

Effects of Fuel Prices and Slot Controls on Air Transportation Performance at New York Airports

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Abstract— Industry strategists and government regulators have focused on addressing concerns over the performance of the air transportation system with respect to delays. Emphasis has been placed on managing the problems at New York slot controlled airports, since 12% of flight delays have been attributed to flights passing through New York. This paper examines the effect of increased fuel prices on the performance of the air transportation system. Analysis identified that the number of markets served and the flights operated have remained constant in the presence of increased operational costs (+59%). Revenue has increased 29% through changes in airfares and the use of smaller aircraft (down 3%), while keeping service to all markets. With aircraft size changes and scheduling adjustments, flight delays have been reduced by 14% in 2008. The effects of seasonality are also discussed.

Keywords: *Economic analysis, Performance metrics, Longitudinal analysis, airport delays, Elasticity curves, market analysis, metroplex.*

I. INTRODUCTION

The summer of 2007 was one of the worst seasons for flight delays. In 2007, passengers flying domestic routes in the U.S. experienced 281.4 million hours of passenger trip delays [2]. The Senate Joint Economic Committee, estimates that these delays represent a \$40B cost to the US Economy. With the country currently engaged in a national economic crisis our economy can ill afford these losses.

This report provides a longitudinal study of the New York Metroplex airports (New York Liberty, New York John F. Kennedy and New York LaGuardia) since they are responsible for 12% of total national delays [1]. Additionally the New York Metroplex is currently the only metroplex in the national network where all three major airports are slot controlled and where there is no ability to expand in the near future. At LaGuardia, the average delay is over 70 minutes most afternoons [3]. Within the next ten years annual air travel is expected to reach 1.1 billion air travelers a year in the United States [4]. Given that some key portions of the national network are already saturated, without strict restrictions on access to runways at capacitated airports, congestion can be expected to get much worse.

Each of the New York Metroplex Airports restricts the use of runways by way of "slot" controls. The Federal Government allocates a given number of slots in each 30-minute time period to the carriers that service the New York City area. A "slot"

provides the holder with the right to announce either a departure or an arrival during this time period. The capacity limits are based on the *maximum* number of arrivals or departures that the runways can handle on a perfect weather day, and assumes that there is little variability in these arrivals or departures. Queuing theory dictates that the greater the variability in the arrival and departure patterns, the greater the likelihood for service deterioration. Whenever weather conditions occur (e.g. storms, ice, fog, high winds), the capacity of the airport is further reduced. Bobby Sturgell, Acting Administrator of the FAA, said on November 24, 2008 "Schedules predicated on a bright sunny day *everyday* are just flat out impractical. These create unrealistic expectations on the part of the passenger, and they create havoc anytime when weather hits."

In this paper, we examine the changes in airline ticket prices, air transportation demand, airline revenues, and flight performance (i.e., delays and cancellations) during a period when there were significant fuel increases, an economic downturn and stricter slot controls.

The following section will outline the objectives and scope of this study. The methodology will be described in Section III. The results of our market, economic and passenger analysis will be described in Sections IV, V, and VI respectively. Section VII will summarize these results and discuss our future analytical efforts.

II. OBJECTIVE AND SCOPE OF STUDY

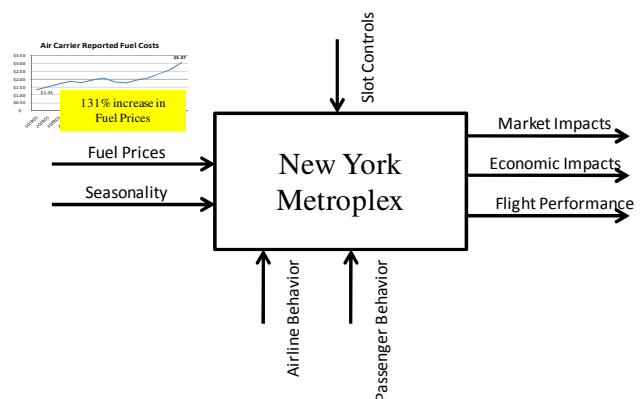


Figure 1. NY Metroplex fuel price study.

III. METHODOLOGY

This study provides a longitudinal study, from 2005 through summer 2008, that describes three major characteristics of the New York Metropolitan Air Transportation System: (a) a description of the markets served from each airport including frequency of service, aircraft size used, and competition within the market; (b) an economic analysis of the markets as specified by ticket prices, airline revenue and costs, and price elasticities; and (c) how airline schedules impact passengers through an analysis of load factors, delays and cancellations. Figure 1 is an illustration of the how fuel prices, seasonal flight patterns and federal regulations impact airline and passenger behavior resulting in changes in market structure, prices, and schedules. These, in turn, determine demands, load factors and delays.

A. Market Analysis

The market impacts are analyzed by examining the following metrics:

1) *Flights per day*: is the number of arrivals per day from other metroplexes as reported to the Bureau of Transportation Statistics (BTS) [6].

2) *Aircraft size*: is the average number of seats per aircraft for various O/D pairs as reported to the BTS.

3) *% Connecting Passengers*: This analysis is limited to domestic connecting passengers, since BTS samples only domestic passenger coupons. A passenger was considered a connecting passenger if their ticket reflected a stop at an airport other than their origin or destination. This analysis examined data from the BTS DB1B_market databases from 1QTR 2005 through 2QTR 2008. The DB1B_market database contains a 10% sampling of tickets of domestic passengers.

4) *Markets Served*: Markets served by the NY/NJ Metroplex is defined as any location served from a NY/NJ airport with at least sixty or more arrivals and departures per month, as reported to BTS.

5) *Market Share*: This metric is the percentage of departures offered by each of the major airlines from each of the three NY/NJ airports (LGA, JFK, EWR), as reported by BTS.

B. Economic Analysis

Economic impact is analyzed by examining the changes in airline revenues, airline costs, ticket prices and demand over time. Specifically:

1) *Price Elasticity*: We report the number of tickets purchased at each price point during a given quarter, as reported in the 10% price sample provided to BTS. Single segment fares were used for this analysis. This analysis does not completely include the cost of travel by the passenger since it does not reflect any baggage, fuel fees, or other incidentals (e.g. blanket, movie, food) not reported to BTS.

