CENTER FOR ADVANCED AVIATION SYSTEM DEVELOPMENT (CAASD)

US Airline Network: A Framework of Analysis and Some Preliminary Results

Dipasis Bhadra and Brendan Hogan

Paper to be presented at the Airline Evolution and Change: Deregulation and Beyond Session of the 46th Annual Forum of the Transportation Research Forum

Aviation Institute, Marvin Center
George Washington University

March 7, 3:30-5:00

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The Airline Industry is Undergoing Structural Change

"What ails the airlines…was evident before 9/11, and goes well beyond the current downturn in the economy, to something more fundamental."

Donald Carty, Chairman and CEO American Airlines
September 6, 2002

But what will the "restructured" future look like?

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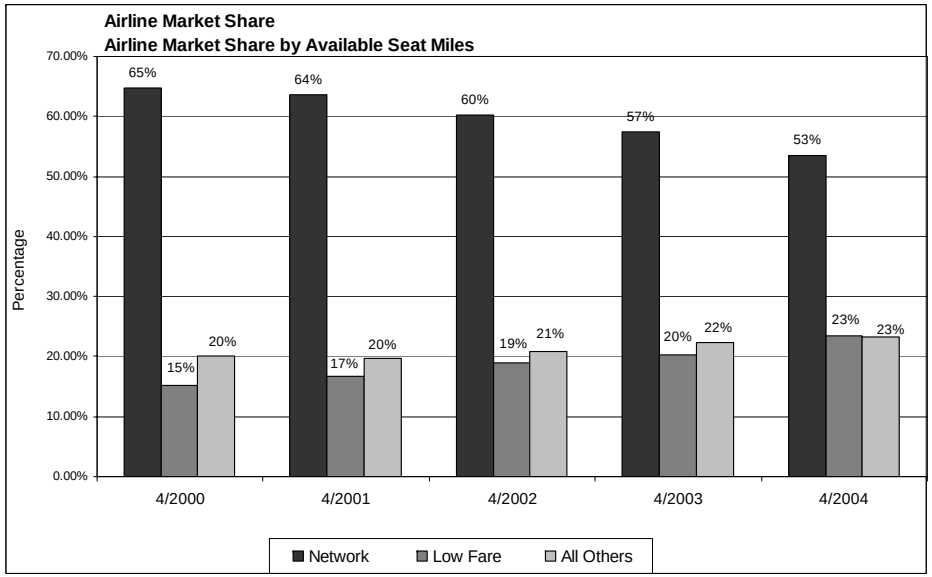
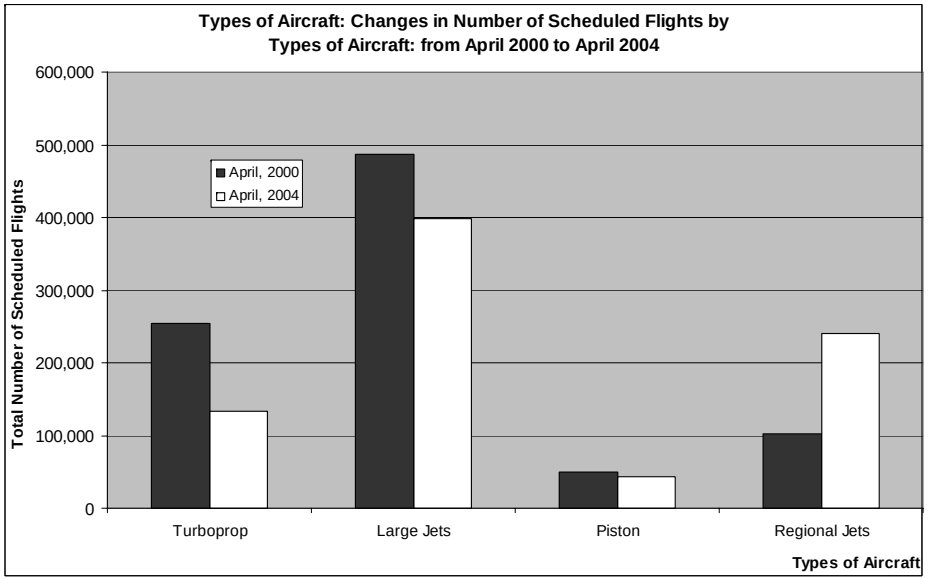
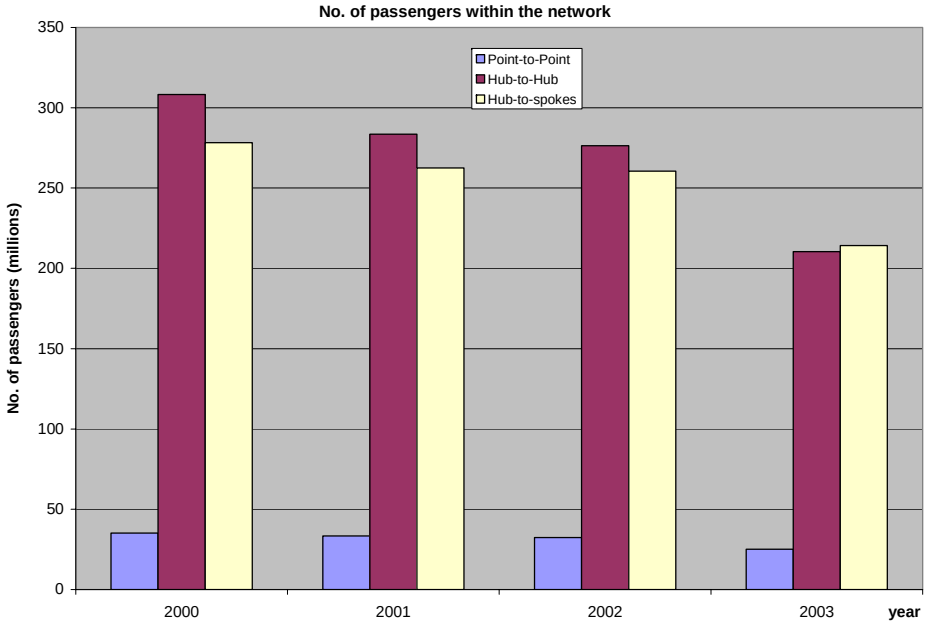
Declining Share of Network Carriers are Being Filled up By LCCs and Regional Carriers; More RJs Substitute for Large Jets and Turbo Props

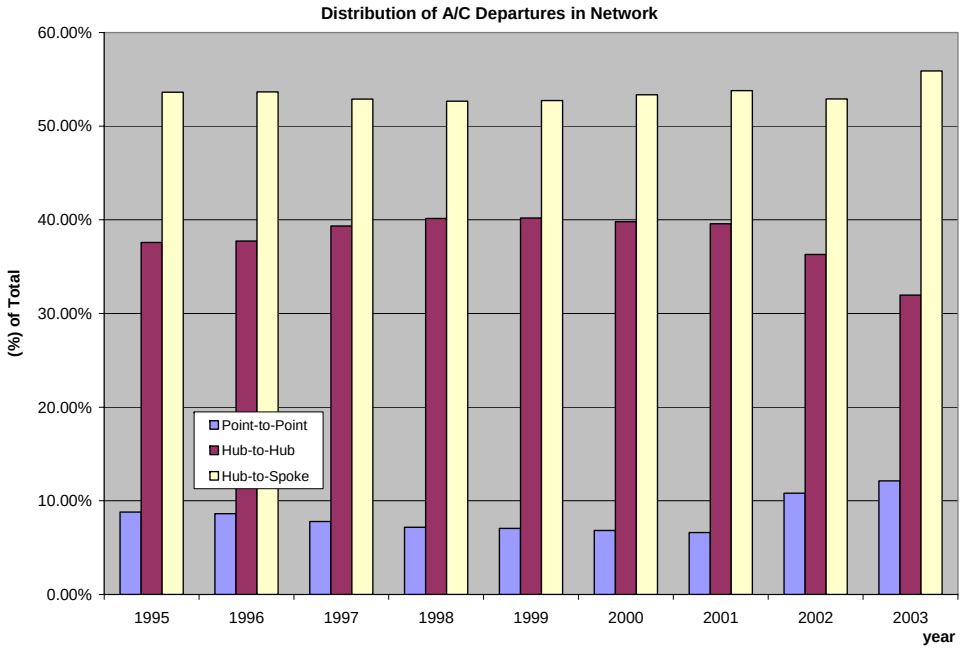




Source: Mark Dayton, 2004

While Large Hub Airports (i.e., OEP 35) Lose Relative Importance, Smaller Airports Gain





Source: Derived from T100 Segment, Bhadra/Texter 2004.

