



# **The effect of secondary market on the efficiency of slot use: evidence from an empirical analysis**

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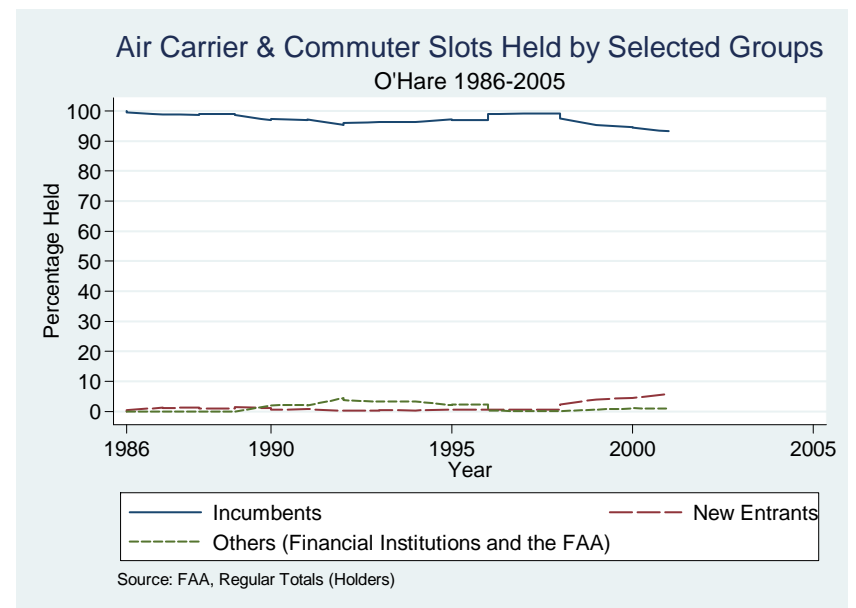
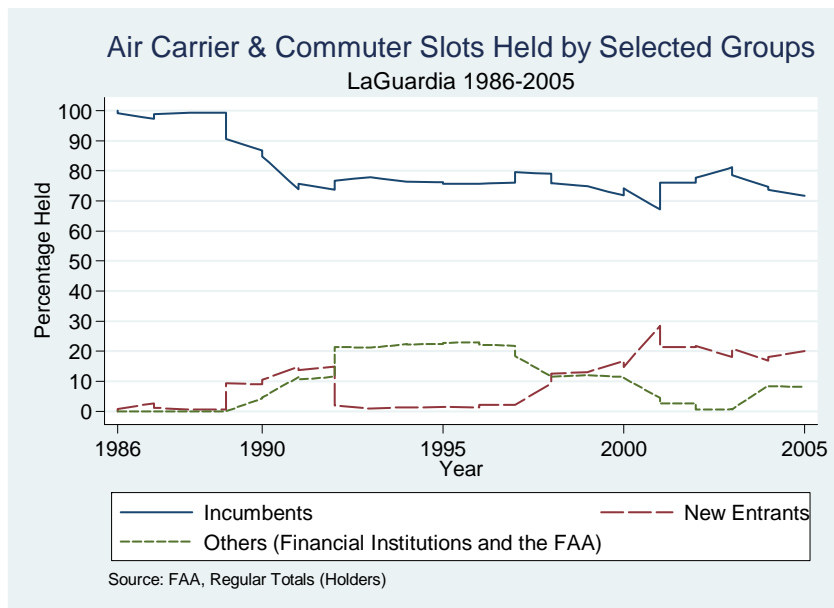
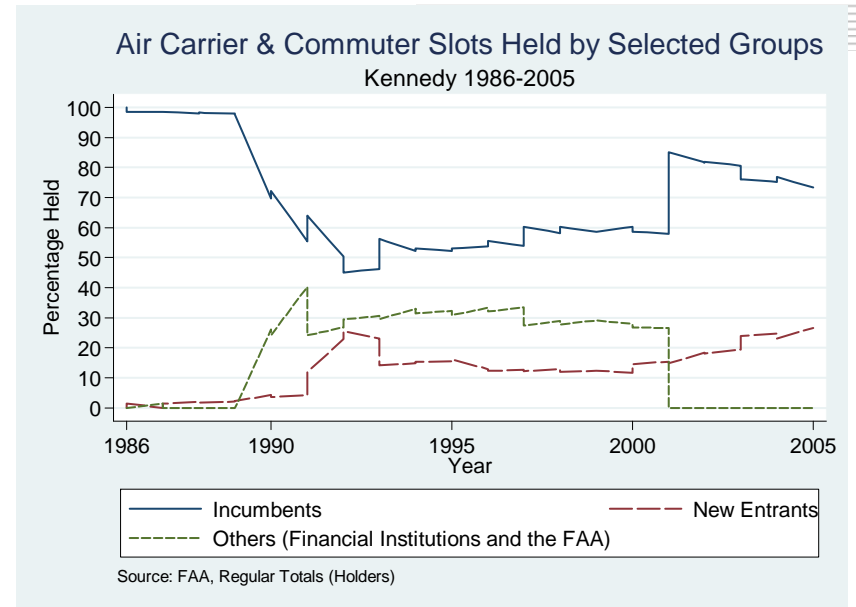
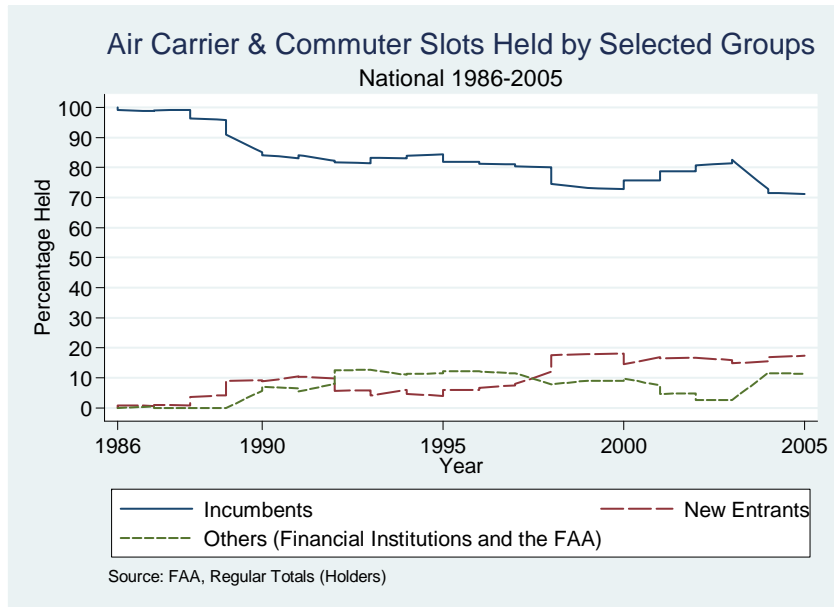