2) *Aircraft Costs*: Costs include personnel, fuel, insurance, taxes, maintenance, and depreciation per flight hour

and reported to BTS by aircraft type. Airline costs as reported here is calculated by multiplying average flight times as reported in the Aviation system performance metrics (ASPM) [7] aircraft cost per flight hour and then multiplying the result by the number of flights per quarter.

3) *Airline Revenue*: Airline revenue is calculated by subtracting airline costs from estimated revenues. For each market, the revenue is determined by calculating the average single segment fare for that O/D pair and multiplying this average fare by the total passengers flown in that quarter. This profit analysis does not consider either any additional fees charged by the airline or any additional costs that the airline might incur due to delays in schedules.

C. Flight Performance

Finally, our flight performance analysis reports the following metrics:

1) *Load Factors*: Load factor is the ratio of passengers flown to the average seat capacity for each O/D pair studied, as reported to BTS.

2) *Flight Cancellations*: is the total number of flights cancelled for each O/D, as reported to BTS.

3) *Flight Delay*: We report two flight delay metrics (a) the number of delayed flights (flights with delays of 15 minutes or more) and (b) the average delay of delayed flights.

4) *Passenger Delay*: is the average delay incurred by passengers from both delayed and cancelled flights, as calculated in the Passenger Trip Delay Database [8].

IV. RESULTS OF MARKET ANALYSIS

A. Flights per day

There was a 4% increase of flights to the New York Metroplex from 2005 to 2007 and a 5% decrease in flights from 2007 to 2008, bringing the number of flights per day in 2008 back to the 2005 levels. The imposition of slot controls imposed by Department of Transportation (DOT) in 2008 is the most likely cause of the reductions in scheduled flights in 2008, although the increase in fuel costs and the downturn in the economy could also have influenced the decision of airlines to reduce schedules. When reviewing schedules, we see that the schedule changes are consistent (neither higher nor lower) with the regulations set by DOT. With the significant costs of fuel, we may have expected a greater decline in scheduled flights. However, current and pending legislation (e.g. the grandfathering of slots based on a current schedule, the forced reduction in schedules and the “use-it-or-lose it” rules) may have incentivized the airlines to continue to use all allocated slots. To help offset these restrictions during high fuel costs, the airlines chose, alternatively, to use all available slots but with smaller aircraft.

Although the number of flights per day remained relatively constant, seasonality trends exist (see figure 2). We see more flights to Miami in the colder months and more flights to overseas locations in the summer. Two other changes in the markets served during this period were: (a) There was a significant drop (~25 less arrivals per day) in the number of

arrivals per day from the Washington D.C. metroplex to EWR, and (b) There has also been a reduction in the number of arrivals per day at EWR and LGA from the Chicago Metroplex.

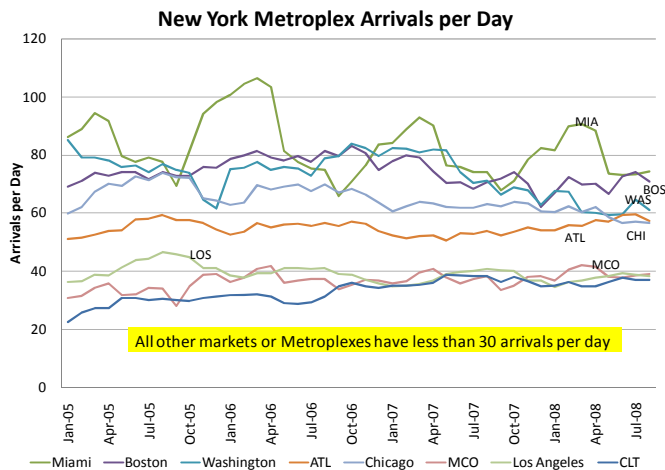


Figure 2. NY Metroplex Arrivals per Day.

B. Aircraft Size

Two important events occurred in 2008: slot controls were imposed and fuel prices soared. Either of these events might have triggered a reduction in frequency coupled with an upgauging to larger, more efficient aircraft since such actions can improve an airline’s profitability. The data does not show any significant upgauging in aircraft (See figure 3). The analysis does indicate that on average, the aircraft used to service the Washington and Boston metroplexes has a larger seat capacity than in 2005 but is still significantly smaller than departures to other metroplexes. A slight down-sizing in seat sizes to other locales has kept the average aircraft size constant over time with little seasonal differences.

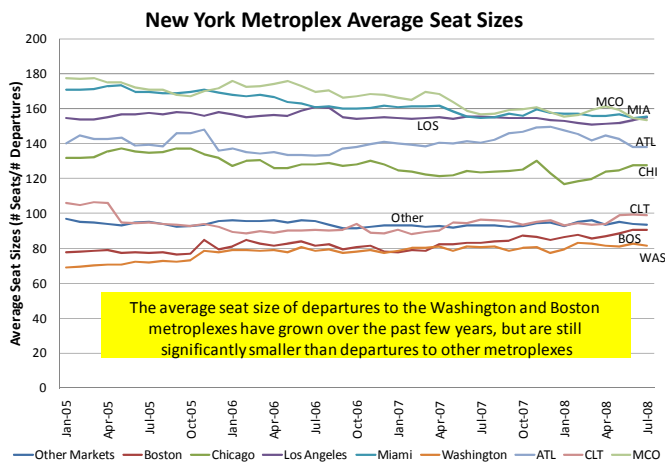


Figure 3. NY Metroplex Average Aircraft Size (# seats).

C. Percent domestic connecting passengers

There appears to be no change of the percent of connecting passengers at the New York Metroplex Airports since January 2005 during the period of tighter slot controls or increased fuel

prices. The percent of domestic passengers connecting through the New York/ New Jersey Metroplex is relatively low and steady at approximately 6%. Most of the connecting passengers at JFK and EWR are connecting to international flights and are not part of this analysis.

D. Markets Served

There was little change to the number of markets served by the New York Metroplex since January 2005. Although the number of markets served is as high as 103, the number of markets served by at least 60 flights per month (i.e. having at least one arrival and departure daily) is approximately 70. Figure 4 provides data on how many airports in the NY Metroplex region serve a specific market. The analysis shows a sharp decrease in markets served by two or more airports in the New York Metroplex starting in the spring of 2008 (when fuel costs were high).

