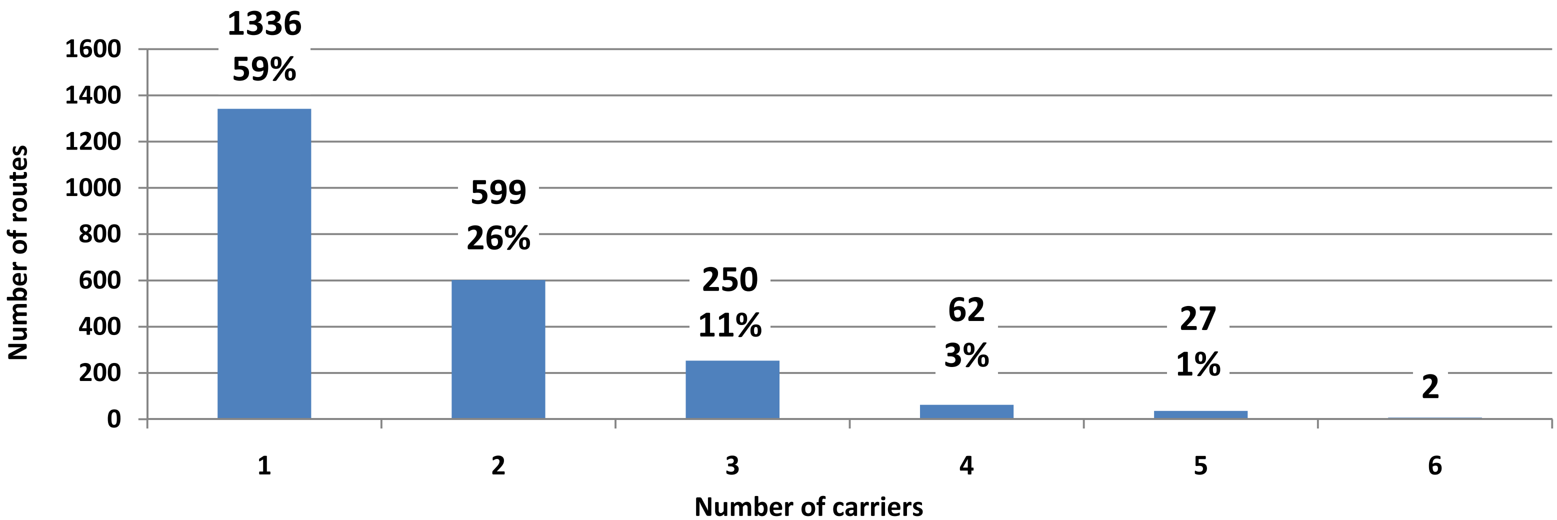
Database

- FAA Aviation System Performance Metrics
- detailed flight data for 77 Airports
- 80% of all scheduled domestic commercial flights in 2009
- 88% of all domestic enplanements (based on the T-100 Domestic Segment)

Final analyzed sample

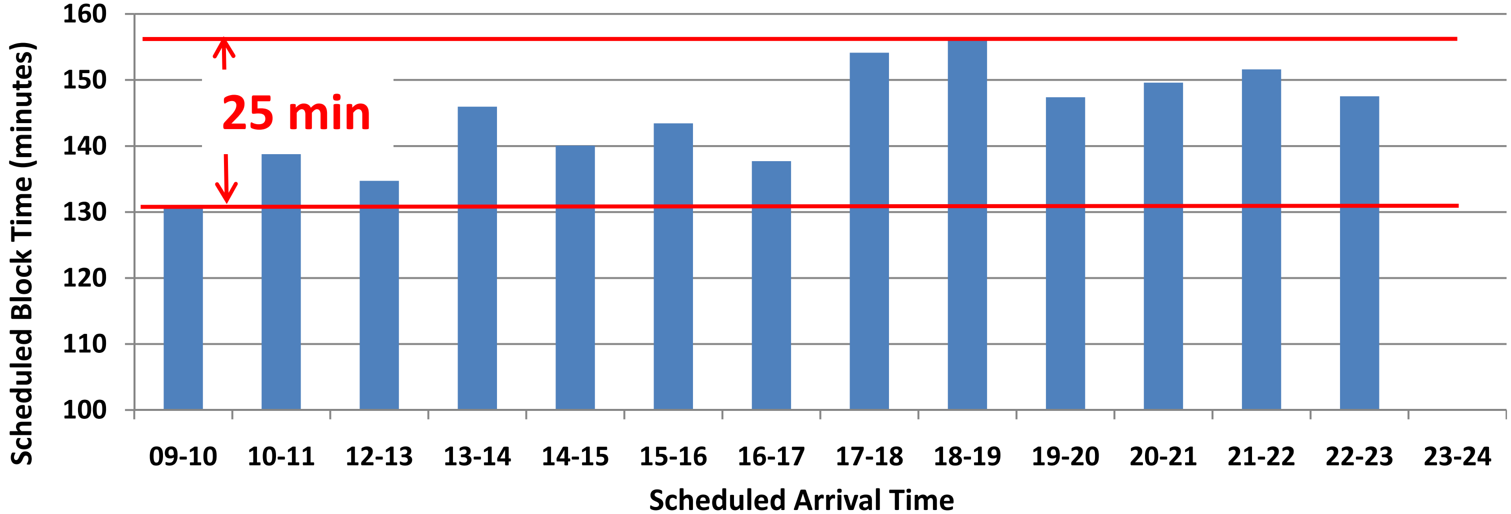
- 2276 directional non-stop routes between 72 ASPM Airports
- operated by 40 US carriers in daily basis
- 54% of the all scheduled domestic commercial flights in 2009.