# 1. Purpose and Background



- Purpose
  - Examine whether the slot markets have improved the efficiency of slot use
- Background
  - Lack of sufficient slots at many major airports
  - Need of effective and efficient slot allocation system
- Have the slot markets worked effectively?
  - Slot markets were established in 1986 in the US

# 2. Figure 1: It has been difficult to purchase slots

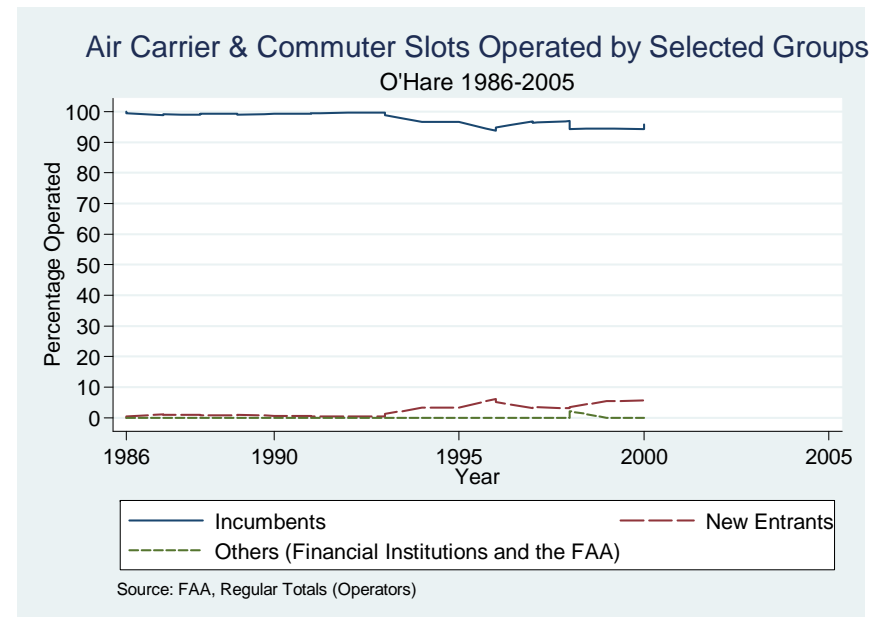
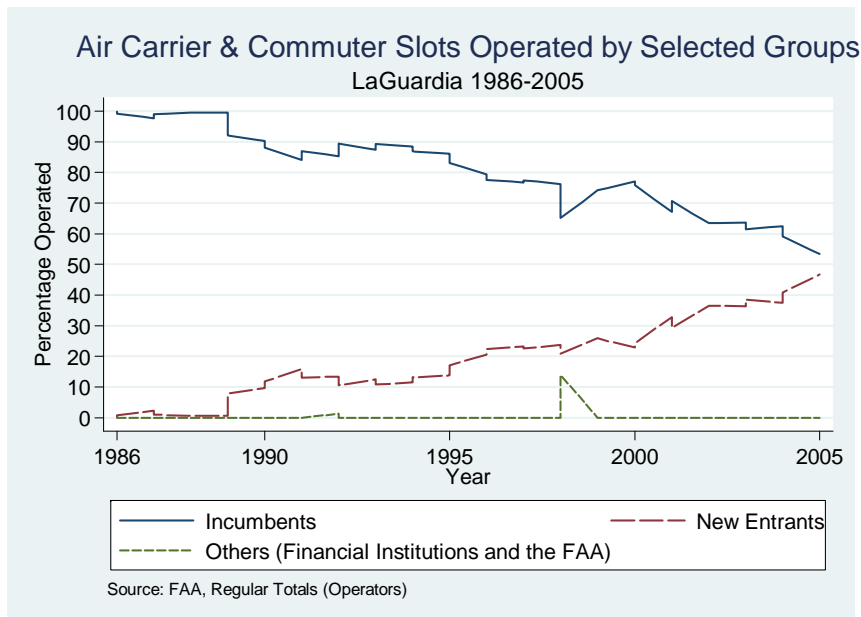
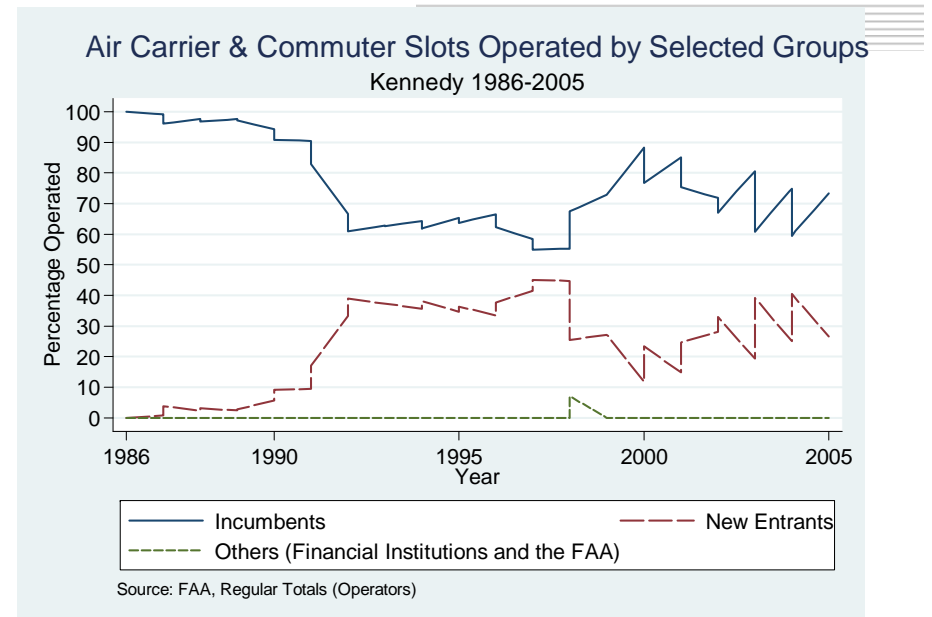
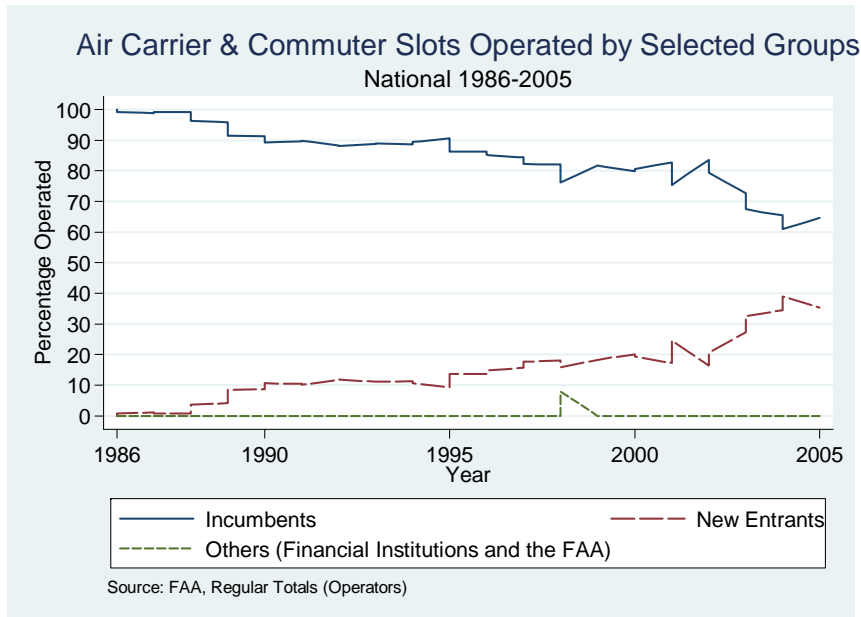