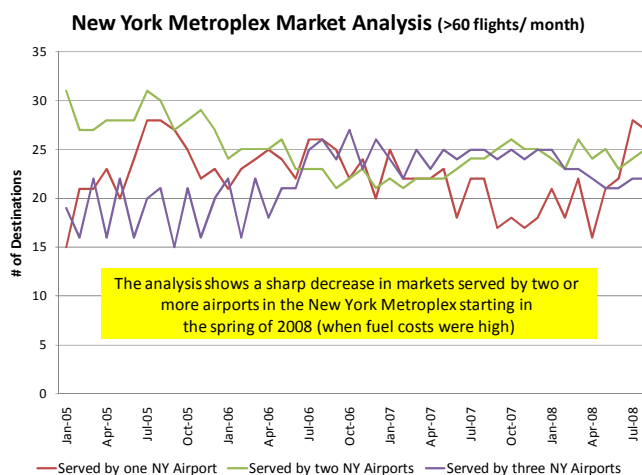


Figure 4. Number of Destinations served with daily service from either one, two or three airports in the NY Metroplex

E. Airline Market Share

There was no change to the airline market share at the New York Metroplex since January 2005. Table 1 shows the 2008 percentage of departures by major carriers, for the entire metroplex and for each airport. Delta, JetBlue, American, and Continental each have similar market share overall although their market share varies significantly by NY airport. The lack of variability over time in market share shows the difficulty of new entrants obtaining access to these three airports.

	NY Metroplex % of departures by Airline			
	EWR	JFK	LGA	NY Metroplex
Continental Airlines	76%	1%	4%	30%
Delta Air Lines	8%	31%	37%	24%
American Airlines	5%	16%	32%	17%
JetBlue Airways	3%	45%	2%	16%
US Airways	2%	2%	11%	5%
United Airlines	3%	4%	6%	5%
AirTran Airways	1%	0%	6%	2%
Mesa Airlines	1%	0%	0%	1%
Frontier Airlines	0%	0%	1%	0%
Alaska Airlines, Inc.	1%	0%	0%	0%

Table 1. 2008 New York Metroplex Market share by airline

V. RESULTS OF ECONOMIC ANALYSIS

To better understand the economic impact of increased fuel prices, slot controls and/or congestion; the price elasticities of the markets served by the New York Metroplex were analyzed. In order to see if trends could be identified by market groups, this study examines the price elasticities for the New York Metroplex as a whole, on shuttle service markets, on low cost carriers, on major hubs, and on long haul markets. The operational costs per flight hour for different aircraft sizes are also examined. And finally the estimated revenue generated by flights to a variety of locations from the New York Metroplex is examined.

A. New York Metroplex Price Elasticities

Figure 5 provides a synopsis of the overall price elasticity of all flights to the New York Metroplex from the second quarter of 2005 through 2008. These elasticity curves are an aggregation of *all* flights for a given year to *all* markets serving the NY region. One interesting result of this analysis shows that, in 2008, there are far fewer inexpensive flights to the NY region (i.e. flights less than \$100 each way) than previously. This price increase is probably due to increased air carrier fuel costs.

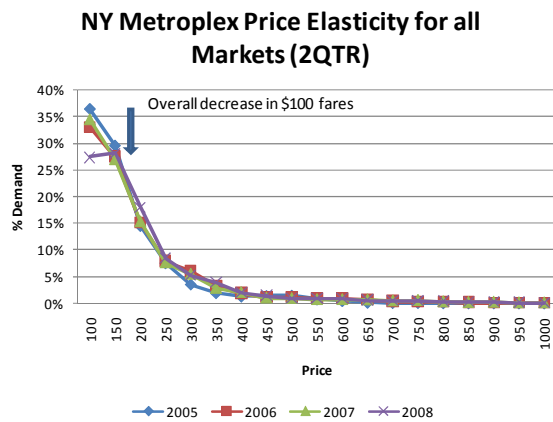


Figure 5. New York Metroplex Price Elasticity (2QTR).

Next the price elasticity curves are examined to determine whether these curves differ for flights of different length, averaged over all such markets at all three airports. Figure 6 compares flights ranging from 500 to 5000 miles. This analysis illustrates that the air fares offered by the air carriers increase proportionately with the distance of the market.

B. Shuttle Service Price Elasticities

LaGuardia airport has shuttle services serving Boston, Washington D.C. and Chicago and price elasticity behavior is examined for these markets. LGA to Boston and LGA to Washington price elasticity behaviors mirror each other from 2005 to 2008 with a significant shift to higher prices in 2007 (See figures 7 and 8). Namely, there were far fewer \$100 (one-way) fares and far greater \$150 fares in 2008. Thus, the average fare has increased by 37% since 2005. Additionally, the fares for the last minute traveler have increased by \$100 from 2005 to 2008.

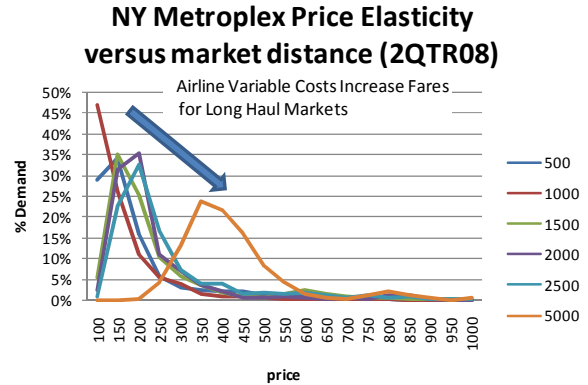


Figure 6. NY Metroplex Price Elasticity by market distance (2QTR08).

LaGuardia - Boston Price Elasticity (2QTR)

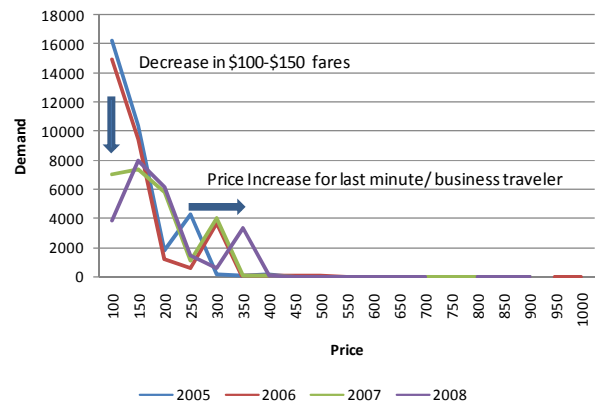


Figure 7. LGA-BOS Price Elasticity (2QTR).