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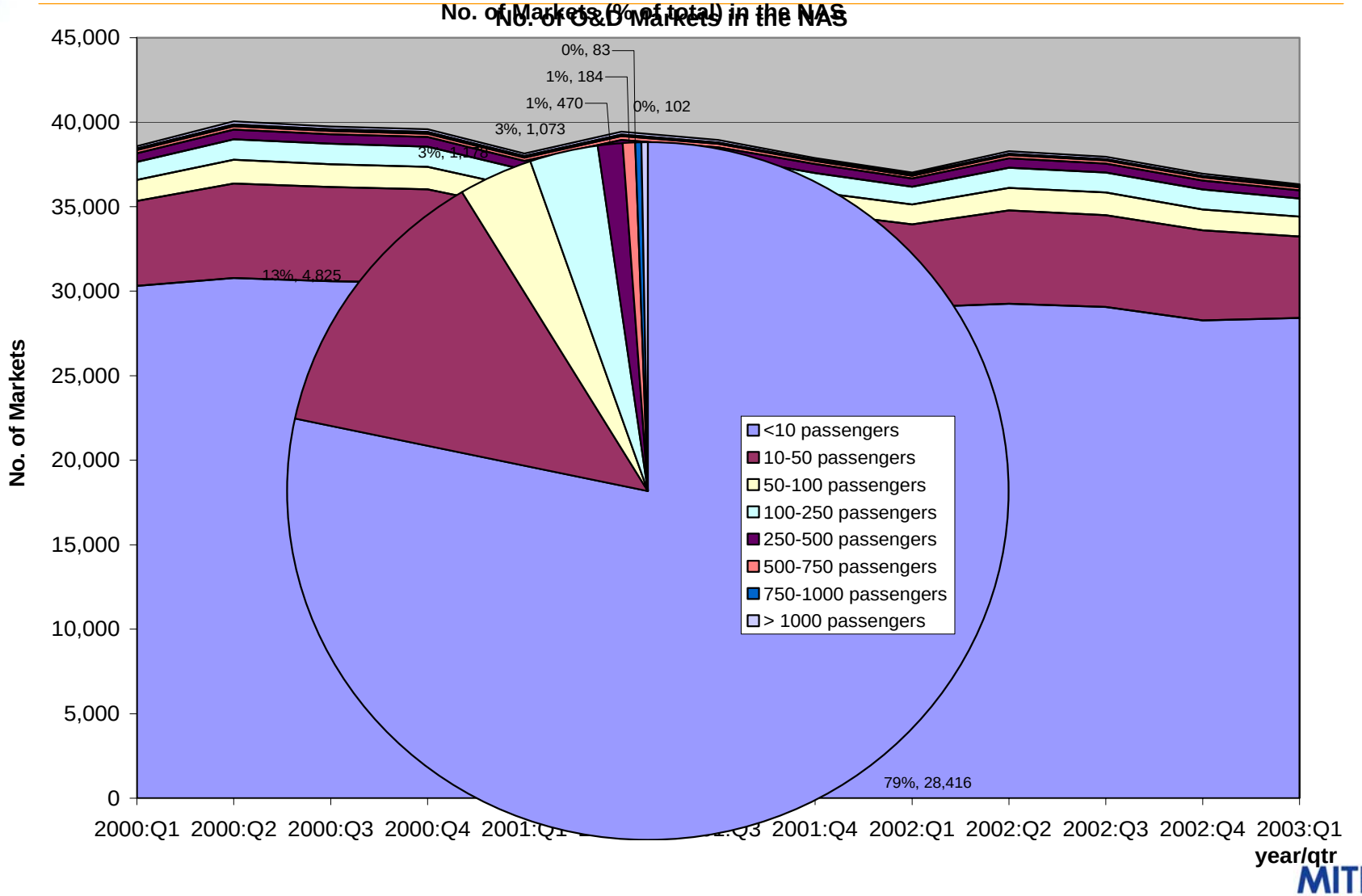
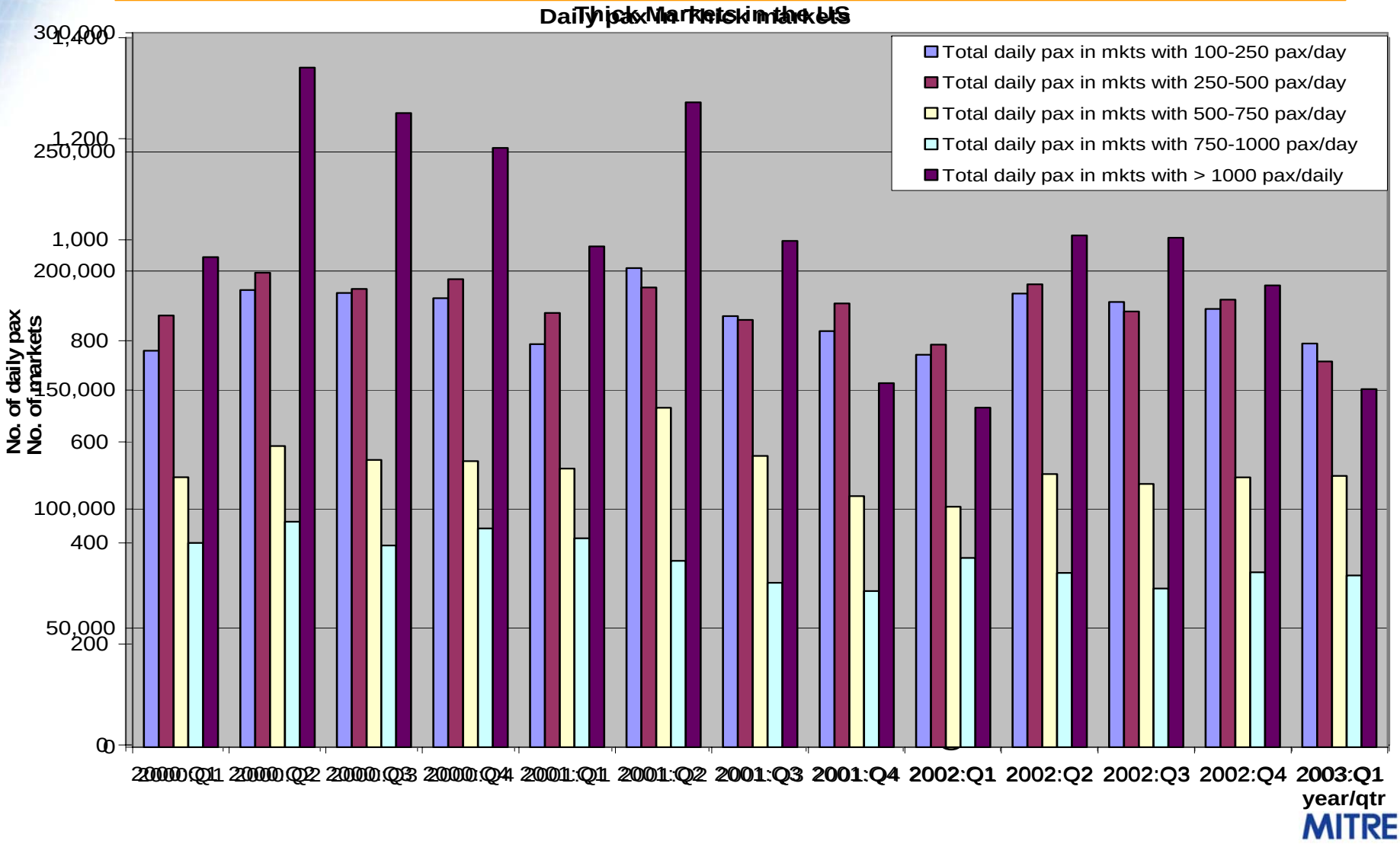
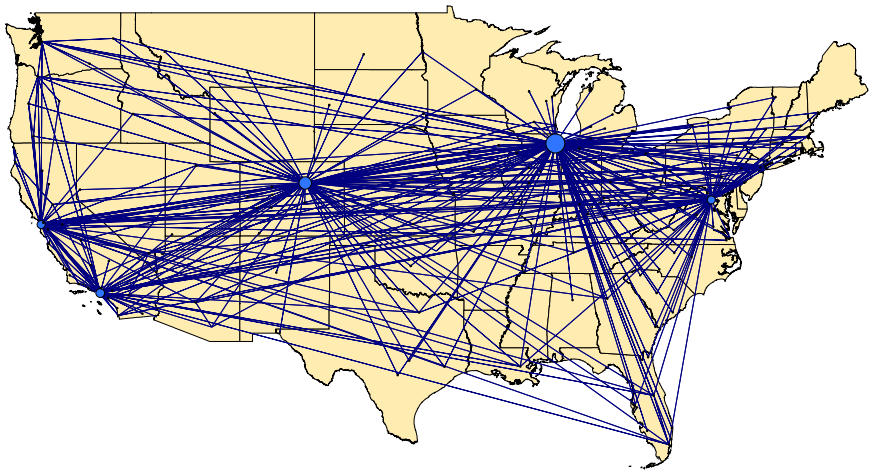
Although the Underlying Market Structures Have Not Changed Fundamentally



Upper End of the O&D Markets (Both in Terms of Numbers and Passengers) Appear To Be Fairly Stable Over Time



Airline Network Used To Be Primarily Hub-and-Spoke



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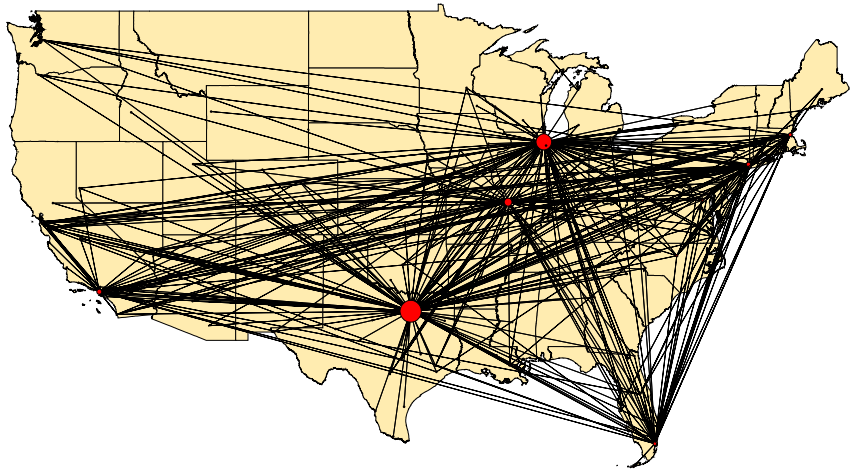

AmericanAirlines

January 03, 2003 (Domestic)

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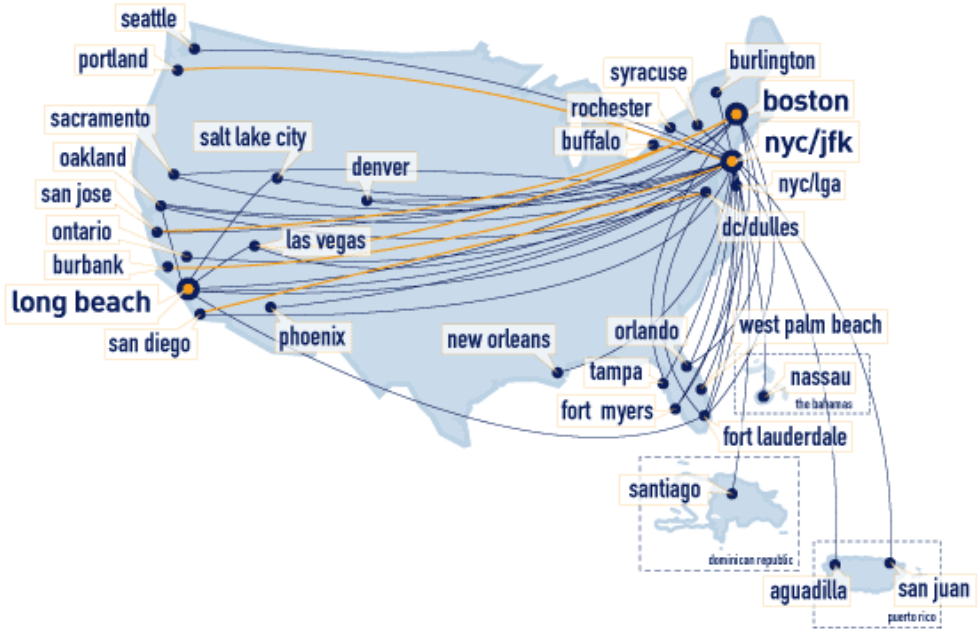
Some of the Leading LCCs are also Hub-and-spoke Network Carriers



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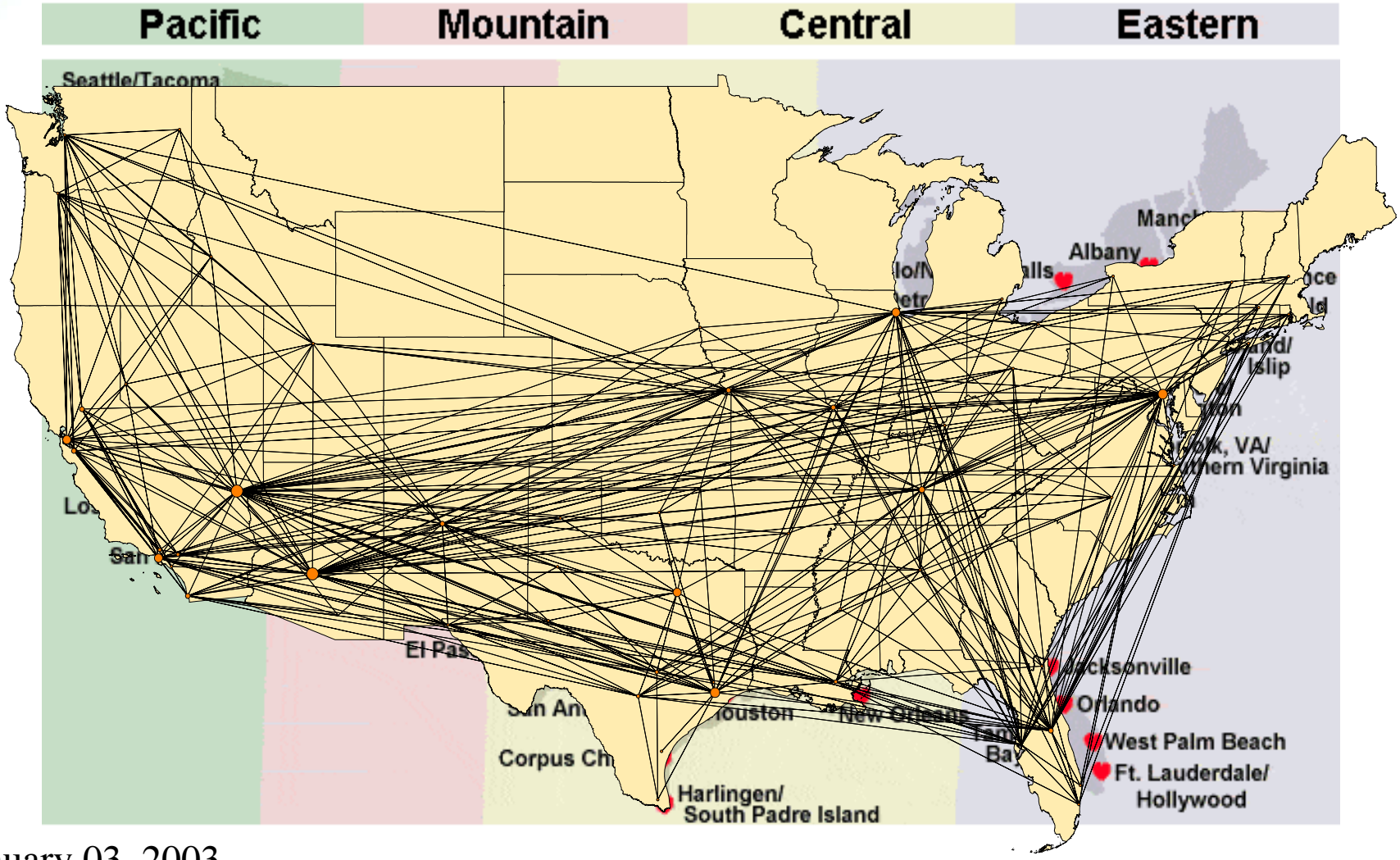
However, with Increasing Importance of Southwest, Network Has become Far More Distributed