### 3. Previous studies: the GAO



- GAO (1990)
  - “It now appears that allowing airlines to buy and sell slots has not produced the active market for distributing slots envisioned in the buy/sell rule. “
- Allegation of a new entrant
  - “Effectively... the major-incumbent slot holders are routinely able to use their slot holdings to exclude the price-based competition of smaller, low-cost airlines...” (Midway Airlines, OST-2000-6970-1, February 22, 2000).

# 4. Figure 2: It has been slightly easier to lease slots



## 5. Previous studies: Borenstein, the FTC, Kleit and Kobayashi, and Sened



- Borenstein (1988)
  - “Buy/Sell” may be viewed as a great success in increasing the productive efficiency of slot use at O’Hare.
- FTC (1994), Kleit and Kobayashi (1996)
  - Concentration in the slot market was not leading to anticompetitive behavior of incumbent airlines
- Sened (1997)
  - The efficiency of the use of slots has improved considerably as a result of the introduction of slot markets.

## 6. Shortcomings of the previous studies



- GAO (1990, 1996, 1999)
  - Detailed analysis of the efficiency of the use of slots is not included
- Borenstein (1988)
  - National, Kennedy and LaGuardia are not examined
  - Period of data after the introduction of slot market is short (only one year)
- FTC (1994), Kleit and Kobayashi (1996)
  - Data periods are too short (only two months)
- Sened (1997)
  - Kennedy and LaGuardia are not examined
  - Period of data after the introduction of slot market is short (only two years)
  - Only the data of holding slots are analyzed
  - The data of operating slots should be analyzed

## 7. The hypothesis to be tested



- The efficient slot market hypothesis
  - The efficiency of the use of slots has improved considerably as a result of the introduction of slot markets.
  - Suggested by Borenstein (1988), FTC (1994), Kleit and Kobayashi (1996), and Sened (1997)