Carrier-Routes in the Sample



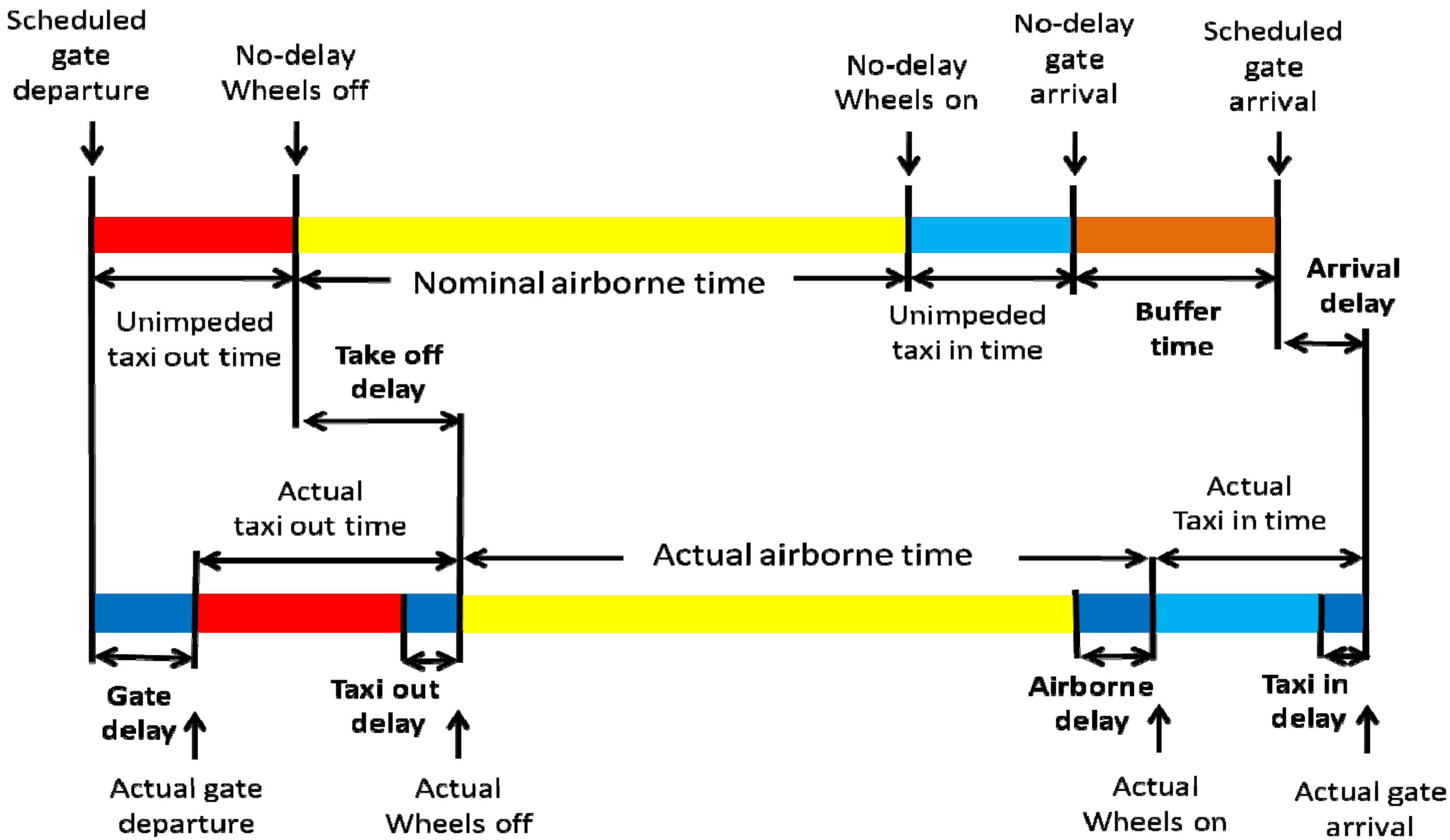
- 3679 distinct directional route-carrier pairs.
- 59% of the routes are served only by one carrier, and 26 % are served by two. In the remaining 15% operate more than 2 carriers.
- We expect that competition affects the schedule padding practices, because the presence of the carriers in the ticket distribution systems depends often on their scheduled block time.

Schedule Padding by Time of Day (ORD – JFK, 2009)



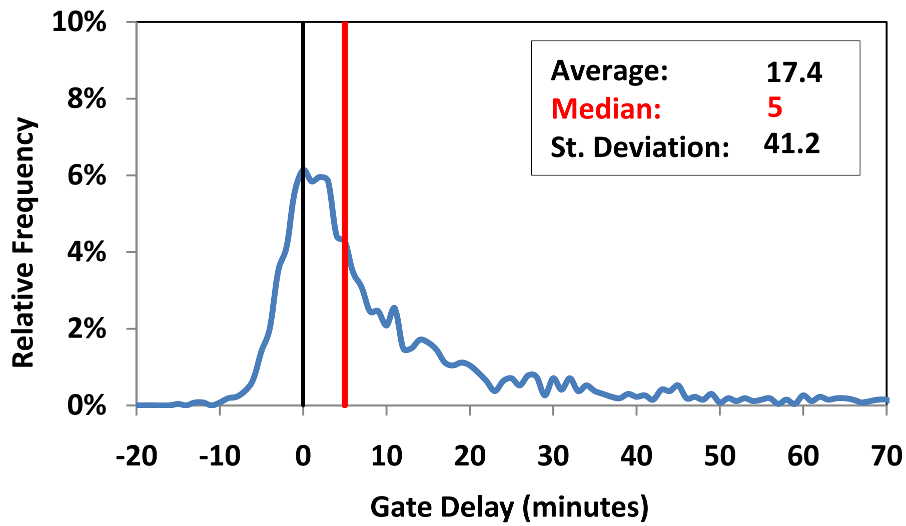
- Airlines lengthen the scheduled block times of their flights to improve
  - the reliability of their schedules
  - their "on-time arrival" statistics (a flight that arrives at the gate more than 15 minutes later than scheduled is considered delayed)
- The time that airlines add to their schedules is called BUFFER.
- BUFFER = Scheduled Arrival Time – Delay-Free Arrival Time.