January 03, 2003

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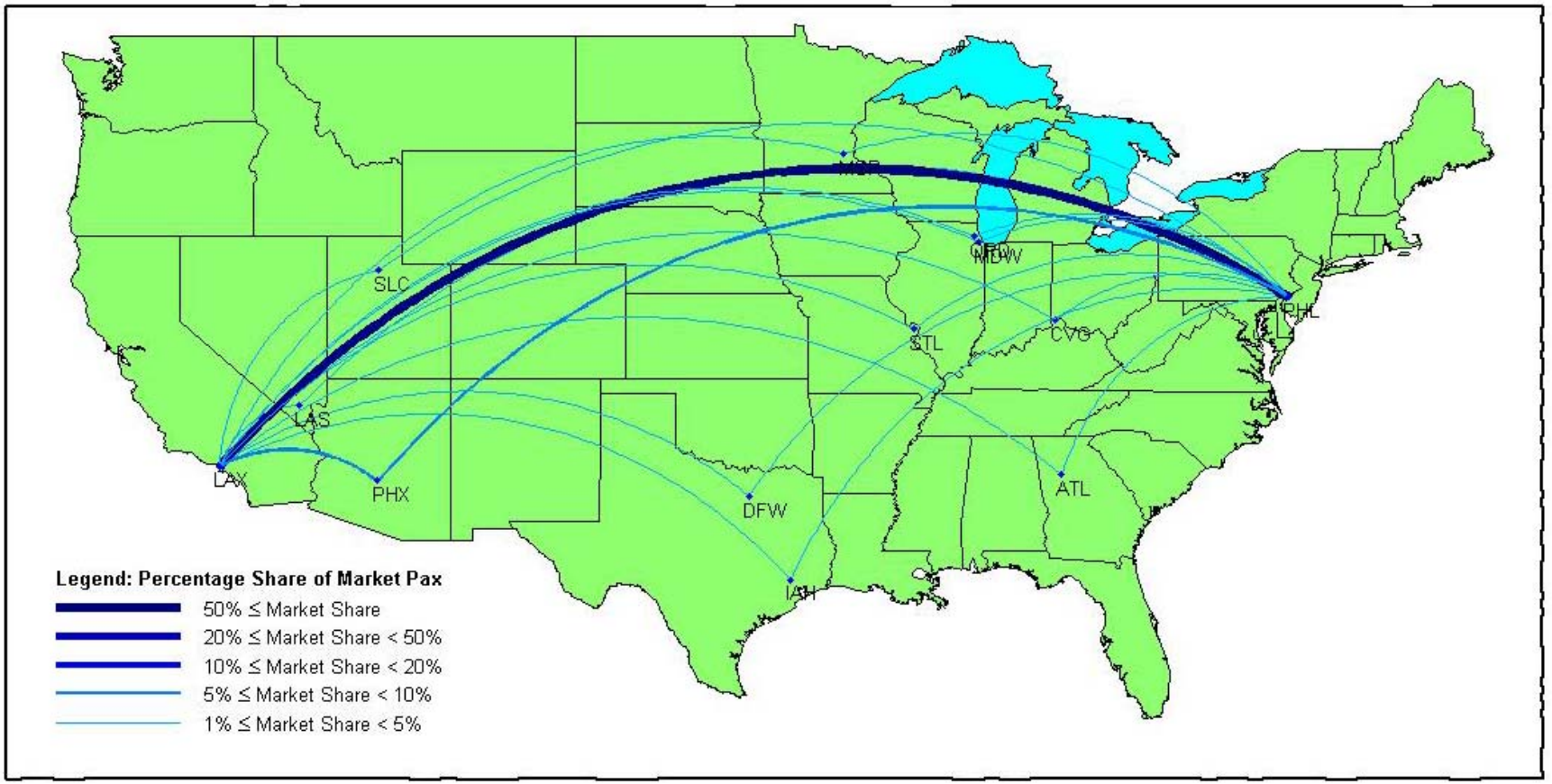
Visual Example of a Centralized Market



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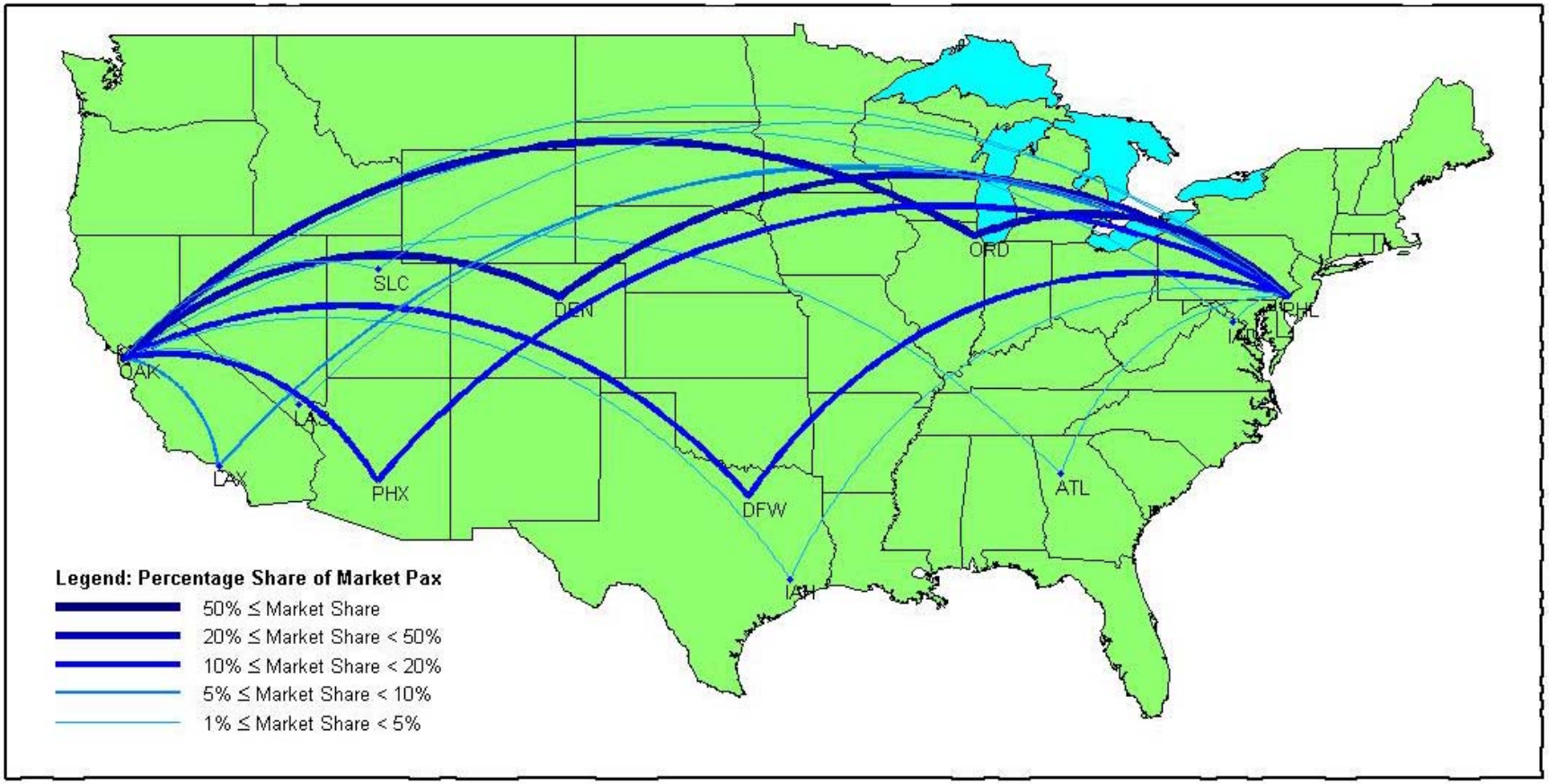
Visual Example of a Distributed Market



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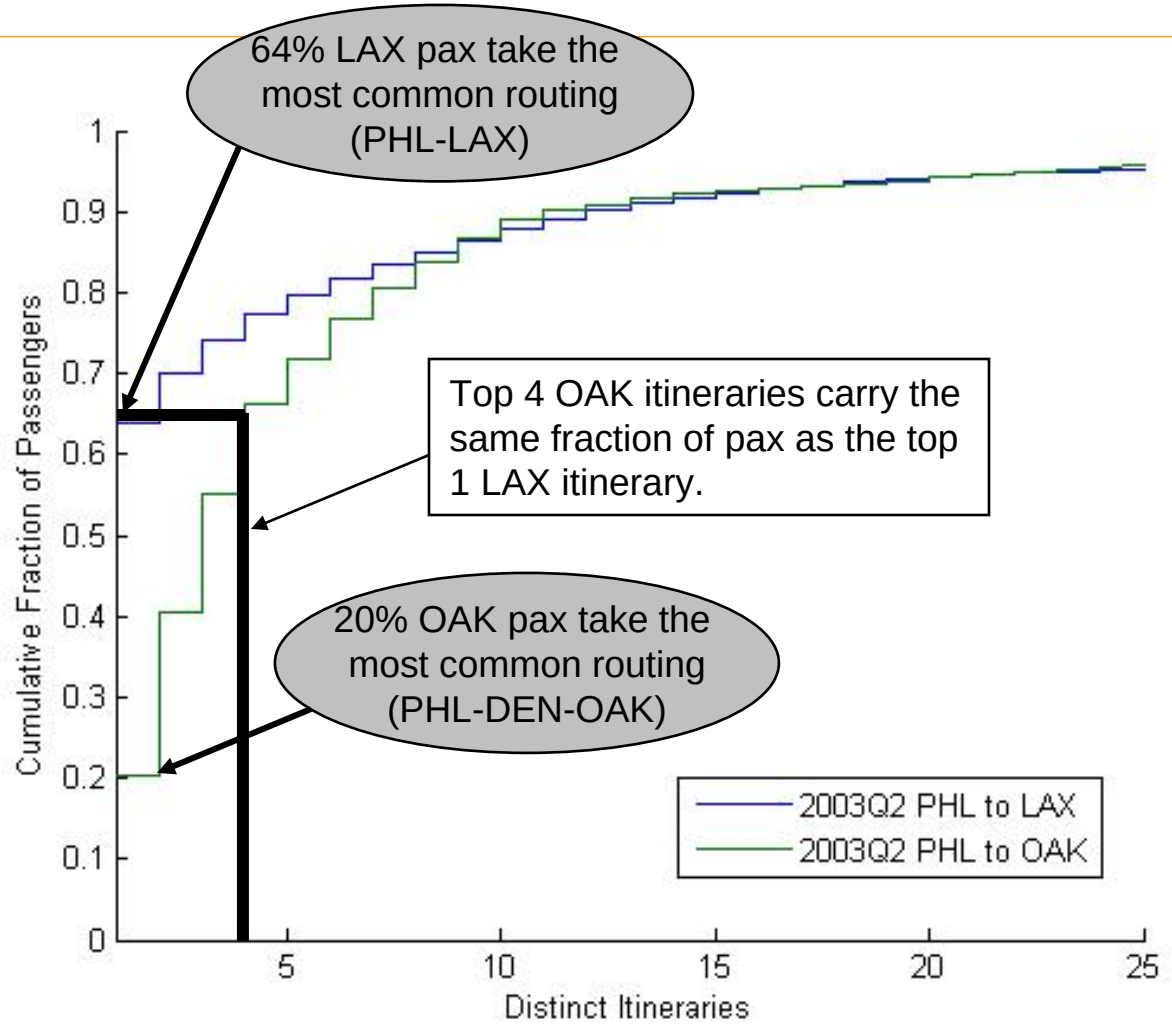
Quantitative Difference between Example Distributed and Centralized Markets