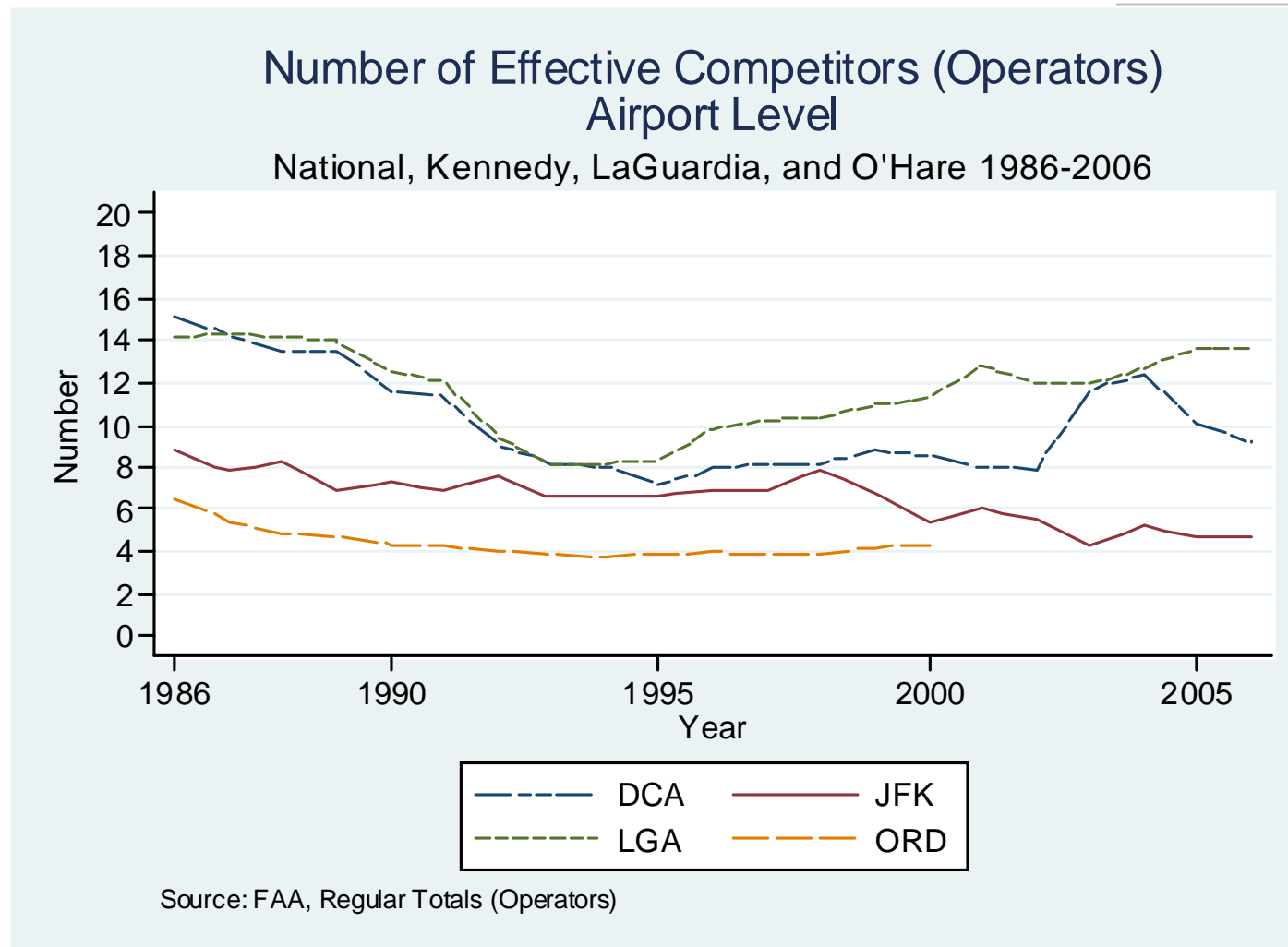


## 8. Data (obtained from the FAA and the DOT)



- Regular Totals
  - FAA's Regular Totals (records of slot allocations) by holder and by operator
  - January and July of each year
  - From 1986 to 2006
- Traffic data
  - DOT's T-100 Domestic Segment (All Carriers) of Air Carrier Statistics (Form 41 Traffic Data)
  - Monthly data
  - From 1990 to 2006
- Financial data
  - DOT's Schedule P-12 of Air Carrier Financial Reports (Form 41 Financial Data)
  - Quarterly data
  - From 1990 to 2006
- The analysis is restricted to the data after 1990
  - Because the traffic and financial data before 1990 could not be obtained

## 9. Figure 3: Number of effective competitors (airport level)



The number of effective competitors is the inverse of the Herfindahl index of slot market concentration, which could be interpreted as representing the number of equal-sized competitors.

The Herfindahl index is defined as the sum of squared percentages of market.

## 10. Advantages and disadvantages of slot concentration

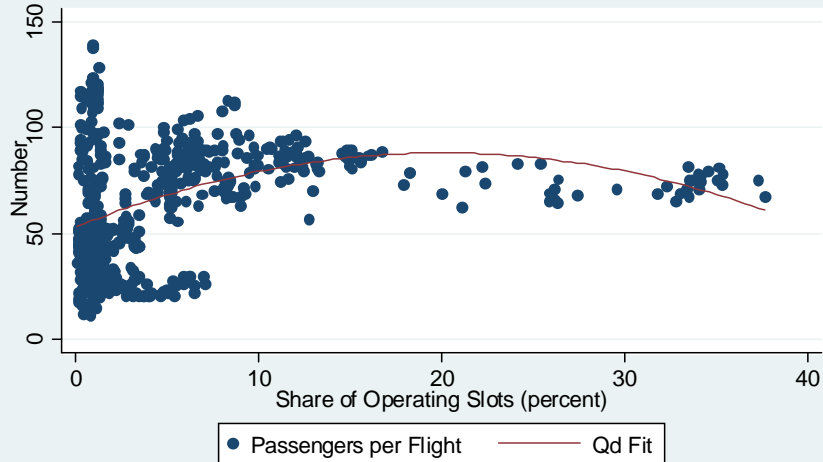


- **Disadvantages**
  - Reduced competition
    - leading to a reduction in welfare
- **Advantages**
  - Efficiency gains from slot concentration
    - Increased connectivity of a carrier
    - Improved service quality
    - Cost advantages (economies of scale or density, etc. )
- **Need to strike balance between the advantages and disadvantages**