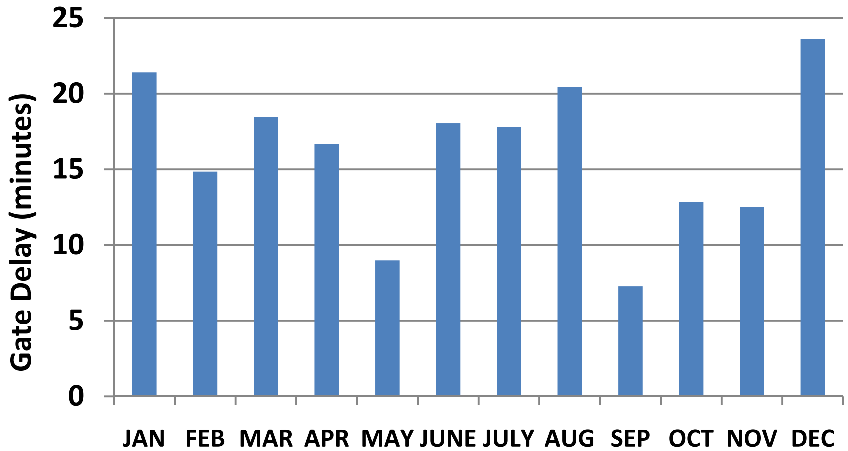
Understanding the Measurement of Delay



Variability in Gate Delays

Newark (EWR) – Los Angeles (LAX), 2009



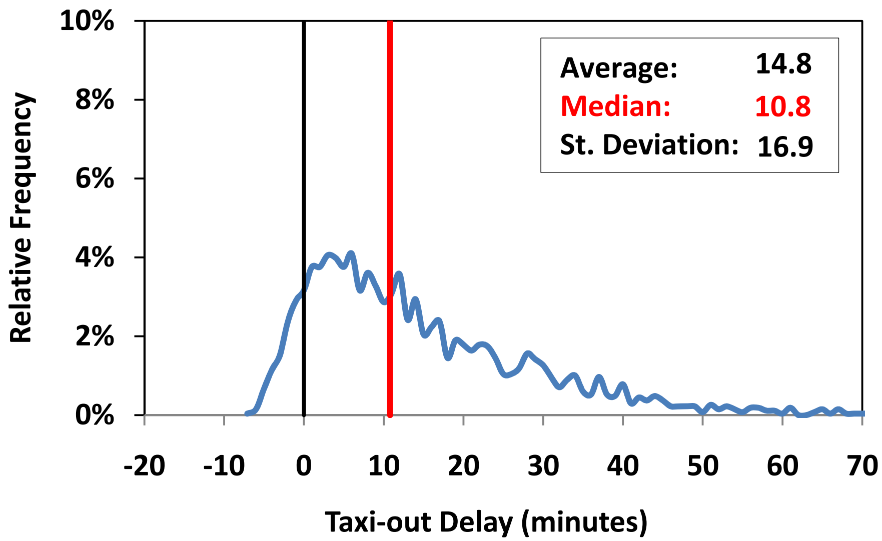


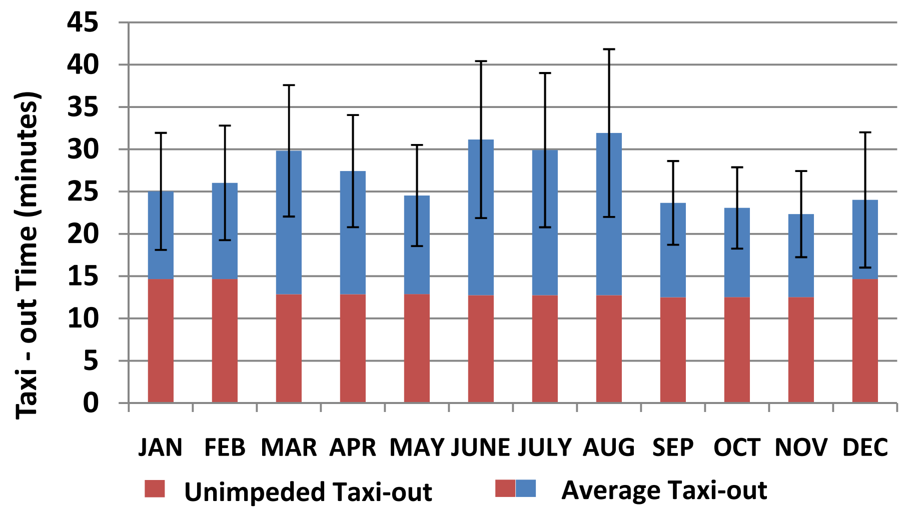
Gate Delay = Actual Gate Departure – Scheduled Gate Departure Time

Causes:
- Airport congestion at origin or destination (ceiling, visibility, winds)
- Airspace congestion
- Propagated delay (aircraft, crew)
- Airline operations (boarding, catering, fueling etc.)

Variability in Taxi-out Delays

Newark (EWR) – Los Angeles (LAX), 2009



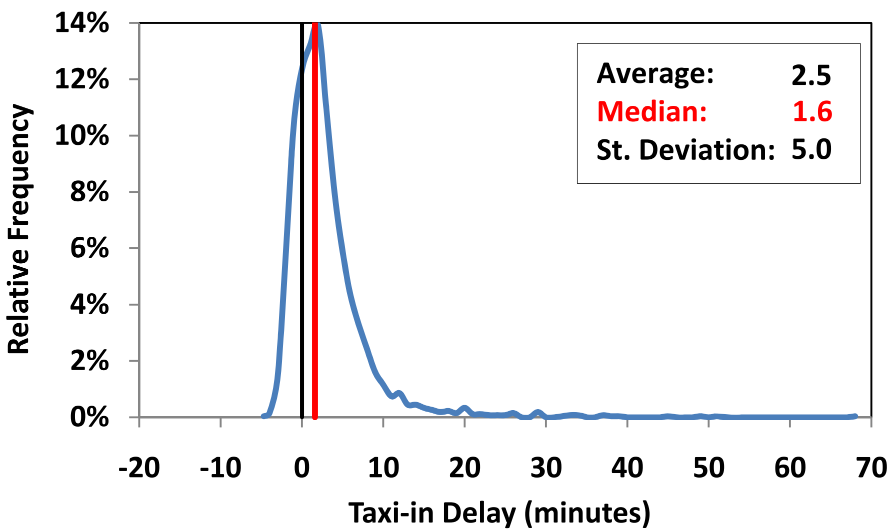


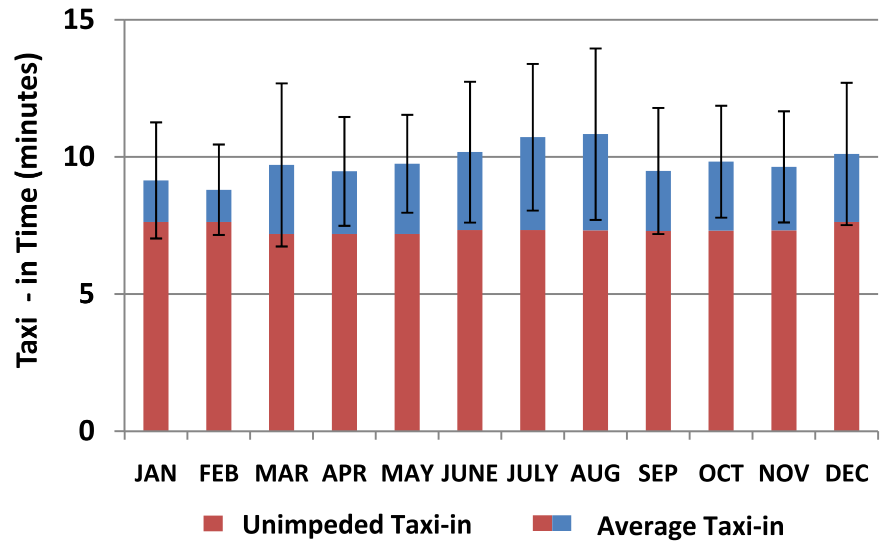
Taxi-out Delay = Actual Taxi-out Time – Unimpeded Taxi-out Time

Causes:
- Airport congestion at origin or destination (ceiling, visibility, winds)
- Airspace congestion
- Delays during pushback