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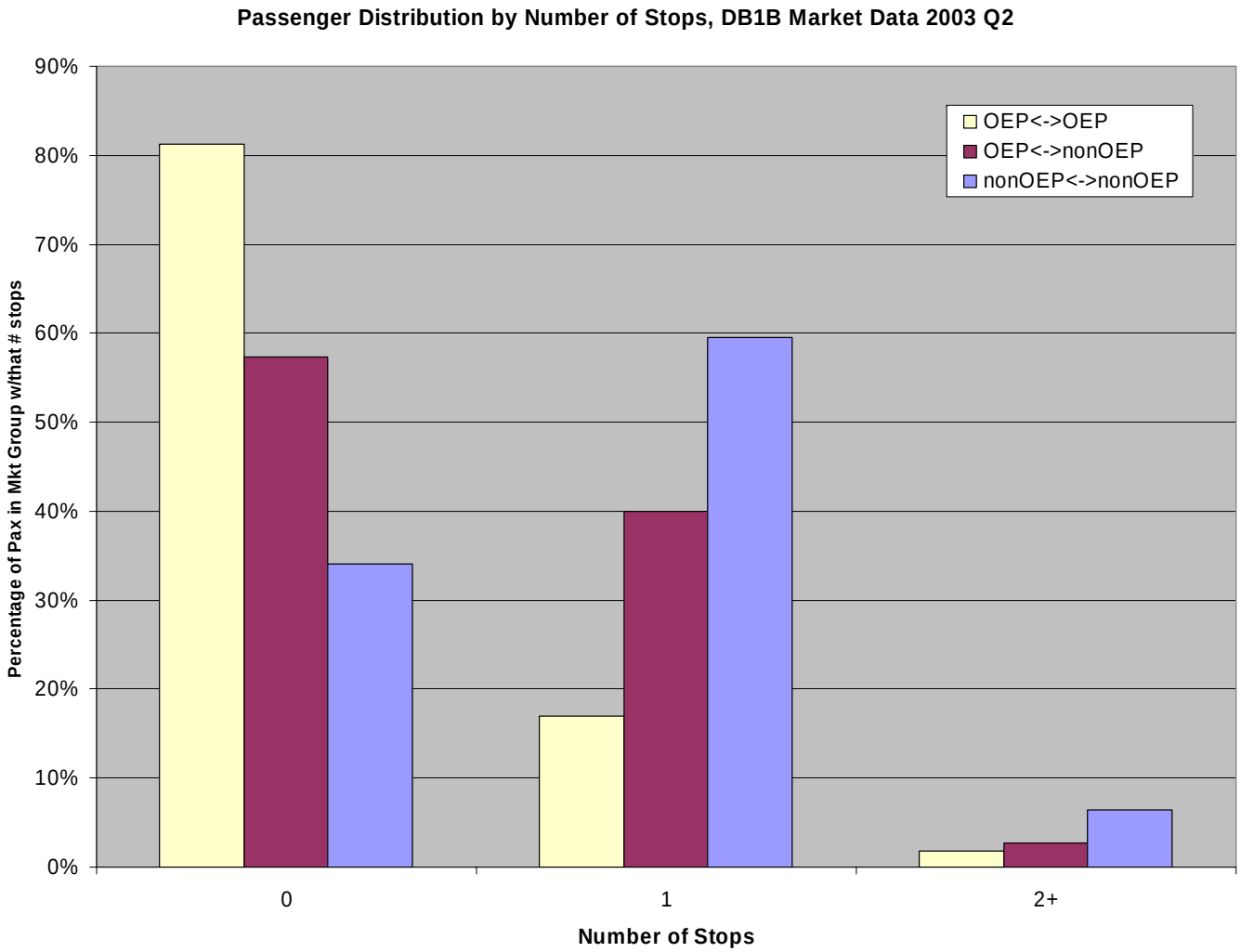
Number of stops observed to vary by market type

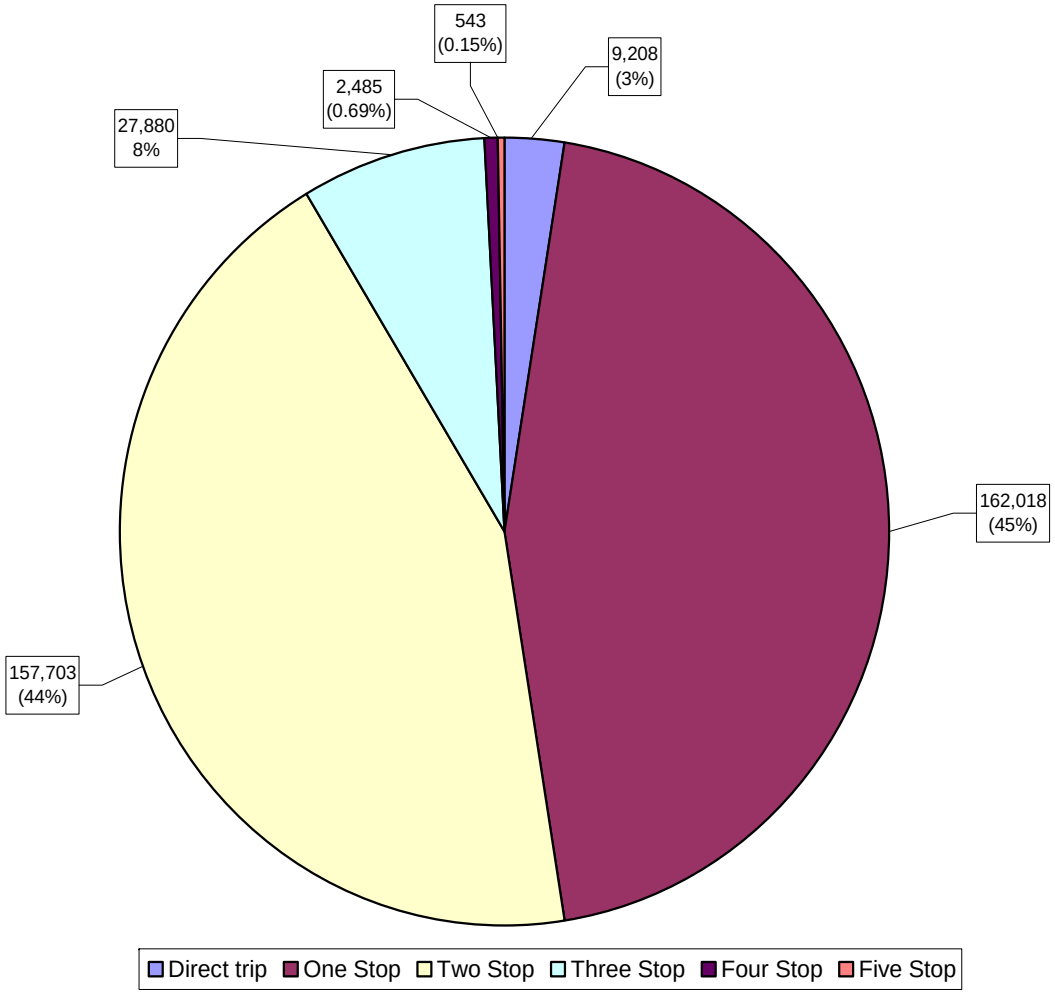


Analytical Model to Determine Itinerary Number of Stops by Market

$$P_i (y_i = j | x_i, \beta) \quad (j = 1, 2, \ldots, 6) = \alpha_{ij} + \beta_1 (\text{passengers\_Inline}) + \beta_2 (\text{Average Distance}) + \beta_3 (\text{Passengers\_O\&D Market}) + \beta_4 (\text{Weighted Average Fare}) + \beta_5 (\text{Presence of Network Carriers}) + \beta_6 (\text{Presence of LCC Carriers}) + \varepsilon_i \qquad \text{(E.1)}$$

Network Information from Itinerary Data

Types of Itinerary in the NAS: Aggregated by Origin and Destination (O&D)
2nd Quarter, 2003: N=359,837



Estimated Results from Multi-nomial Logit

Parameters*	One Stop Vs. Direct Route	Two Stop Vs. Direct Route	Three Stop Vs. Direct Route	Four Stop Vs. Direct Route	Five Stop Vs. Direct Route	Direct Route Vs. All Non-Direct Routes**
Intercept	1.3093	1.7519	0.8474	-1.3892	-2.2153	-1.5764
Passengers_Inline	-0.0129	-0.4963	-1.8749	-2.9525	-2.6818	0.0154
Passengers_O&D Market	0.00177	0.00187	0.00192	0.00196	0.00199	-0.00182
Weighted Average Fare	0.00616	0.00496	0.00460	0.00538	0.00502	-0.00586
Average Distance	0.000282	0.00128	0.00161	0.00176	0.00181	-0.00062
Presence of Network Carriers	0.4609	0.4126	0.6635	1.0609	-0.00869	-0.4640
Presence of LCC Carriers	-0.7429	-1.4307	-1.4664	-1.5098	-2.7836	0.9311

'*' : All parameters are statistically significant at greater than 99% level of significance ; '**' : There are two ways of deriving this. First, we can rerun logit program using different base and derive the parameters; and/or use all non-direct routes (i.e., itinerary stops $\geq$ 1) as a choice against the alternative of direct route as a binary model. We run the latter to extract the model parameters for direct route.

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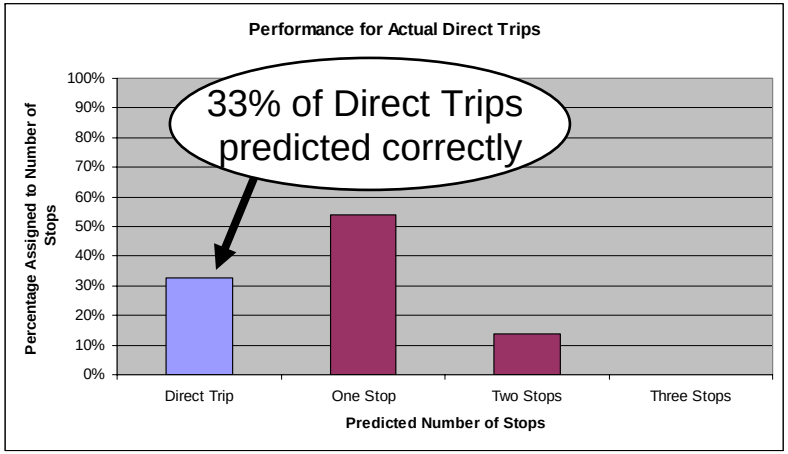
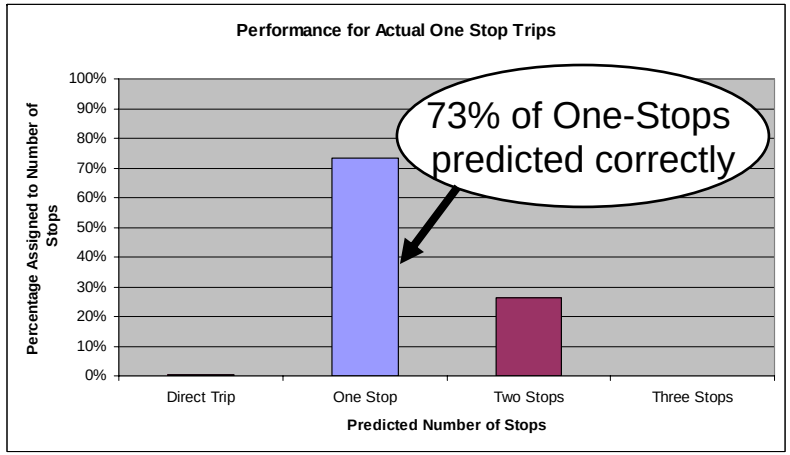
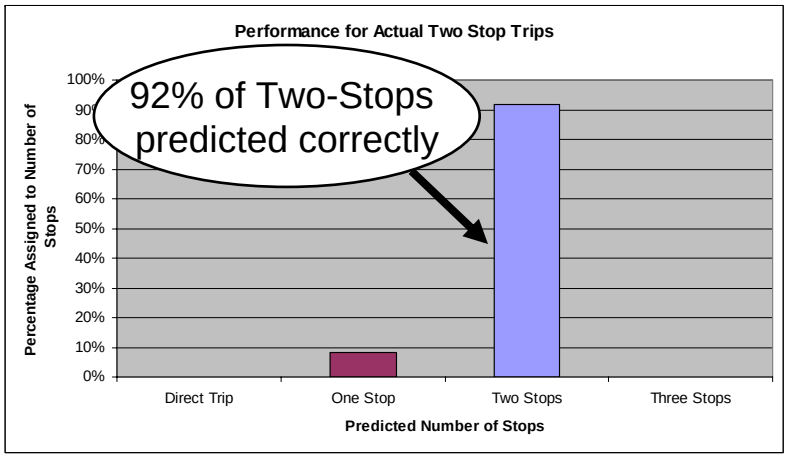
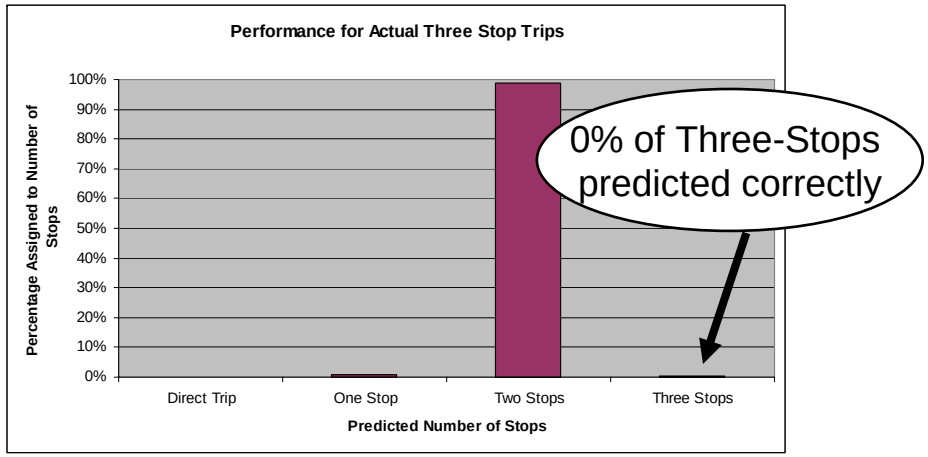
Predictive Performance of Logit Model