# 11. Figure 4: Slot share and passenger transportation

Share of Operating Slots and Number of Passengers per Flight

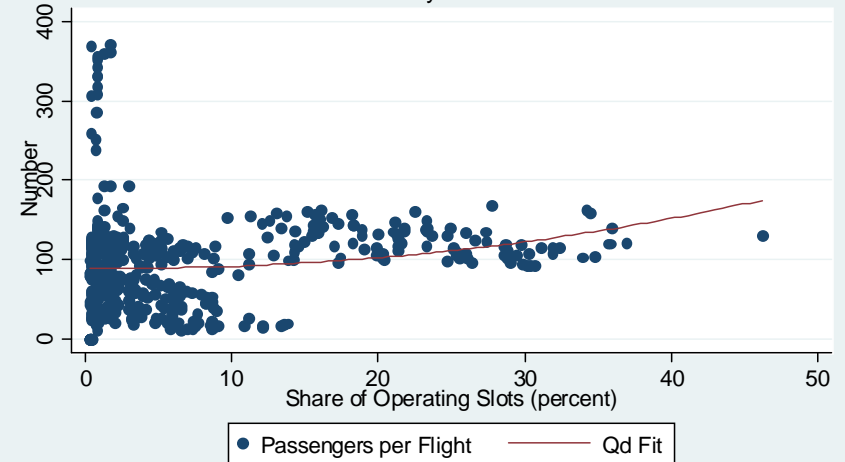
Air Carrier Slot  
National 1986-2006



Source: FAA, Regular Totals (Operators); DOT, T-100 Domestic Segment (All Carriers)

Share of Operating Slots and Number of Passengers per Flight

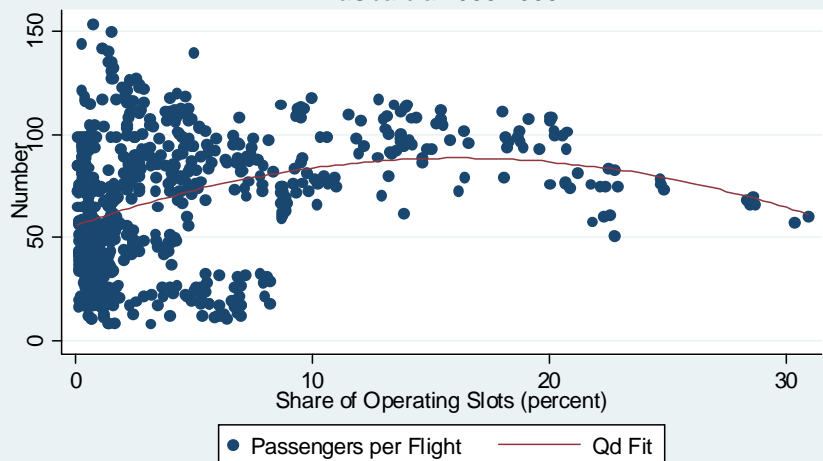
Air Carrier Slot  
Kennedy 1986-2006



Source: FAA, Regular Totals (Operators); DOT, T-100 Domestic Segment (All Carriers)

Share of Operating Slots and Number of Passengers per Flight

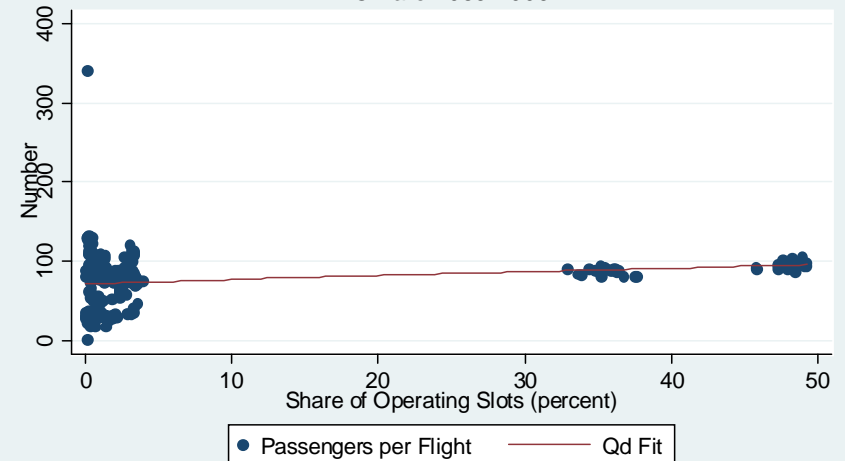
Air Carrier Slot  
LaGuardia 1986-2006



Source: FAA, Regular Totals (Operators); DOT, T-100 Domestic Segment (All Carriers)

Share of Operating Slots and Number of Passengers per Flight

Air Carrier Slot  
O'Hare 1986-2006



Source: FAA, Regular Totals (Operators); DOT, T-100 Domestic Segment (All Carriers)

# 12. Regression analysis

$$\text{PASS}_{\text{cah}} = \beta_0 + \beta_1 \text{SHARE}_{\text{cah}} + \beta_2 \text{SHARE}^2_{\text{cah}} + X\delta + \varepsilon$$

- PASS: the number of passengers per flight
- SHARE: the share of operating slots
- SHARE<sup>2</sup>: the squared term of SHARE (to capture possible nonlinearities)
  - “c,” “a,” and “h” index carriers, airports, and half-year term, respectively
- $X\delta$ : an array of control variables that control for other factors that might affect efficiency of slot use
  - such as operational profit ratio, economies of scale and density
- Descriptions and descriptive statistics of these variables are presented in Appendices A and B.
- Estimated by OLS

# 13. Tables 1 : Estimation result (air carrier slots)

Operating Slots	National		Kennedy		LaGuardia		O'Hare	
Variables	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.
SHARE	2.421***	0.443	-2.919***	0.813	1.040**	0.379	0.787	0.554
SHARE2	-0.046***	0.010	0.086***	0.023	-0.027	0.014	-0.002	0.008
R <sup>2</sup>	0.496		0.294		0.554		0.599	
N	581		472		708		260	
Turnaround Value of SHARE	26.451 (Max)		17.040 (Min)		19.215 (Max)		254.220 (Max)	

Dependent variable is **the number of passengers per flight** of each carrier at each airport during each half year period.