Variability in Taxi-in Delays

Newark (EWR) – Los Angeles (LAX), 2009



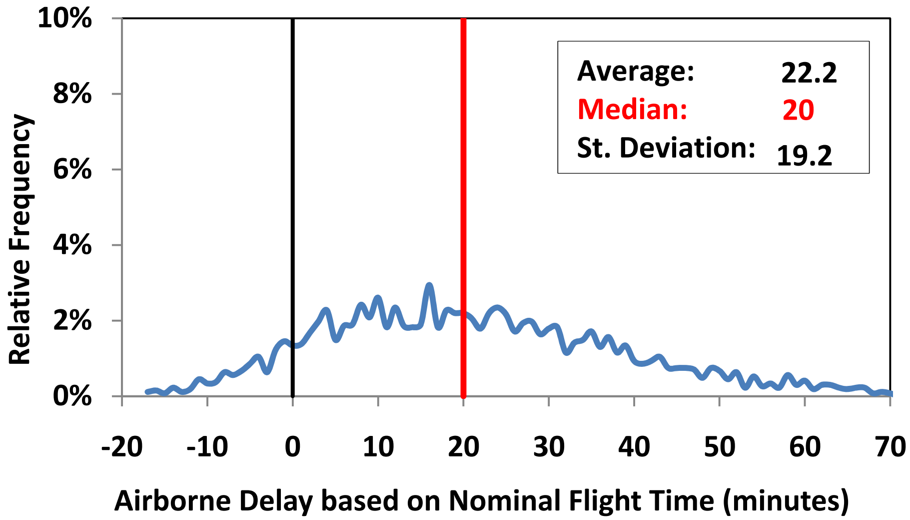


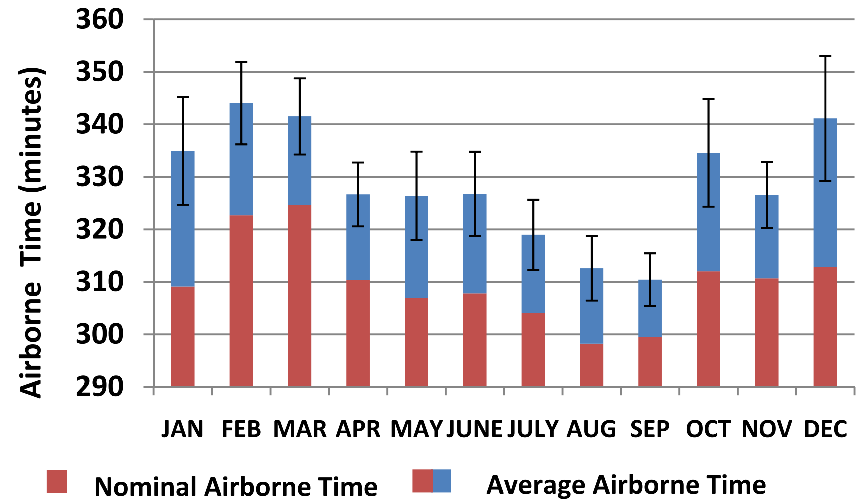
Taxi-in Delay = Actual Taxi-in Time – Unimpeded Taxi-in Time

Causes:
- Weather conditions at airport of destination, Runway configuration
- Gate unavailability

Variability in Airborne Delays

Newark (EWR) – Los Angeles (LAX), 2009





Airborne Delay = Actual Airborne Time – Nominal Airborne Time

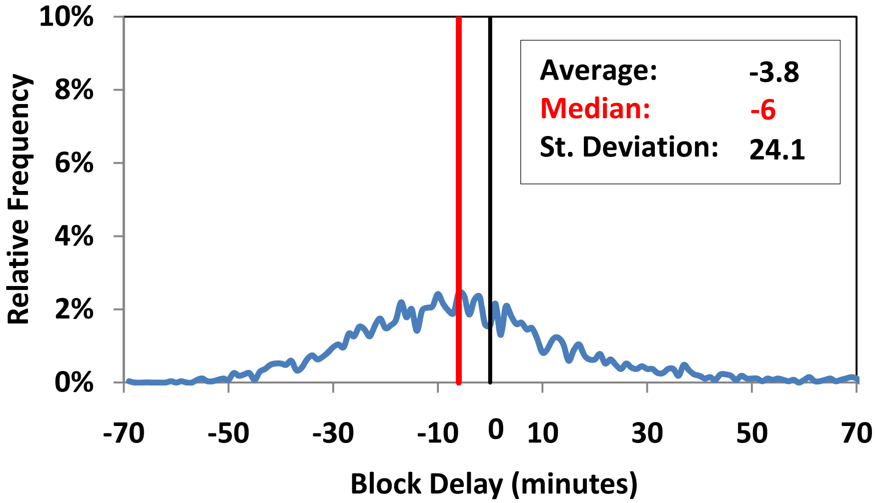
Actual Flight Time = Wheels On – Wheels Off

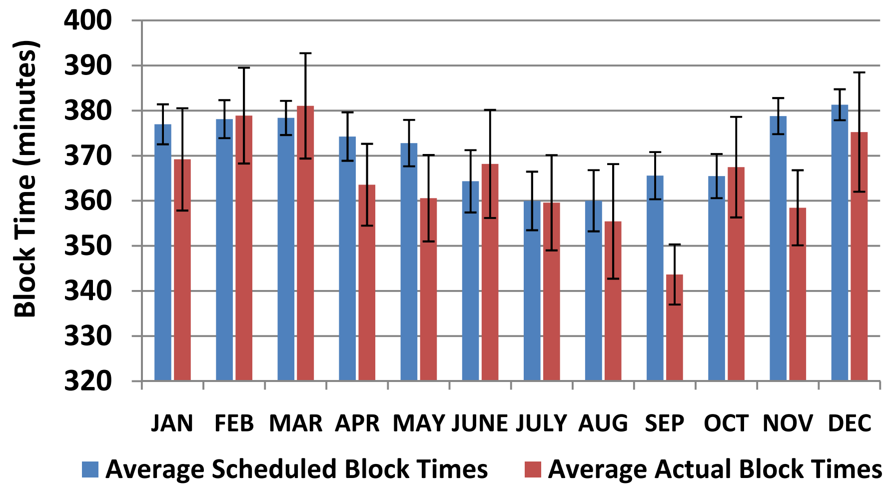
Nominal Airborne Time = 10th percentile of Actual Airborne Time Distribution

Causes:
- Airspace congestion
- Winds (strength and direction)