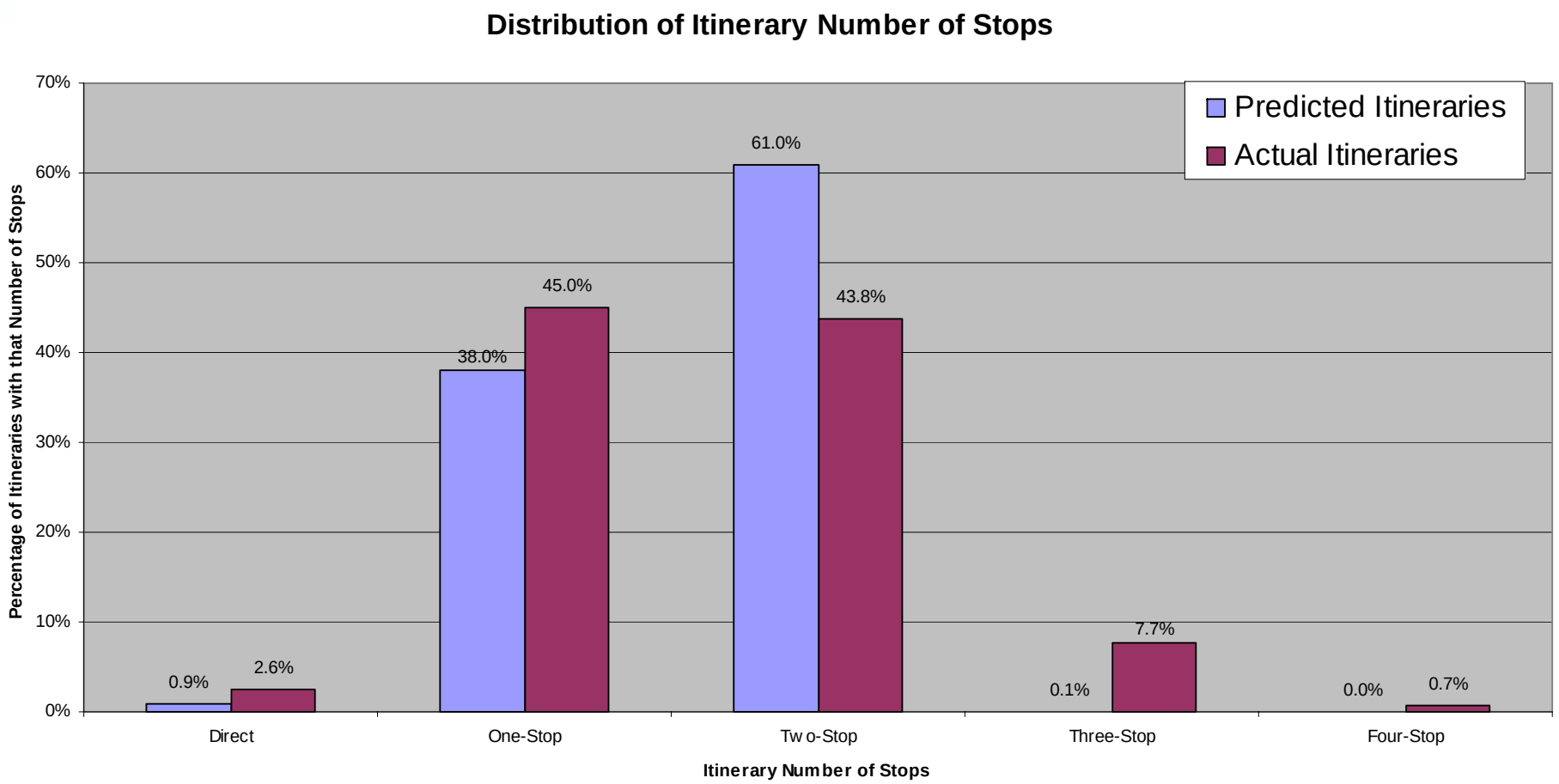








Overall Allocation of Number of Stops



Recap…and Next Steps

- **We have developed a model for the number of stops between an OD pair**
  - **Carriers have been aggregated together to do this**
- **It remains to determine where they will stop**
- **The economics of hubs and the cost advantages between carriers must be built into the model**

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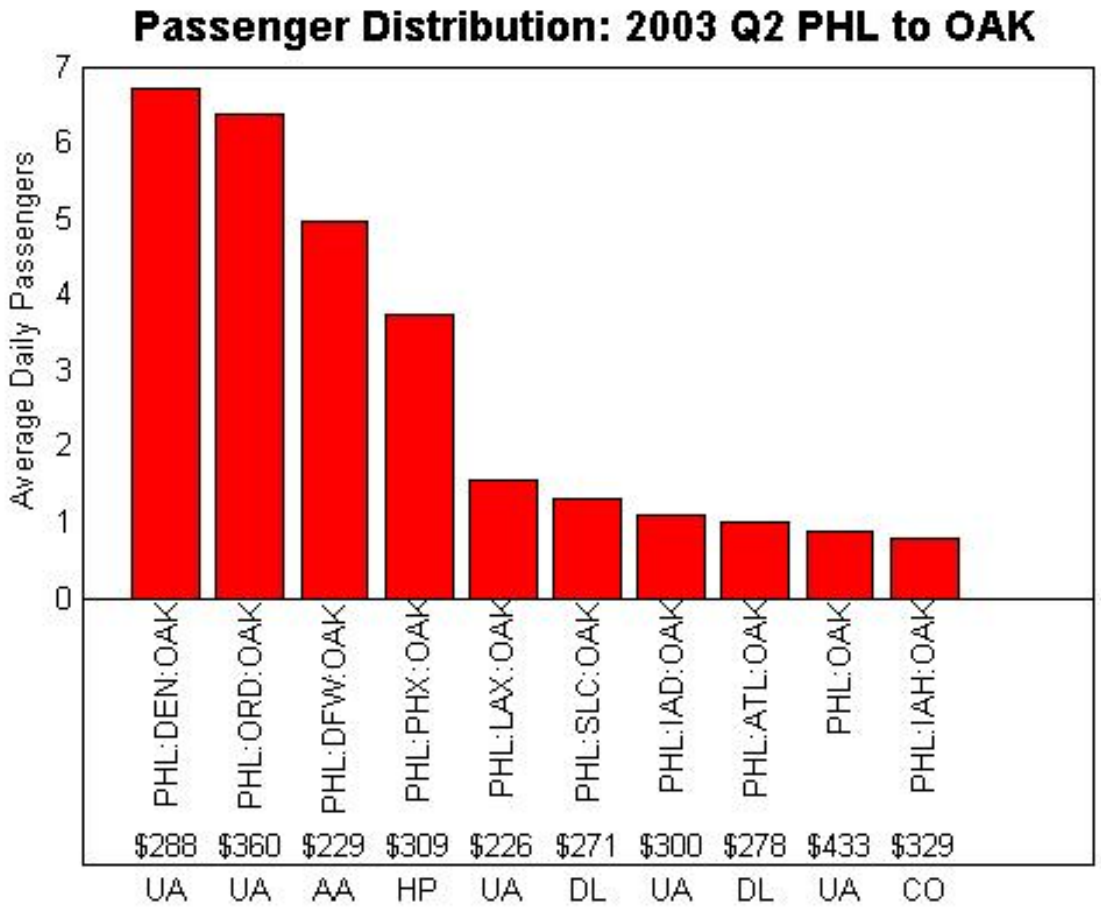
Passenger Routings Give Insight into Airline Cost Advantages



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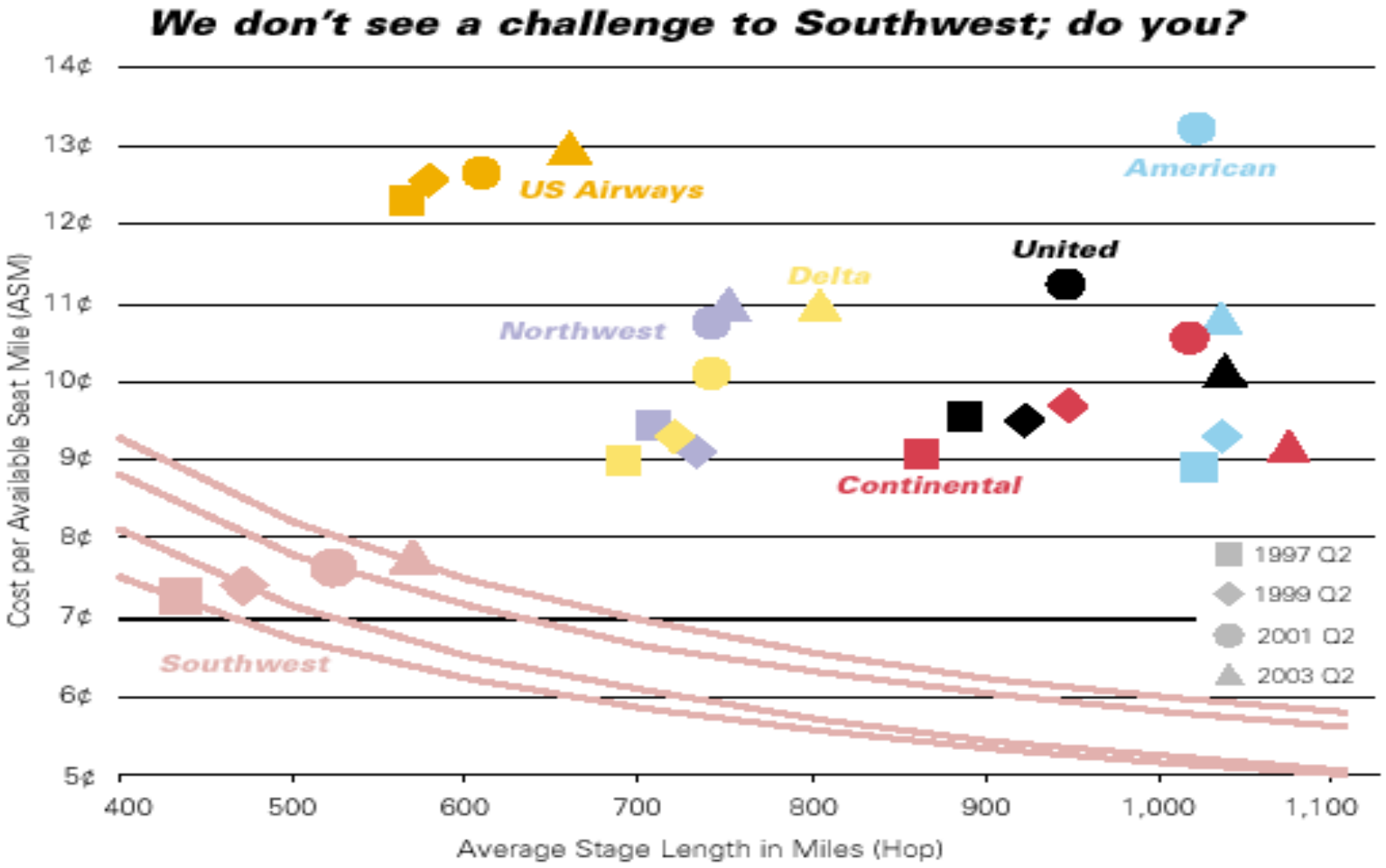
Southwest's cost advantage over others