LaGuardia - DCA Price Elasticity (2QTR)

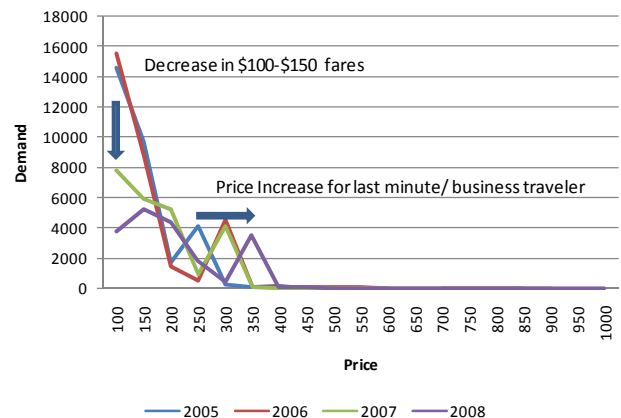


Figure 8. LGA-IAD Price Elasticity (2QTR).

C. Low Cost Carriers

Examining airports that are predominately served by a Low cost carrier (CLT and PIT), in figures 9 and 10 shows: (a) there

are significantly fewer high prices (i.e. there were significant fares in the \$400-\$500 range in 2005; In 2006, these have shifted to fares in the \$250 to \$350 range; By 2007 the fares have shifted even lower to the \$150 to \$200 range). (b) in 2008, there were far fewer \$100 fares than in 2007. (c) over time there is far less variance in prices than in 2005 or 2006, representing an overall decrease in revenue.

NY Metroplex - CLT Price Elasticity (2QTR)

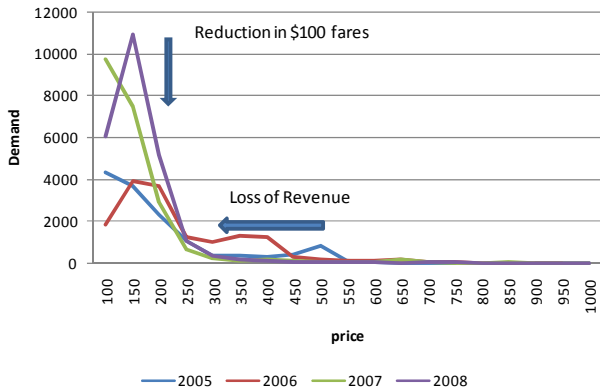


Figure 9. NY Metroplex-CLT Price Elasticity (2QTR).

NY Metroplex - PIT Price Elasticity (2QTR)

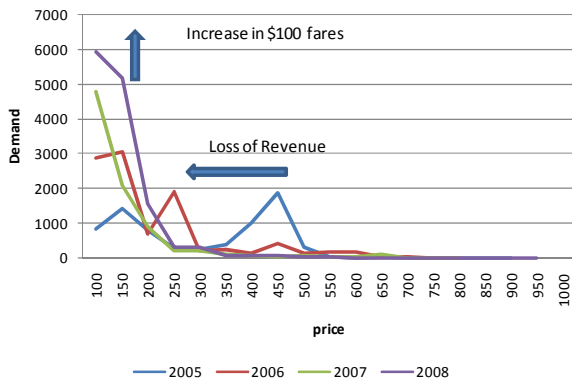


Figure 10. NY Metroplex-PIT Price Elasticity (2QTR).

D. Hub Price Elasticities

On the other hand, the hub airports serving the New York Metroplex show a different pattern (see figure 11). At these airports, the average traveler is spending on average \$184 in 2008 compared with \$161 in 2005, and there are fewer \$100 fares available. Thus, the average per passenger revenue at hubs is significantly greater than at airports dominated by low cost carriers.

NY Metroplex - ATL Price Elasticity (2QTR)

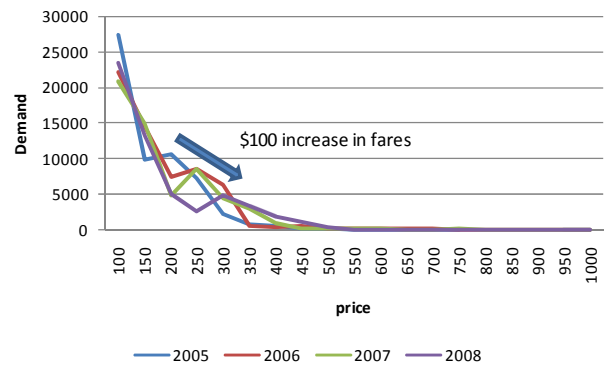


Figure 11. NY Metroplex-ATL Price Elasticity (2QTR).

E. Long Haul Price Elasticities

Finally, the pricing trends for long haul markets are examined, at Los Angeles (LAX) and San Francisco (SFO). Figures 12 and 13 illustrate that the price elasticities for SFO remain relatively unchanged, while there is a moderate (\$50) increase in prices for fares to LAX. It appears that the long haul markets may be facing sufficient competition to not be able to raise fares, even when fuel prices are increasing.

NY Metroplex - SFO Price Elasticity (2QTR)

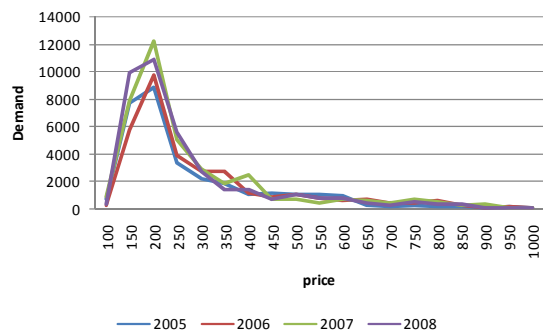


Figure 12. NY Metroplex-SFO Price Elasticity (2QTR).