Variability in Block Delays

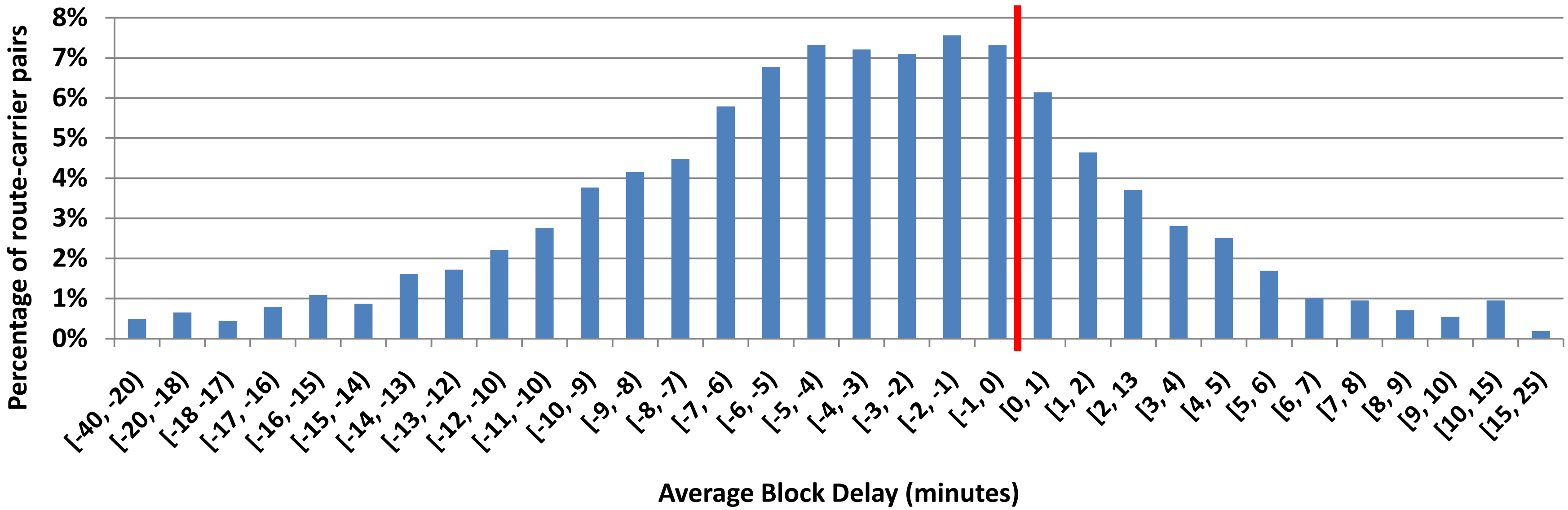
Newark (EWR) – Los Angeles (LAX), 2009





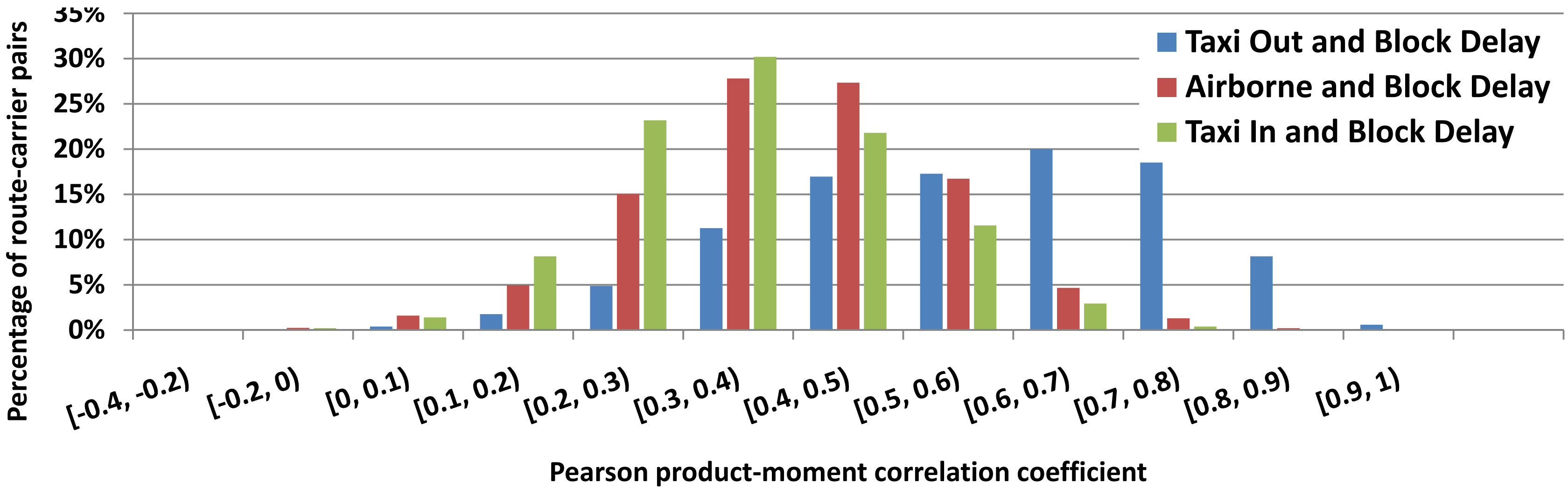
- Huge variability in block delays
- The average block delay is very close to zero (most often negative)
- The average block delay is larger than the median, because there is a small percentage of flights with excessive delays that moves the average to the right.
- The block delay distribution is almost symmetric around the median.

Distribution of Block Delays (January 2009)



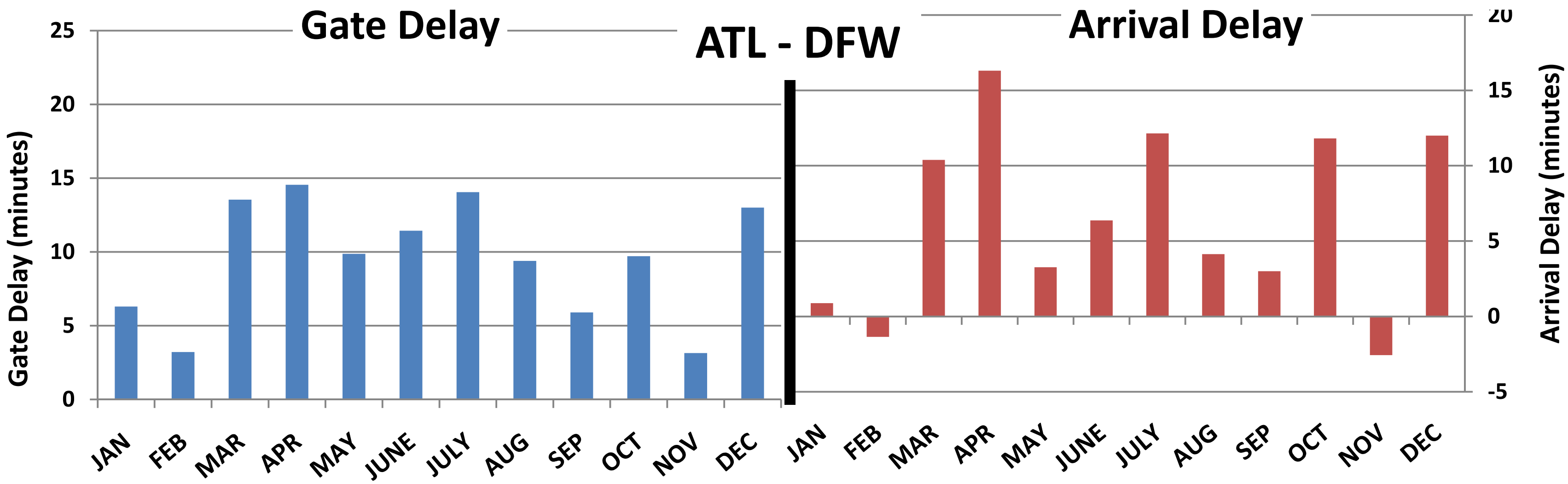
- 74% of the 3679 studied route-carrier pairs have negative average block delays
- 20% have average block delays between zero and five minutes,
- only 6% have delays longer than five minutes
- In absence of gate delays, 92% of the flights would arrive on time (with gate delays 80%)
- Flights on most routes suffer lengthy gate delays (shown next), that are difficult to be predicted. This results to significant arrival delays