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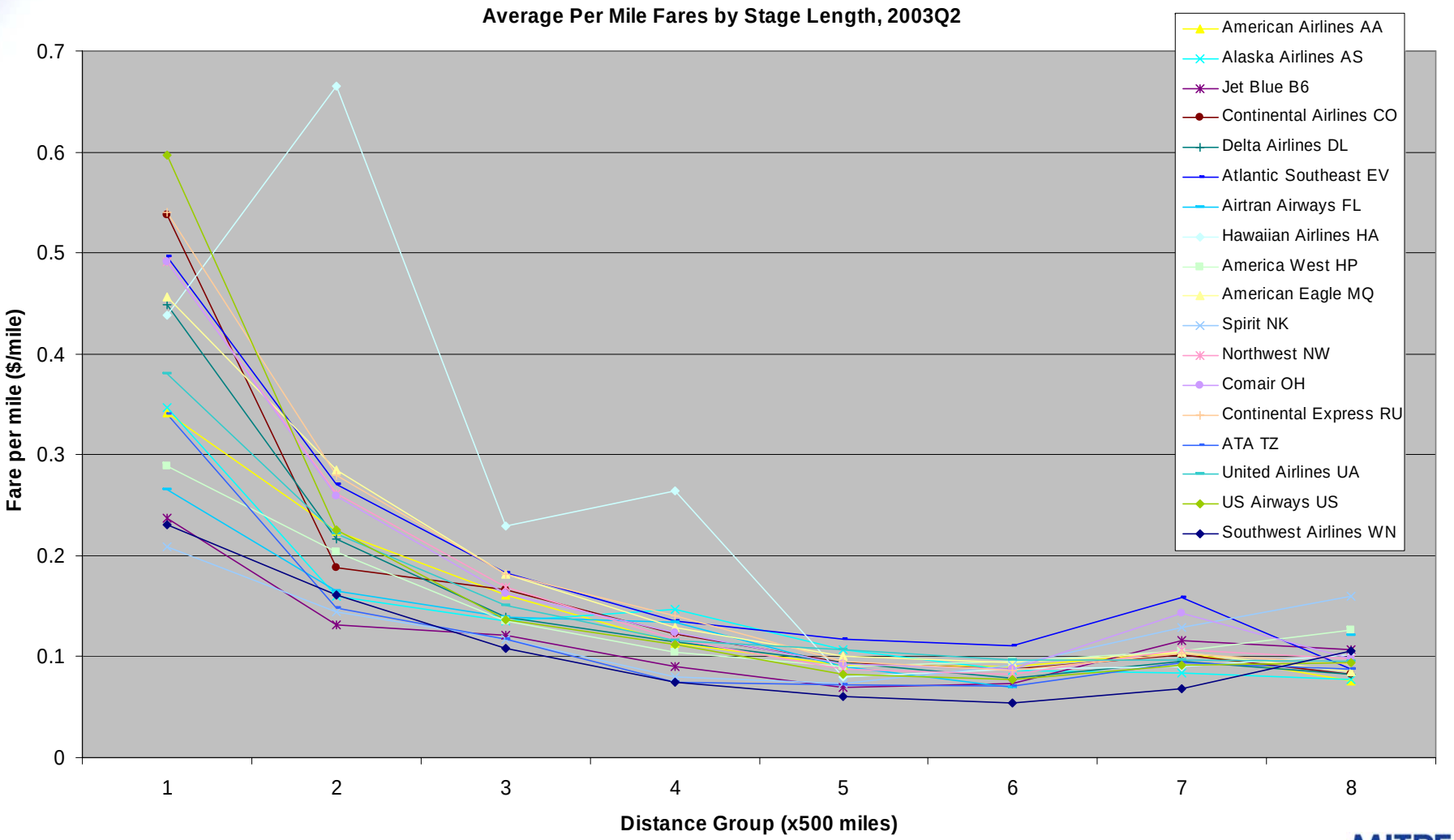
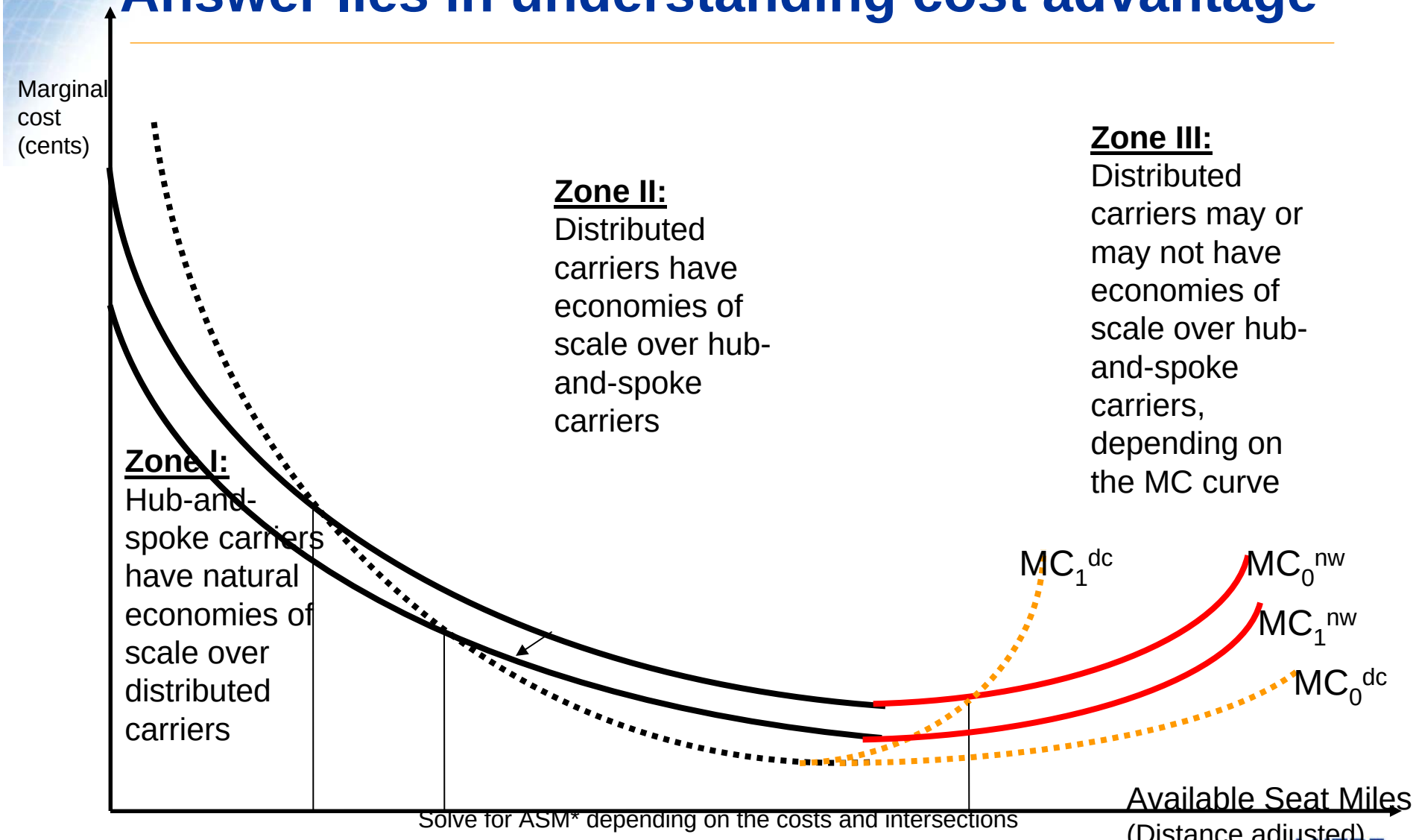
Carrier Average Fares by Distance Group



Will low-cost carriers and hence their nework structure inherit the earth?

Answer lies in understanding cost advantage



nw: network carriers; dc: distributed carriers

Please leave us your contacts for details and a revised paper

- **Dipasis Bhadra: dbhadra@mitre.org**
- **Brendan Hogan: bhogan@mitre.org**
- **Visit us at: www.mitrecaasd.org**

Thank you

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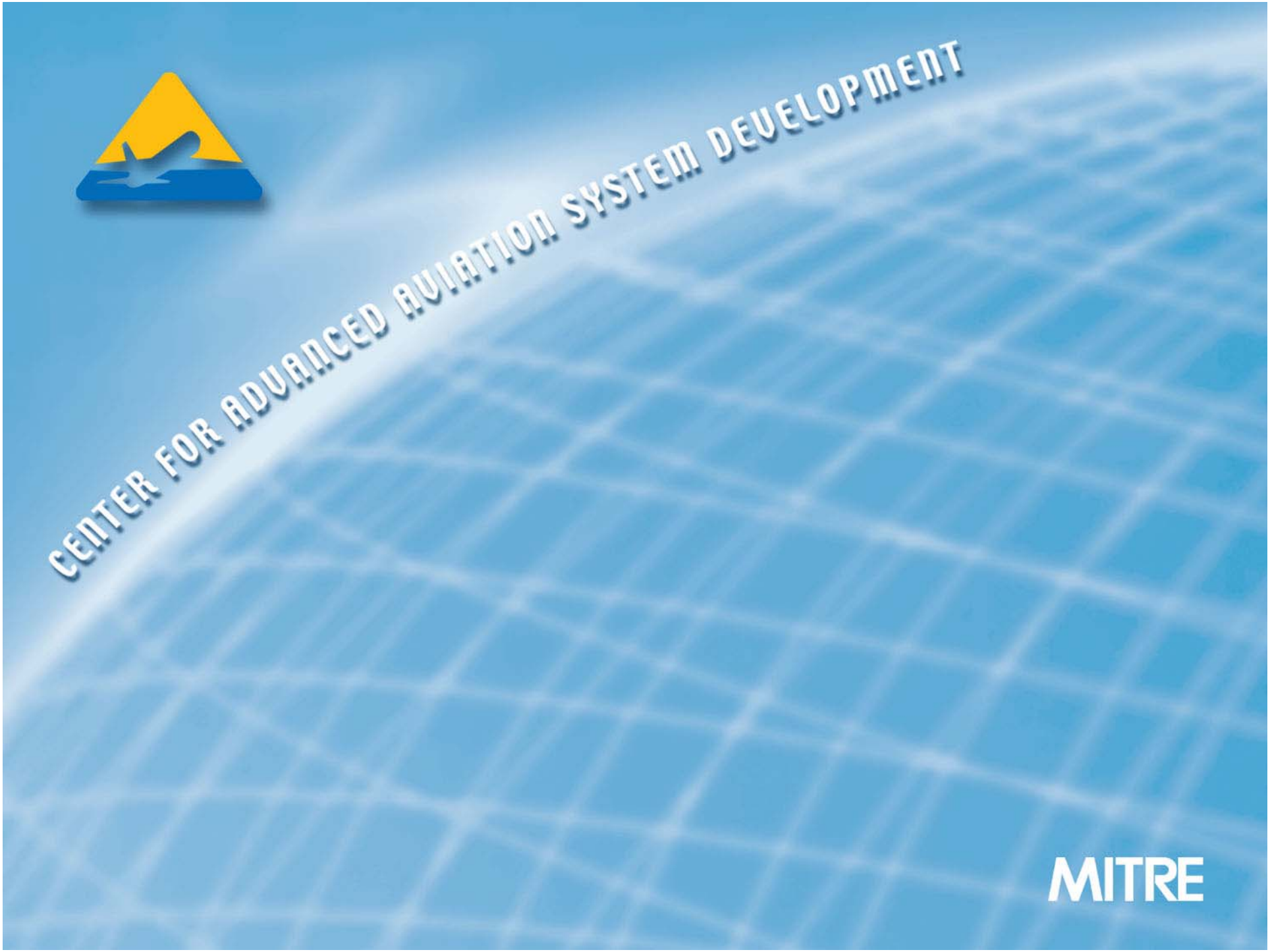
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Back Up Slides