NY Metroplex - LAX Price Elasticity (2QTR)

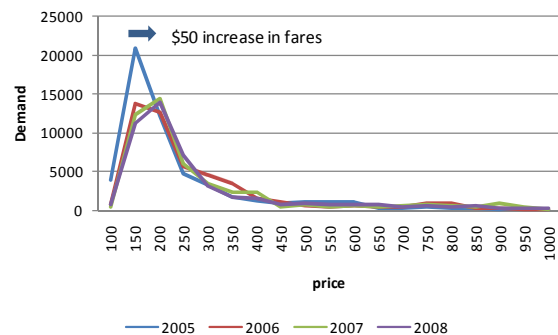


Figure 13. NY Metroplex-LAX Price Elasticity (2QTR).

F. Airline Aircraft Costs

The airline costs per hour of flight since 1QT 2005 reflect the changes to fuel prices and show no seasonality, see figure 14. While personnel, training, maintenance, and depreciation costs have remained level, the fuel costs have increased 131% since first quarter 2005. The air carriers have experienced over 60% of this increase fuel since the first quarter 2007. The only significant variability in airline costs over this period is fuel costs.

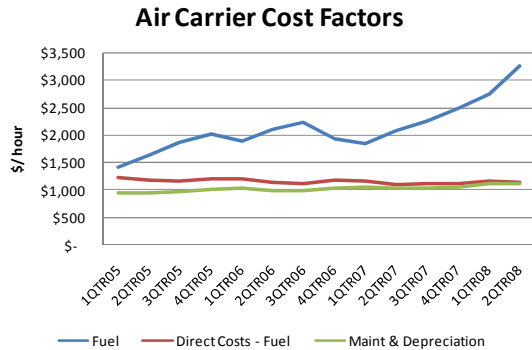


Figure 14. Air Carrier Cost Factors.

When applying these cost factors to operations at the New York Metroplex the analysis shows a 59% increase in costs resulting from the 131% increase in fuel costs, see figure 15.

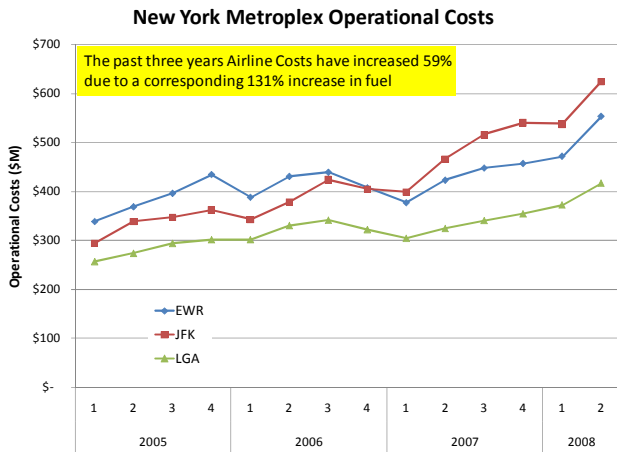


Figure 15. New York Metroplex Operational Cost 2005-2008.

G. Airline Revenue

The estimated revenue generated by flights in and out of the New York Metroplex since 1QT 2005 shows seasonality similar to the trends seen in airline costs, figure 16. Our analysis shows that airlines have compensated for the increased operational costs. Even without the additional revenue generated from new fuel, baggage, food, blanket, movie and other similar fees, the airlines have increased revenue 29% from 2005 through 2008.

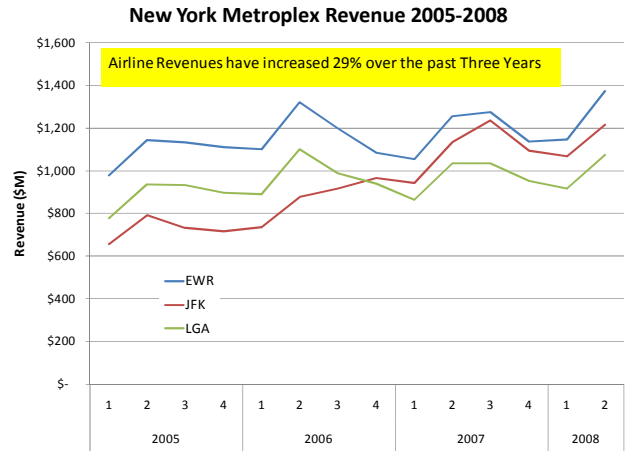


Figure 16. New York Metroplex Revenue 2005-2008.

When evaluating the average annual revenue realized by different sized aircraft serving the New York Metroplex. We find that the airlines revenue comes primarily from aircraft in the 38-62 range (14% of the revenue) and in aircraft between 113-187 seat ranges (76%), see figure 17. When we look at the three airports individually, we see that there is substantially more revenue being generated at JFK from larger seat flights than from either LGA or EWR.

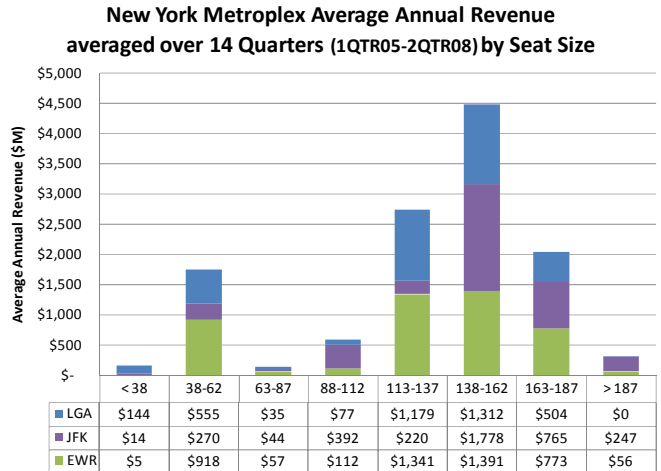


Figure 17. NY Metroplex Annual Revenue (\$M) averaged over 14 Quarters (1QTR05-2QTR08) by Seat Size.

VI. RESULTS OF FLIGHT PERFORMANCE ANALYSIS

The New York Metroplex has consistently had high average load factors (>.8) since 2005. With tight slot controls, high load factors and increases in cancellations (especially during the summer and winter months) passengers experienced significant delays.