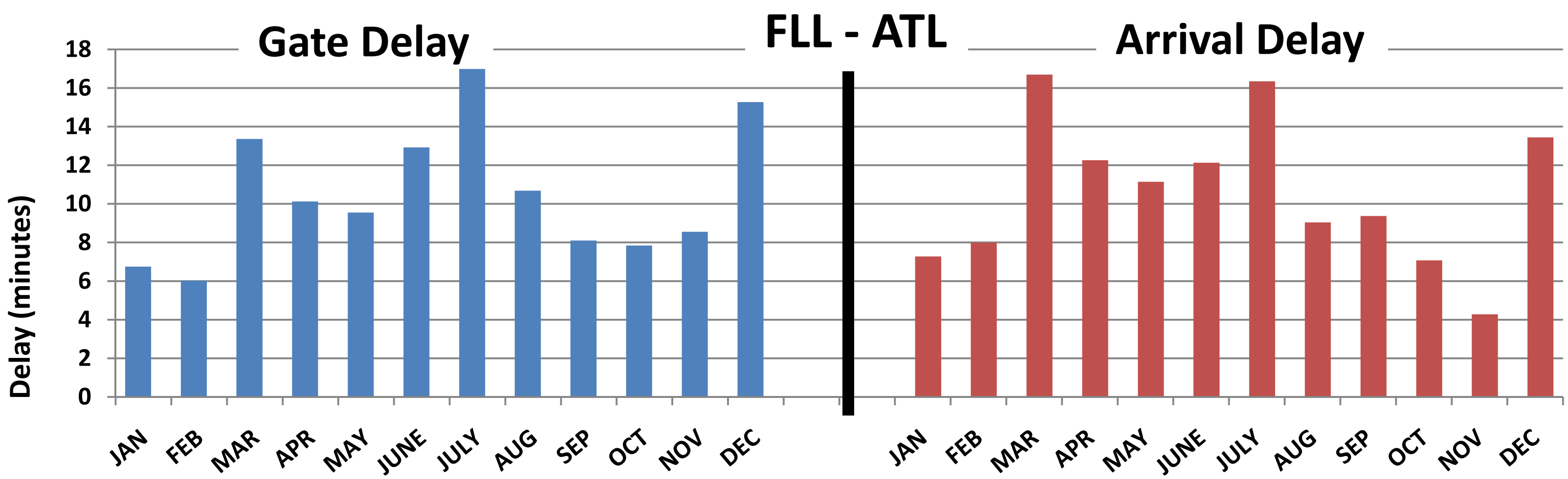
Correlation between Block Delay and Delay Components



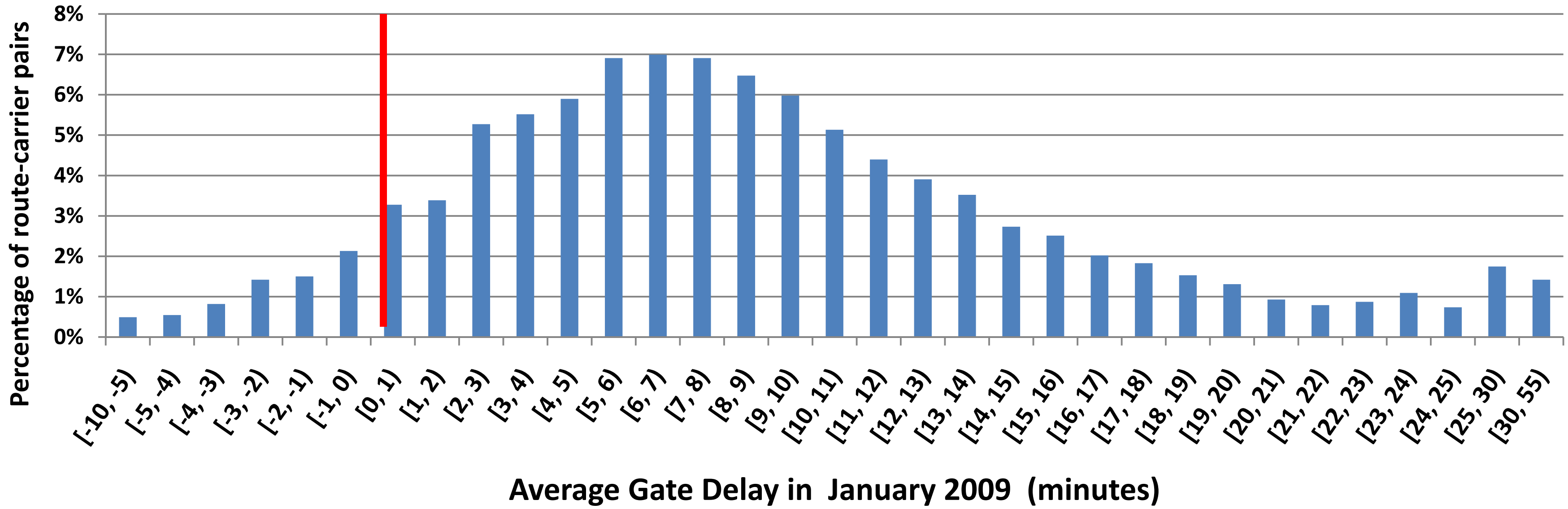
- Very strong positive correlation between block delays and taxi-out delays
  – Taxi-out delays responsible for the biggest portion of the block delays
- Strong positive correlation between block delays and airborne delays
  – Smaller than the correlation of the taxi-out delays
- Small correlation between block delays and taxi-in delays
  – Taxi-in delays are usually very small compared to the taxi-out and the airborne delays