Only the coefficients on SHARE and SHARE<sup>2</sup> are reported. Full results are reported in Appendix C.

Estimated by OLS. Robust standard errors. \* p<0.05, \*\* p<0.01, \*\*\* p<0.001

# 14. Summary

- National
  - Slot share (SHARE) has a significant **negative effect** on the number of passengers per flight beyond the turning point
  - Turning point: 26.451 percent
- Kennedy
  - Slot share (SHARE) has a significant **positive effect** on the number of passengers per flight beyond the turning point
  - Turning point: 17.040 percent

Increase in Slot Share (percentage point)

10% → 11%    20 % → 21%    30 % → 31%    40 % → 41%

Effect on the number of passengers per flight	National	<b>1.501</b>	<b>0.581</b>	<b>-0.339</b>	<b>-1.259</b>
	Kennedy	<b>-1.199</b>	<b>0.521</b>	<b>2.241</b>	<b>3.961</b>

# 15. Conclusion



- Efficient slot market hypothesis
  - Supported partially for National and Kennedy
  - Indeterminate for LaGuardia and O'Hare
- Efficiency gains from slot concentration
  - Potential evidence at Kennedy, but not at National
- Policy implications
  - Need to strike a reasonable balance between the advantages and disadvantages of slot concentration
- Topic for future research
  - Mechanisms for striking such a balance between the advantages and disadvantages of slot concentration



## Appendix A Variable descriptions

<b>Dependent Variable</b>	
PASS	<p>The number of passengers per flight of each carrier at each airport during each half year.</p> <p>This is a measure of the average efficiency which each carrier converts a slot into passenger transportation. In other words, PASS is considered to be representative of the marginal use to which operating carriers put their newly acquired or leased slots.</p> <p>Source: DOT's T-100 Domestic Segment (All Carriers) of Air Carrier Statistics (Form 41 Traffic Data)</p>
<b>Independent Variables</b>	
SHARE	<p>The share of operating slots of each carrier at each airport on the first calendar day of each half year.</p> <p>Source: FAA's Regular Totals (records of slot allocations) by holder and by operator</p>
SHARE <sup>2</sup>	<p>The squared (quadratic) term of SHARE.</p> <p>It captures decreasing or increasing marginal effects of the share of slots on PASS (the number of passengers per flight of each carrier). If the marginal slots transferred from some carriers to other carriers are used efficiently to produce air transportation, the coefficients on SHARE<sup>2</sup> are expected to be positive.</p> <p>Source: FAA's Regular Totals (records of slot allocations) by holder and by operator</p>
LOADFAC	<p>The average load factor of each carrier at each airport during the previous half year.</p> <p>Other things being equal, an increase of load factor on flights leads to an increase of PASS (the number of passengers per flight of each carrier). In addition, if the load factor on flights increases, the per-passengers cost of the flight declines. It may lower fares of the flight and attract more passengers for the carrier. Thus, the coefficients on LOADFAC are expected to be positive.</p> <p>Source: DOT's T-100 Domestic Segment (All Carriers) of Air Carrier Statistics (Form 41 Traffic Data)</p>
ROUTE	<p>The number of routes served by each carrier at each HDR airport during the previous half year (that captures the effects of economies of scale).</p> <p>This variable, which is indicator of the size of each carrier's flight network, is included to control for economies of scale associated with the carriers' flight networks. If there are economies of scale, the average cost of production will decline as the network expands and the output increases. It may lower average fares of the carriers and attract more passengers for the flights of carriers. Thus, the coefficients on ROUTE are expected to be positive.</p> <p>Source: DOT's T-100 Domestic Segment (All Carriers) of Air Carrier Statistics (Form 41 Traffic Data)</p>