From 2005 to 2007 the reduced aircraft size (-4%) combined with an increase in arrivals per day (4%) significantly increased load factors, delays and cancellations for the New York Metroplex, see Table 2. However, we see a reversal in this trend in 2008, with airlines reducing flights (-5%) and increasing aircraft size (1%). As a result from 2007 to 2008 the New York Metroplex showed significant reductions

in the number of Flight Delays (-14%), average flight delay (-10%), the number of flight cancellations (-16%), and overall passenger delays (-16%) from both cancellations and delayed flights. During this time, DOT imposed tighter slot controls at all three NY Metroplex airports and, concurrently, fuel prices soared. Overall from 2005 to 2008 there were significant increases in the number of Flight delays (+26%), average flight delay (+41%), the number of flight cancellations (+25%), and in the delay incurred by the passenger (+39%) from both cancellations and delayed flights (see Table 2).

A. Load Factor Analysis

Figure 18 shows the average load factors of departures from the New York Metroplex Airports. There is significant seasonality in load factors with highest load factors in the winter and summer and lowest load factors in the spring and fall. JFK has the largest load factors of any of the New York Metroplex airports.

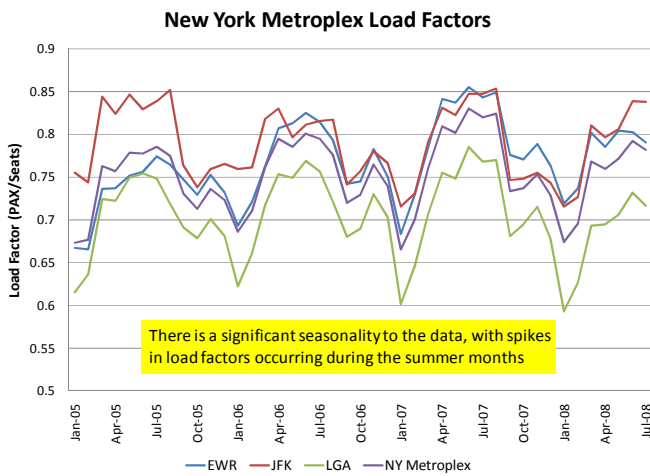


Figure 18. NY Metroplex average load factors.

Figure 19 illustrates that flights to the Washington D.C. and Boston metroplexes have significantly lower load factors than any other metroplexes or markets.

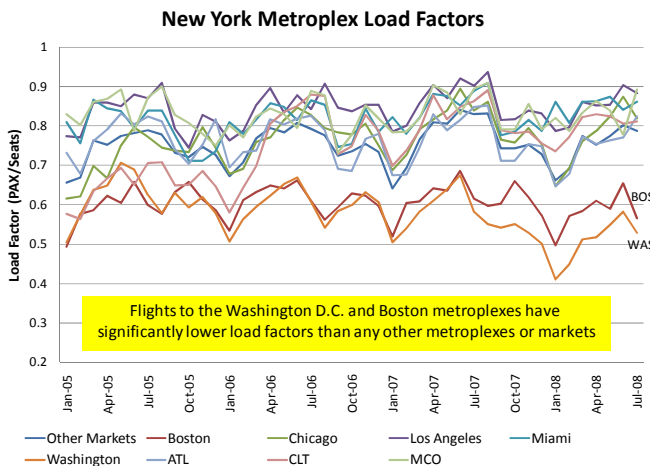


Figure 19. NY Metroplex average load factors (by Metroplex served).

B. Flight Cancellations

Figure 20 shows seasonality in flight cancellations and a significant spike in cancellations during the spring, followed by a smaller spike in cancellations in the summer. The summer of 2007 had the highest cancellation rates while 2008 cancellations are similar to those of 2006. During the summer of 2008, caps were placed on schedules. During this time the reduced number of flights (-5%) and the redistribution of flights during the day (see figure 28) reduced the flight cancellations by 16%.

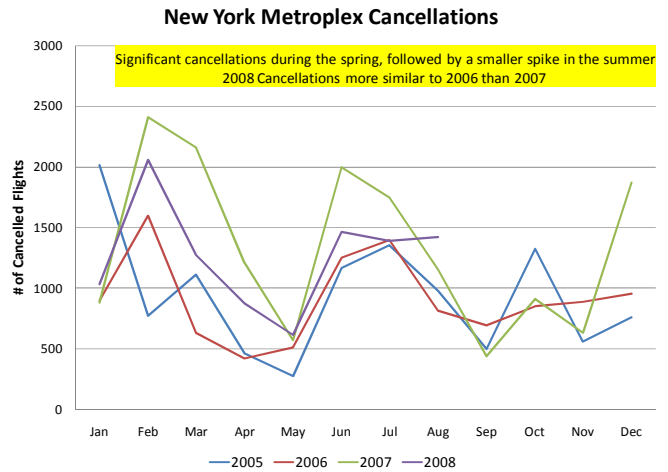


Figure 20. NY Metroplex Cancellations.

Figure 21 shows the percentage of cancelled flights from other airports to the NY airports, with the two Chicago airports showing the sharpest spike in cancellations. Winter cancellations are likely due to weather while summer cancellations are more likely due to over-scheduling.

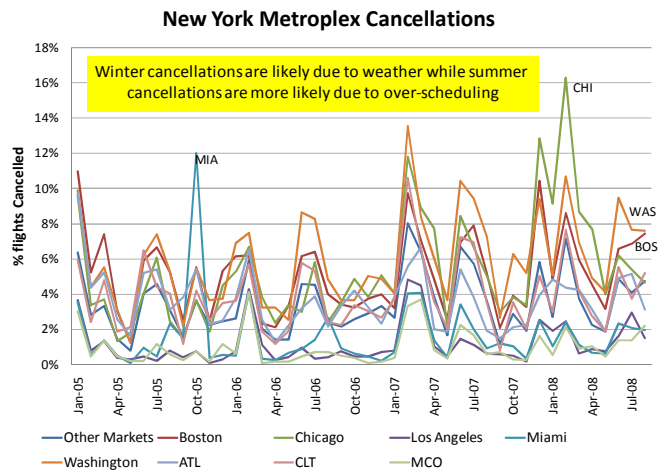


Figure 21. NY Metroplex Cancellations (by Metroplex served).