Arrival and Gate Delays



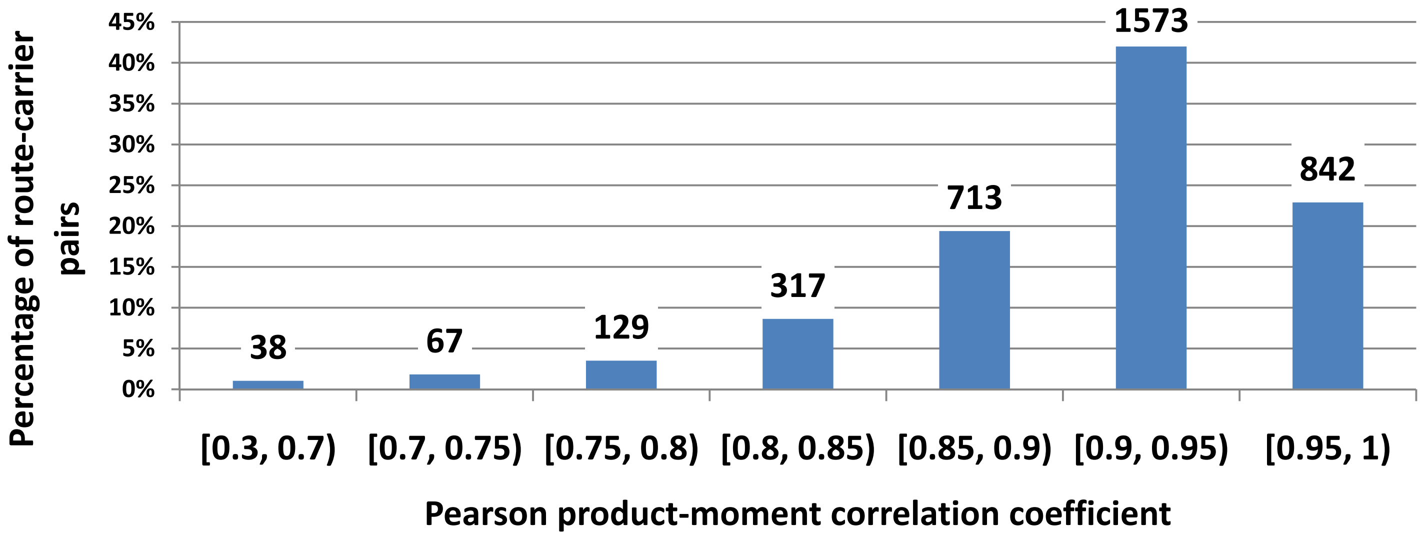


Distribution of Gate Delays (January 2009)



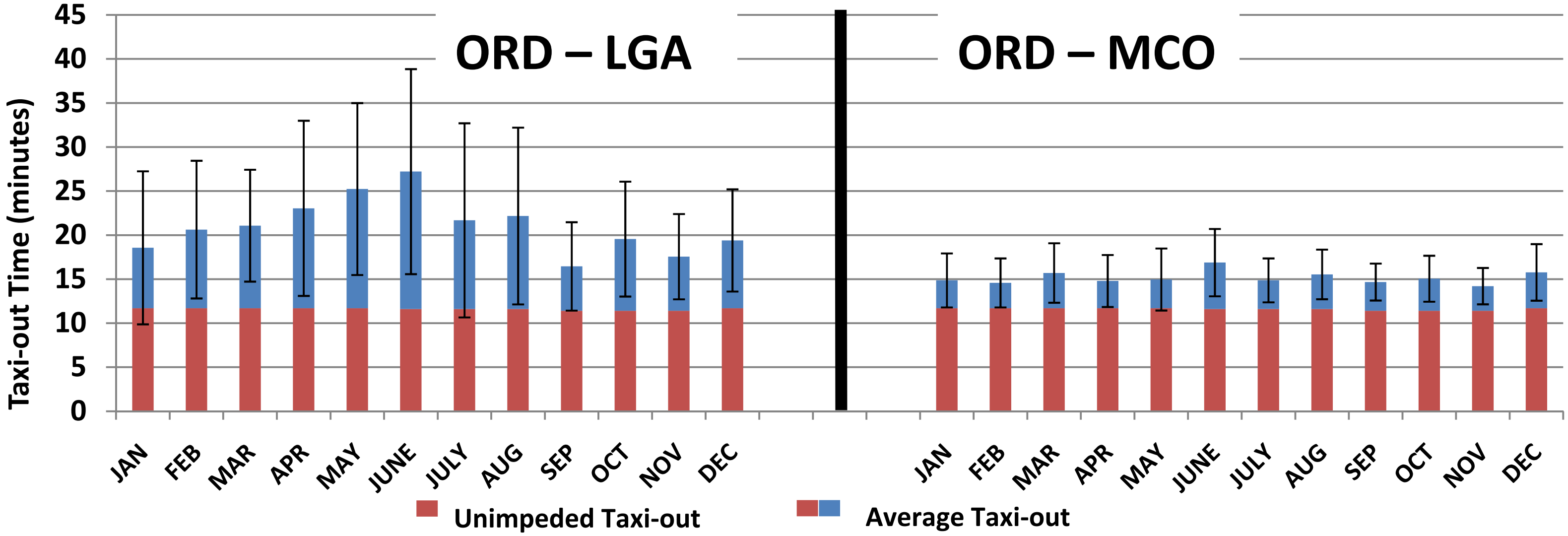
- The average gate delays (Jan 09) of 17% route-carriers are longer than 15 min
- The annual range of the monthly average gate delays can be very large and there is no seasonality
- It is very difficult for airlines to predict the gate delays
- We expect that this will result to a strong correlation between the gate delay and the arrival delay

Strong Correlation between Gate and Arrival Delays



- Very strong positive correlation
- A delayed pushback results most often to a delayed arrival
- Gate delays are caused mostly by stochastic factors, such as propagated delays (aircraft, crew) and airline operations (boarding, catering, fueling etc.). Therefore, airlines can not predict them and schedule without taking into account the variability in gate delays