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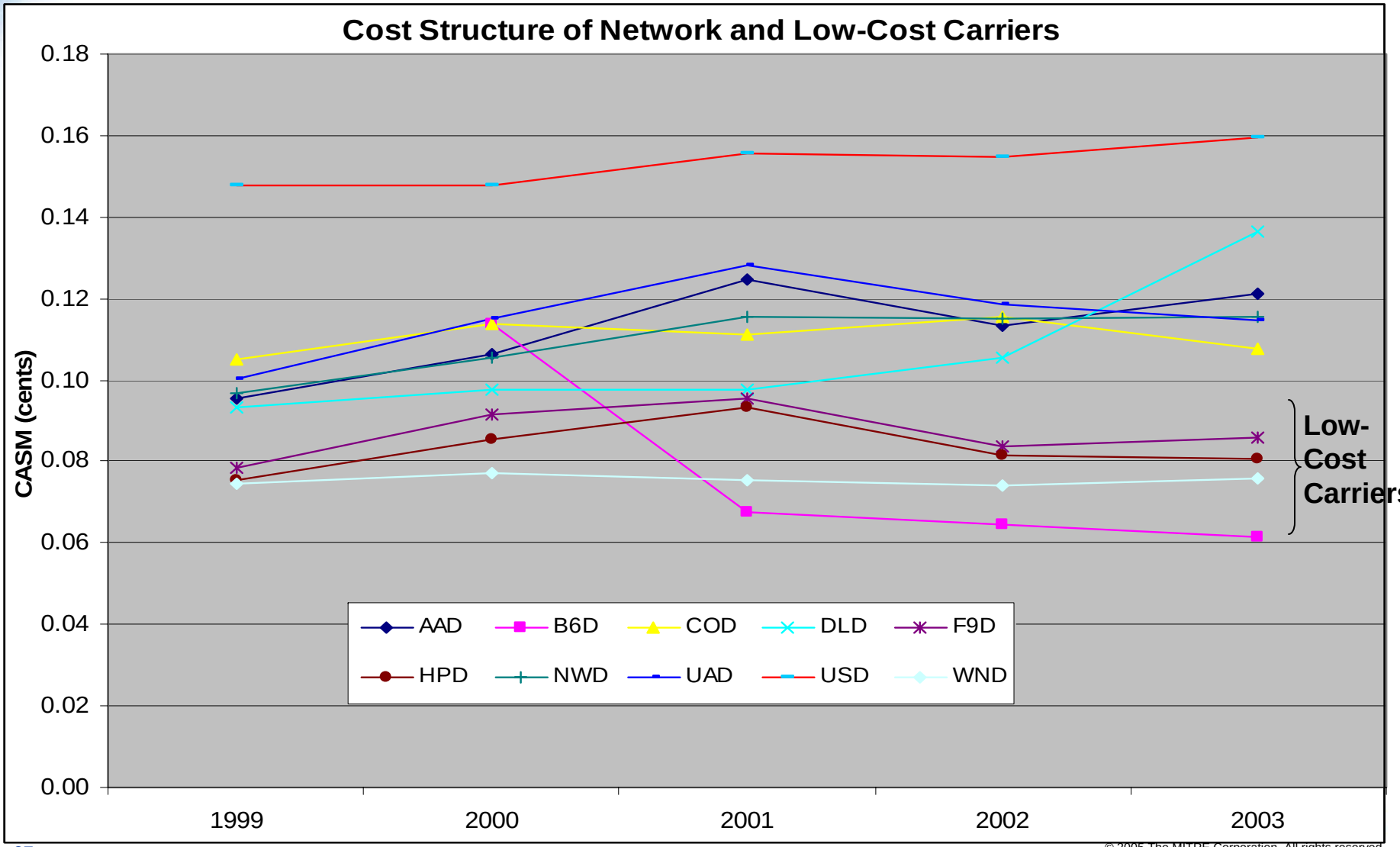
Relative cost advantage of low-cost carriers have been maintained over time



Airline Network: Our Definition for this Analysis

- ***Spoke Network:*** **Travel is between non-major hubs and airports;**
  - **example: TEB-HGA;** ***network = 0*****;**
- ***Hub Network:*** **Travel is between major hubs;**
  - **example: travel between ATL-BOS;** ***network = 1*****;**
- ***Outbound:*** **Origin is a major hub but destination is not a major hub, i.e., variation of HS;**
  - **example: ATL-TEB;** ***network = 2*****;**
- ***Inbound:*** **Origin is not a major hub but destination is a major hub, i.e., variation of HS;**
  - **example: TEB-ATL;** ***network = 3*****;**

- **Major Hubs (35), according to the last OEP Definition:**

ATL; BOS; BWI; CLT; CVG; DCA; DEN; DFW; DTW; EWR; HNL; IAD; IAH; JFK; LAS; LAX; LGA; MCO; MEM; MIA; MSP; ORD; PHL; PHX; PIT; SAN; SEA; SFO; SLC; STL; TPA; MDW; FLL; PDX; and CLE;

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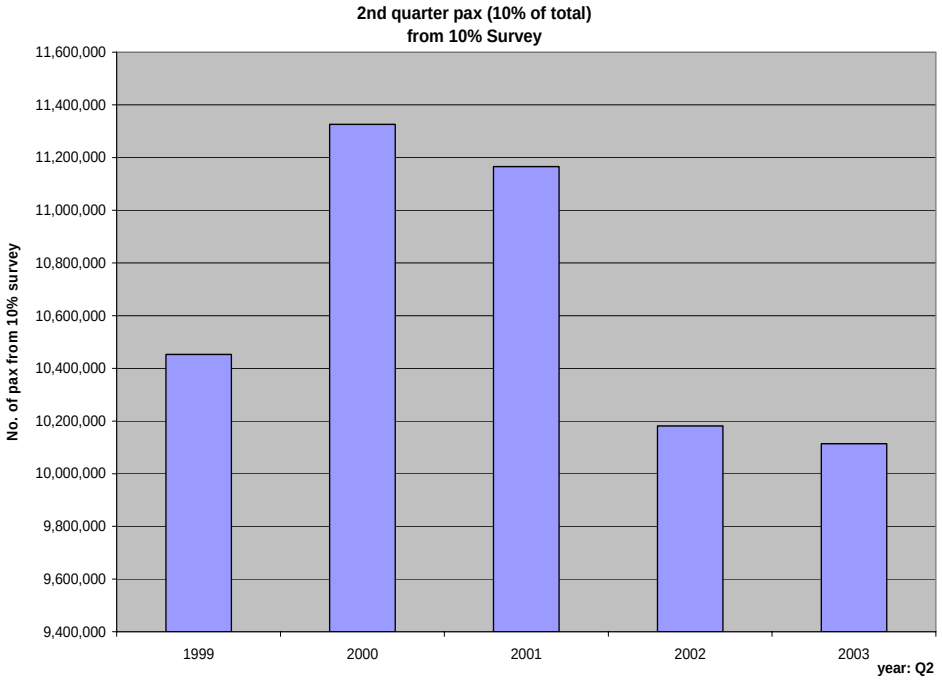
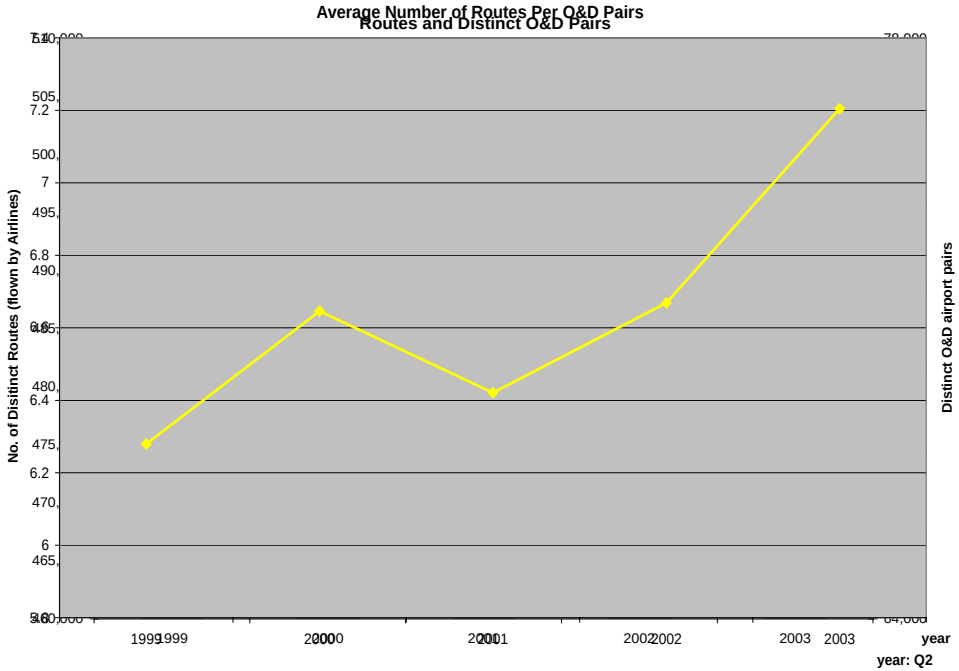
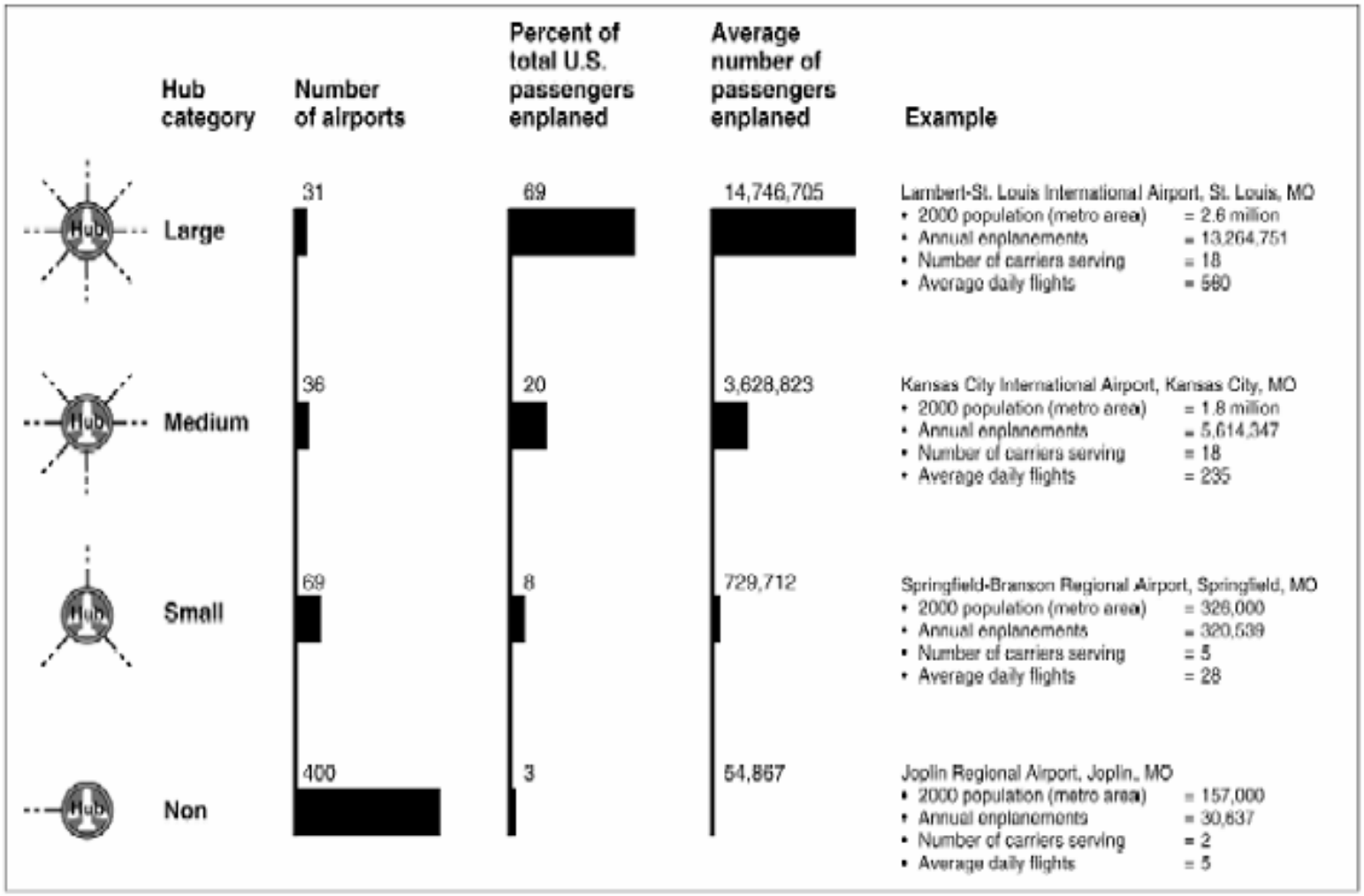
Analytical Model to Determine Itinerary Number of Stops by Market

$$P_i(y_i = j \mid x_i, \beta) \quad (j = 1, 2, \ldots, 6) = \alpha_{ij} + \beta_1(\text{passengers\_Inline}) + \beta_2(\text{Average Distance}) + \beta_3(\text{Passengers\_O\&D Market}) + \beta_4(\text{Weighted Average Fare}) + \beta_5(\text{Presence of Network Carriers}) + \beta_6(\text{Presence of LCC Carriers}) + \varepsilon_i \qquad \text{(E.1)}$$