C. Delayed Flights

Figure 22 shows the number of departure delays (> 15 min) over the past few years. Similar to the cancellation data, the number of delayed flights in 2008 is similar to that of 2006. The analysis shows that although the number of delays has

decreased from 2007 to 2008, the average *length* of the delay has increased. However, the number of delayed flights from JFK has significantly increased during the summer months of 2008.

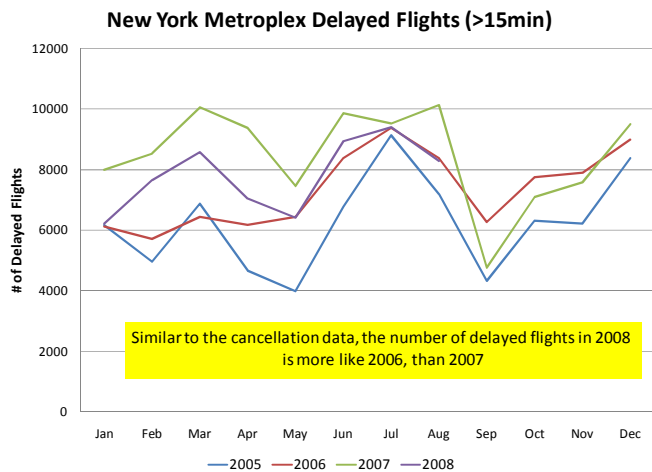


Figure 22. NY Metroplex number of Delayed Flights (> 15 min).

Figure 23 shows that the number of delays to the Miami, Atlanta and Chicago are significantly higher than to other major hubs/metroplexes. Again this is consistent with our cancellations analysis and indicates that delays to these airports may propagate delays throughout the air transportation network.

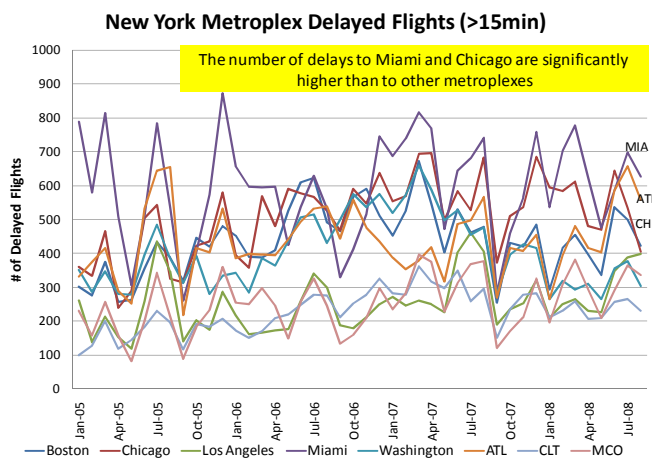


Figure 23. NY Metroplex number of Delayed Flights (by Metroplex served).

D. Departure Delay

Figure 24 shows the average departure delays of flights delayed over 15 minutes for departures from the New York Metroplex Airports since 2005. The analysis shows a clear growth in average delays of delayed flights over the past few years and is most pronounced in the summer of 2008.

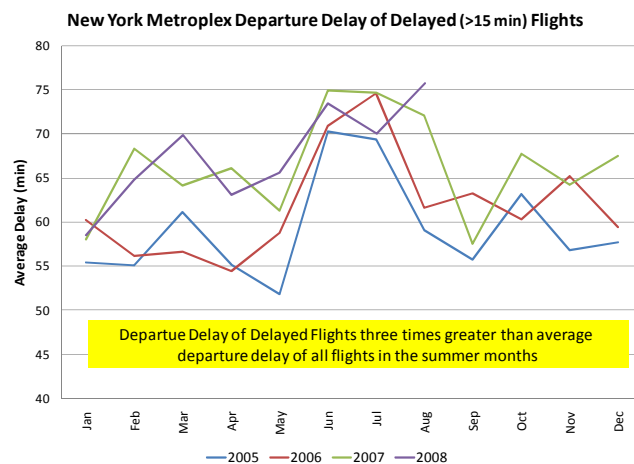


Figure 24. NY Metroplex Average Departure Delay of Delayed Flights.

Figure 25 shows departure delays to other metroplexes. This analysis illustrates that delays to the Chicago metroplex dominate delays to all other metroplexes. The analysis shows significantly lower delays to the Washington and Boston Metroplexes.

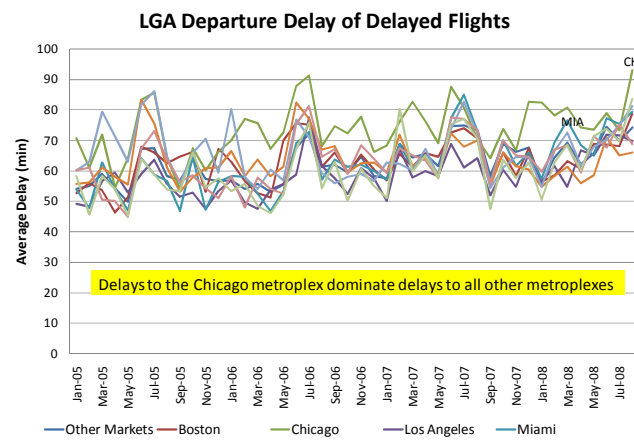


Figure 25. NY Metroplex Average Departure Delay of Delayed Flights.

E. Passenger Delay

Our analysis of passenger delays from canceled and delayed flights shows clear seasonality as was seen in cancelled flights and load factors, see figure 26.

Figure 27 illustrates the problems experienced by the Chicago Metroplex during the winter of 2007-2008. Previous analysis showed this market experienced as high as 18% cancellations of flights during this winter. Even though the average delays from delayed flights were about 31 minutes the average delay the passenger experienced from both delayed and cancelled flights *combined* approached 180 minutes.