Destination can affect the Taxi out Times



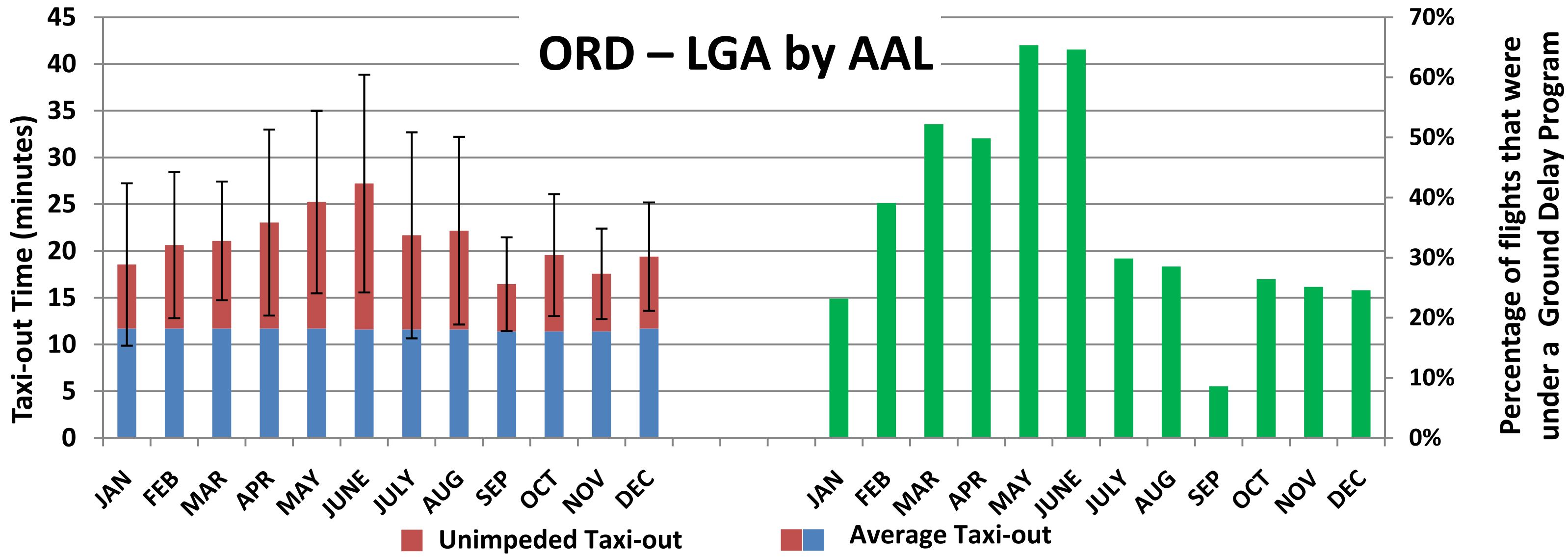
- Flights from the same airport (ORD) and by the same carrier (American Airlines) but with different destinations (LGA and MCO) do not follow the same distribution of taxi-out times

The annual range of monthly average taxi-out times is

- 11.3 minutes on the ORD-LGA route
- 2.6 minutes on the ORD-MCO route

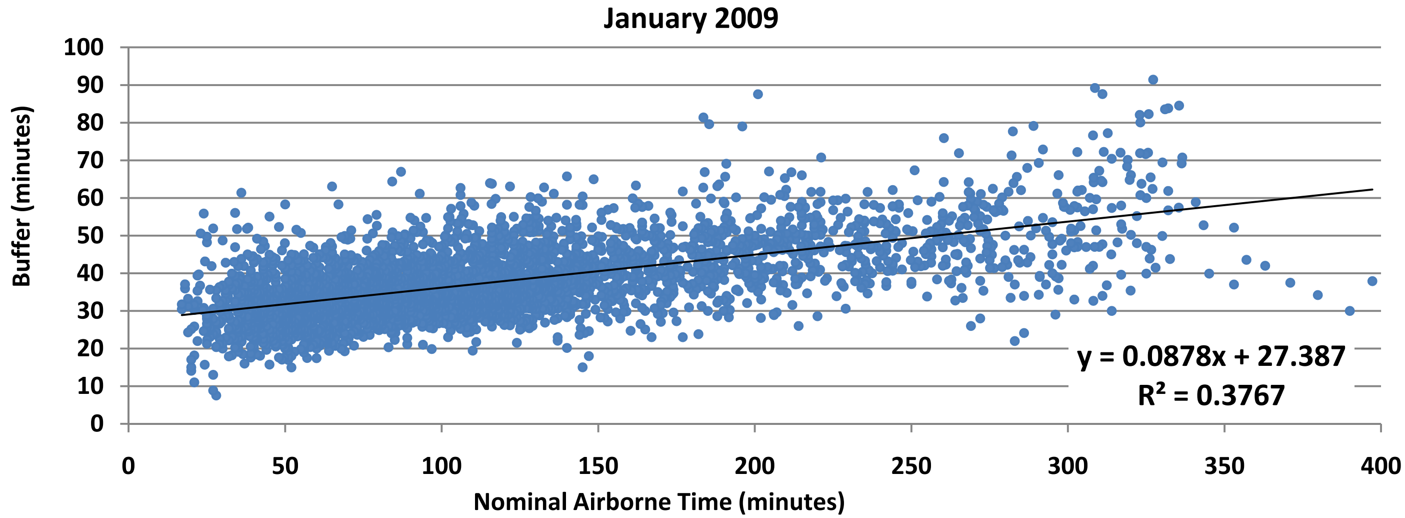
- We expect that this happens due to the existence of Ground Delays Programs that hold the flights that are destined to LGA on the ground

Destination can affect the Taxi out Times



- The taxi-out times of the flights from ORD to LGA are affected by the GDPs
- May and June have the highest average taxi-out times and the highest percentage of flights that were held on the ground by GDPs
- September has the smallest average taxi-out times and the smallest percentage of held flights
- Only 3 flights that were destined to MCO were held in 2009

Buffer in Schedule increases with Distance



- Each point corresponds to the average buffer time and nominal airborne time for a route-carrier pair in January 2009
- Some linearity between buffer and distance.
- Carriers hide more delays in the long-haul flights to handle the increased uncertainty in the airborne times (winds).
- We expect that the extensive padding of some short-haul flights compensates the gate delays and the taxi-out, taxi-in delays rather than the airborne delays.

Conclusions

- The average block delay is most of the times negative, and close to zero. Taxi-out delays, airborne delays and taxi-in delays are very effectively hidden in the schedule
- Very strong Correlation between gate delays and arrival delays. Carriers schedule without taking into account the variability in gate delays because its difficult to predict them
- Large seasonality in taxi-out and airborne times. This makes necessary a month basis analysis of the schedule padding practices
- Limited seasonality and variability in taxi-in times
- The congestion in the arrival airport affects the gate delays and the taxi-out times through the Ground Delay Programs
- Linearity between buffer and distance. Long-haul flights have in average larger delays than short-haul flights

Future Research

1. For two selected months , use
    - linear regression methods
    - non-parametric regression trees

   to study the relationship between the buffer time and the

   - fight components
   - distance
   - ground hold times
   - time of the day
   - route competition
   - carrier type (LCC vs. NLC)

2. Measure quantitatively and qualitatively the benefits and the costs of padding for the carriers and the airports.

<u>For airlines:</u>
- Crew costs
- Utilization costs
- Recovery costs/ delay propagation
- Presence in ticket distribution systems
- Reliability – on time performance

<u>For airports:</u>
- Delays
- Level of Service
- Traffic
- Revenues
- Cost for investments in terminals, runways, ATC technologies