<b>Independent Variables (continued)</b>	
LN_RPM	<p>The logarithmic transformed revenue passenger miles (in millions) per route served by each carrier at each HDR airport during the previous half year.</p> <p>This variable, which is indicator of the productivity due to the traffic density per route of each carrier, is included to control for economies of density associated with the carriers' flight networks. Economies of density allow a more intense use of equipment or larger equipment, thus possibly increasing the number of passengers per flight. Therefore, the coefficients on LN_RPM are expected to be positive.</p> <p>Source: DOT's T-100 Domestic Segment (All Carriers) of Air Carrier Statistics (Form 41 Traffic Data)</p>
PRO_RATIO	<p>The operating profit ratio of each carrier during the previous half year.</p> <p>PRO_RATIO captures the effects of profitability of each carrier. High profitability allows a carrier to grow in size. Thus, the coefficients on PRO_RATIO are expected to be positive.</p> <p>Source: DOT's Schedule P-12 of Air Carrier Financial Reports (Form 41 Financial Data)</p>
INC	<p>Incumbent dummy that denotes whether the lessee is an incumbent (new entrant) carrier.</p> <p>For the purposes of this study, a new entrant refers to a carrier that did not hold a slot at a particular HDR airport before April 1, 1986, when it became possible to buy, sell, or lease slots. If incumbent carriers have some advantages in buying or leasing slots, the coefficients on INC are expected to be positive.</p> <p>Source: FAA's Regular Totals (records of slot allocations) by holder and by operator</p>
HALF	<p>Half year dummy variables that control for unobservable or difficult-to-measure factors that may change over time. These factors include such as air travel trends.</p> <p>The omitted base category is the first half year of 1990.</p>

**Appendix B Descriptive statistics**

Variables	National				Kennedy			
	Mean	Standard deviation	Minimum	Maximum	Mean	Standard deviation	Minimum	Maximum
PASS								
SHARE	5.680	7.508	0.152	37.652	6.984	9.057	0.370	46.237
SHARE2	88.535	236.140	0.023	1417.706	130.639	276.820	0.137	2137.820
LOADFAC	56.681	13.399	12.950	96.000	57.350	17.216	5.901	100.000
ROUTE	11.382	10.735	1.000	47.000	15.891	12.745	1.000	55.000
LN_RPM	16.348	1.699	6.842	19.005	16.570	1.824	6.632	19.418
PRO_RATIO	-23.884	229.572	-2480.528	19.449	-8.654	115.098	-2480.528	24.131
INC	0.453	0.498	0.000	1.000	0.426	0.495	0.000	1.000
N		581				472		
Variables	LaGuardia				O'Hare			
	Mean	Standard deviation	Minimum	Maximum	Mean	Standard deviation	Minimum	Maximum
PASS								
SHARE	4.661	5.840	0.100	30.936	8.077	15.128	0.059	49.222
SHARE2	55.778	129.198	0.010	957.050	293.227	694.632	0.004	2422.785
LOADFAC	54.786	14.401	14.639	100.000	58.280	12.018	17.618	94.981
ROUTE	13.488	12.836	1.000	50.000	29.650	32.347	1.000	115.000
LN_RPM	16.300	1.953	7.333	19.720	16.661	1.518	8.332	18.863
PRO_RATIO	-34.974	278.171	-2480.528	19.449	-28.354	265.672	-2480.528	14.637
INC	0.352	0.478	0.000	1.000	0.735	0.442	0.000	1.000
N		708				260		

Half year dummies are omitted from the table to save space.

**Appendix C Estimation result: National, Kennedy, LaGuardia, and O'Hare, 1990 - 2006**

Dependent Variable: Number of passengers per flight (PASS)

Independent Variables	National			Kennedy			LaGuardia			O'Hare		
	Coeff.		Std. Err.	Coeff.		Std. Err.	Coeff.		Std. Err.	Coeff.		Std. Err.
SHARE	2.421	***	0.443	-2.919	***	0.813	1.040	**	0.379	0.787		0.554
SHARE2	-0.046	***	0.010	0.086	***	0.023	-0.027		0.014	-0.002		0.008
LOADFAC	0.645	***	0.085	0.717	**	0.268	0.668	***	0.111	0.620	***	0.172
ROUTE	-0.705	***	0.113	0.380		0.255	-0.656	***	0.116	-0.519	***	0.100
LN_RPM	6.052	***	0.871	10.894	***	3.088	4.322	***	0.876	13.148	***	2.945
PRO_RATIO	0.010	**	0.003	-0.004		0.006	-0.020	***	0.003	0.002		0.005
INC	5.895	*	2.738	-0.472		5.025	33.018	***	3.012	1.364		3.486
Constant	-71.254	***	14.872	-133.895	***	36.318	-62.066	***	13.020	-176.261	***	45.802
Half Year Controls	Yes			Yes			Yes			Yes		
R <sup>2</sup>	0.496			0.294			0.554			0.599		
Number of Observations	581			472			708			260		
Turnaround Value of SHARE	26.451 (Max)			17.040 (Min)			19.215 (Max)			254.220 (Max)		

Estimated by OLS. Robust standard errors. \* p<0.05, \*\* p<0.01, \*\*\* p<0.001

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