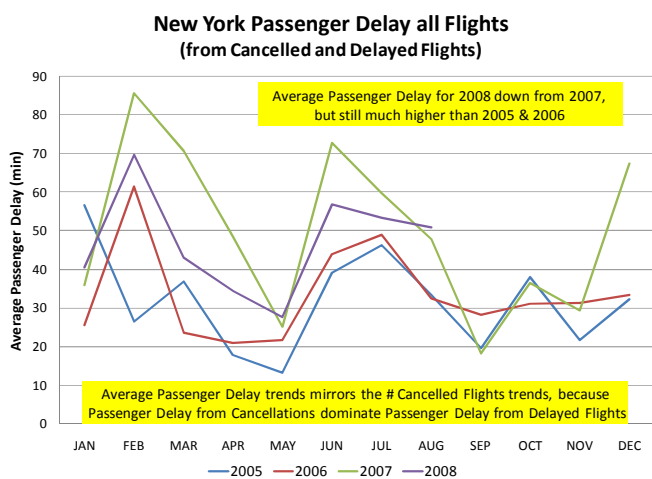


Figure 26. NY Metroplex Average Passenger Delay of all Flights.

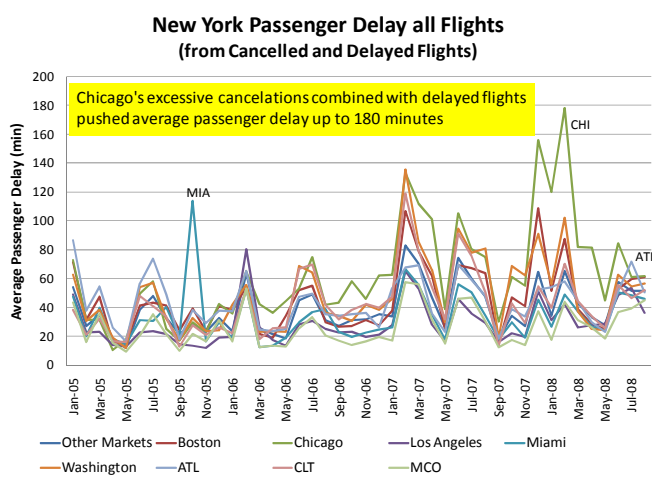


Figure 27. NY Metroplex Average Passenger Delay of all Flights.

VII. SUMMARY AND FUTURE ANALYSIS

A. Impact of Increased Fuel Prices and/or Slot Controls

DOT imposed tighter slot controls at LaGuardia and imposed slot controls at JFK and EWR. Our analysis shows no reduction of operations or markets served at the New York Metroplex during this time period, but did show a significant down-gauging of aircraft serving a number of markets (e.g. Dallas to JFK, NY to DC and Boston). One might infer from this analysis, that airlines may choose to continue to serve the same markets, but, when costs increase, they choose to downsize the plane gauge.

In 2008, slot controls and increased fuel increases have triggered the airlines to redistribute flight schedules (see figure 28) and reduce flights by 5%, see table 2. These actions had the effect of reducing the number of Flight Delays (-14%), average flight delay (-10%), the number of flight cancellations (-16%), and the delay incurred by the passenger (-16%) from both cancellations and delayed flights, see table 2. Market access has remained constant.

The air carrier cost factor analysis clearly shows that increased fuel prices are significantly increasing the operational costs and clearly impacted the price elasticities for the New York Metroplex. Overall, lower price fares are shrinking for flights to major hub markets and to shuttle service markets. On the other hand, where low-cost carriers have major presence, the prices have increased relatively little. The total impact on price cannot be measured, because our data does not include fees not reflected on the ticket price (e.g. fuel, baggage, and change of flight fees).

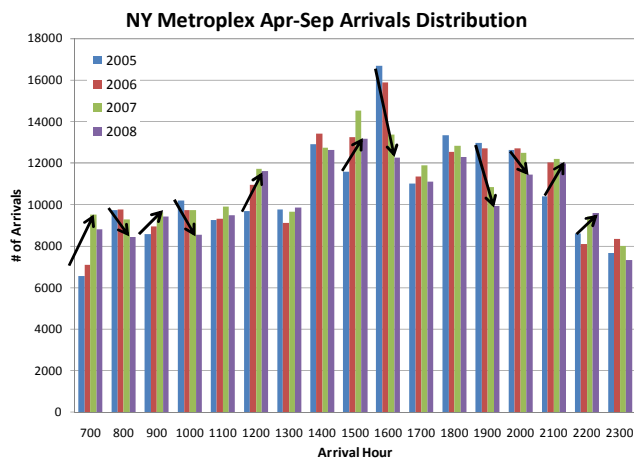


Figure 28. NY Metroplex Arrival Distribution Adjustments

Summary of Longitudinal Analysis

Metric	% Change 2005 to 2007	% Change 2007 to 2008	% Change 2005 to 2008
Fuel Prices	60%	44%	131%
Operating Cost	23%	30%	59%
Revenue	19%	8%	29%
Average Fare	7%	7%	15%
Aircraft Size	-4%	1%	-3%
Arrivals per Day	4%	-5%	0%
# of Flight Delays	47%	-14%	26%
Average Flight Delay	57%	-10%	41%
Flight Cancellations	49%	-16%	25%
Passenger Delay	66%	-16%	39%

No significant change for:

% Connect Pax Markets Served Market Share Load Factors

Table 2. Summary of NY Metroplex Longitudinal Analysis

B. Price Elasticities

Our price elasticity analysis illustrates that the air fares increase proportionally with the distance of the market. The fares for the business travelers or last minute travelers to shuttle markets have increased by \$100 from 2005 to 2008. And that the average per passenger revenue at hubs is significantly greater than at airports dominated by low cost carriers. Finally, long haul markets are unable to raise fares, even when fuel prices are increasing, due to low-cost carrier competition.

C. Seasonality

The analysis shows a significant seasonality in cancelled flights, delayed flights, and load factors with the summer months having the highest volume, flight cancellations and flight delay. November through December is the second

highest period of volume and delays. Although DOT has placed caps on arrivals and departures at all three airports, the cap settings did not reduce delays as much as anticipated.

D. Future Analysis

Since the fuel prices have dropped in 4QTR 2008, we will have an opportunity to see if the same behaviors we observed during the increase are reversed during the decrease. We intend to perform a similar analysis for the Los Angeles region in order to better understand the impact that regulations in the NY Metroplex have had on airline behavior. We also hope to obtain a better understanding of elasticity curves in order to predict how future regulations might impact delays, airfares, competition, and coverage to various markets.

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