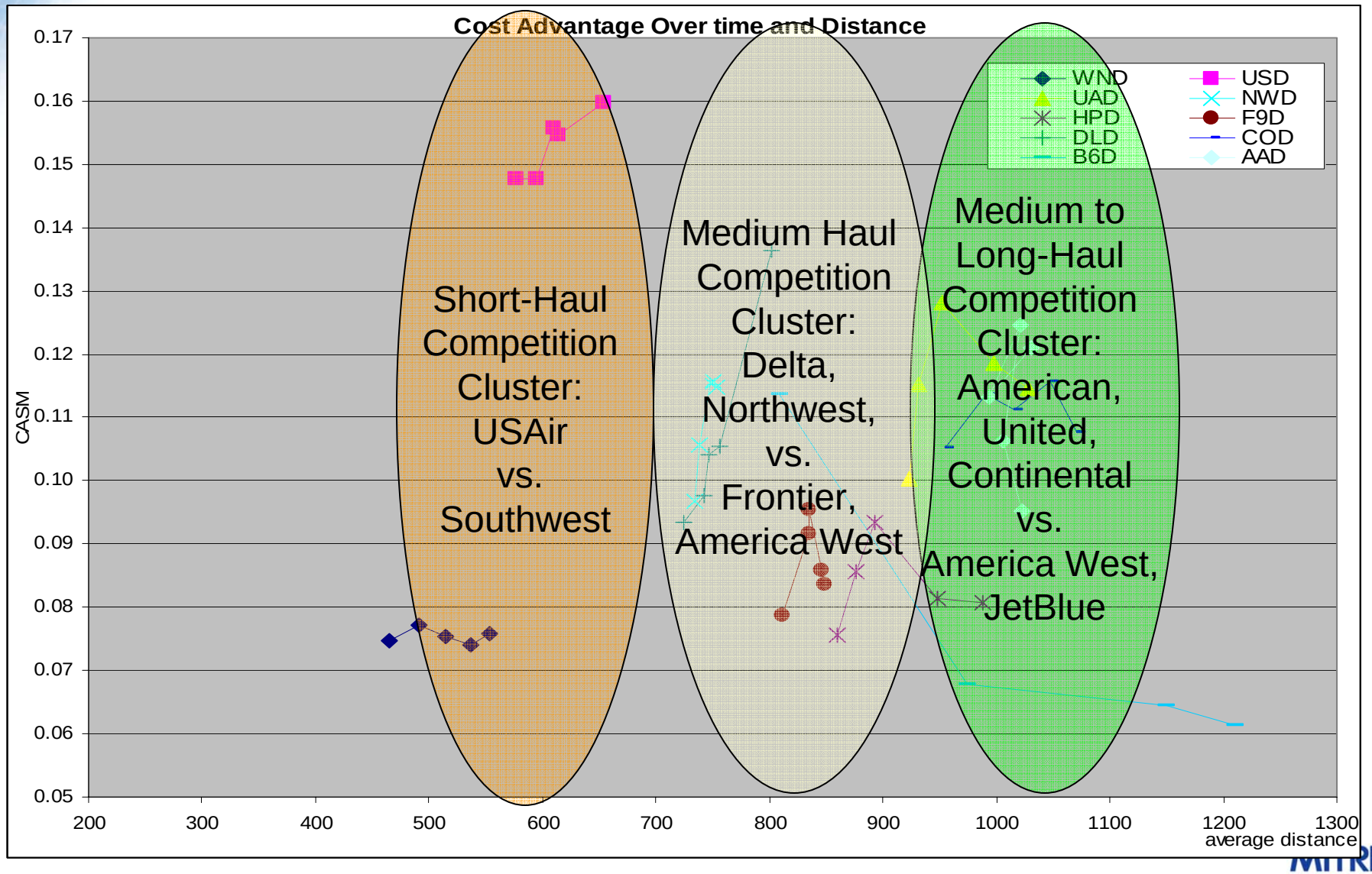


Airline Network Used To Be Primarily Hub-and-Spoke



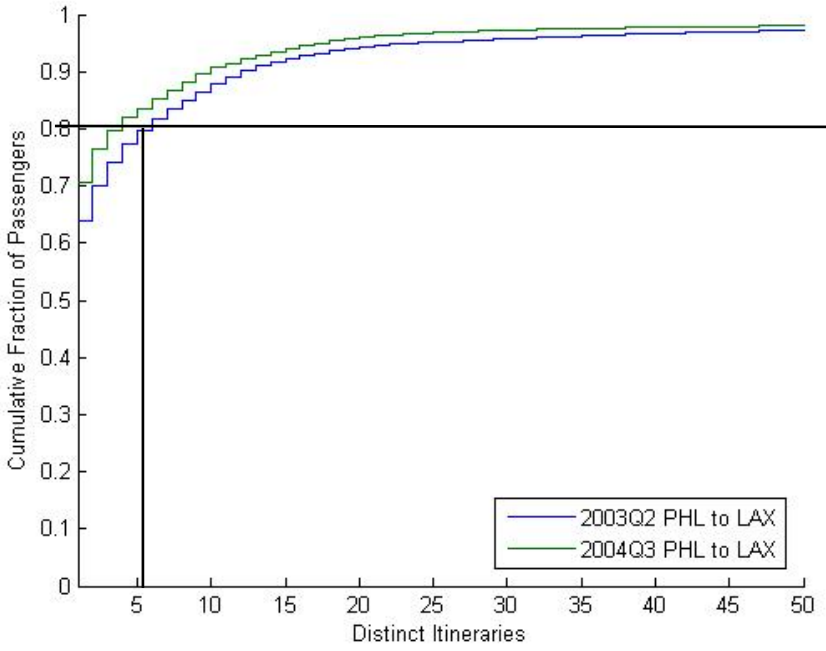
Source: GAO (analysis), FAA (data), Sabre (data), and U.S. Census Bureau (data).

Competition Cluster

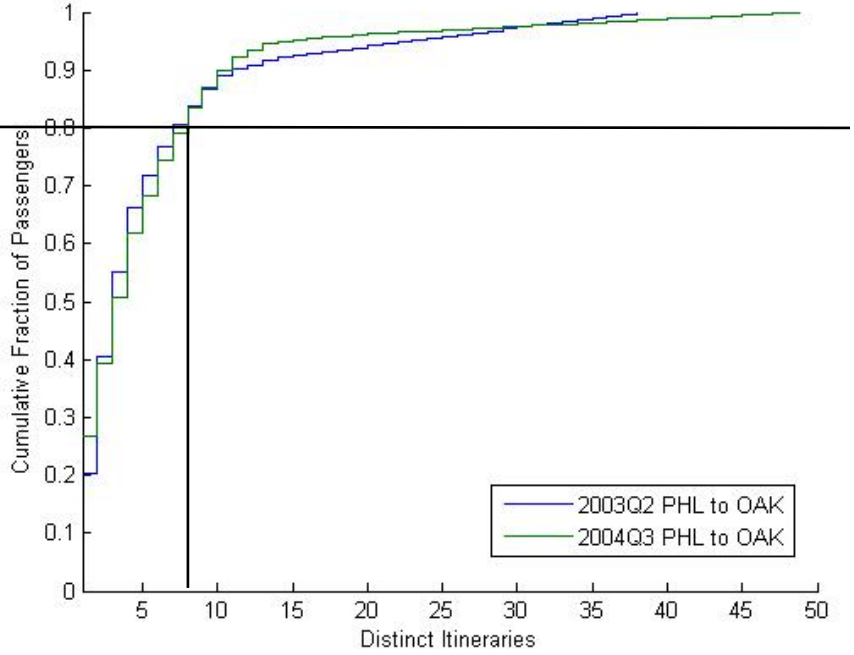


Quantitative Difference between Distributed and Centralized Markets

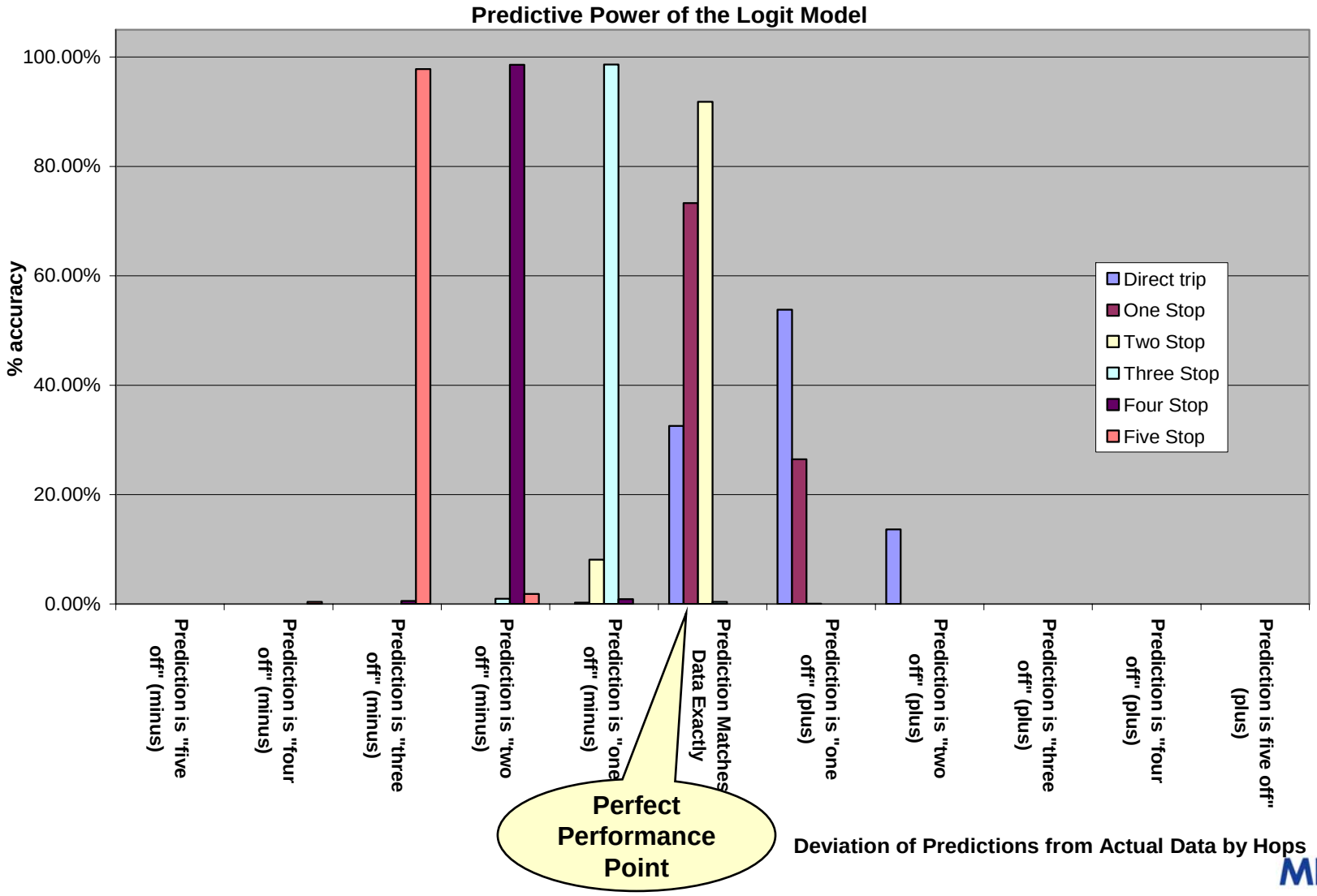
70% take the most common routing (direct)



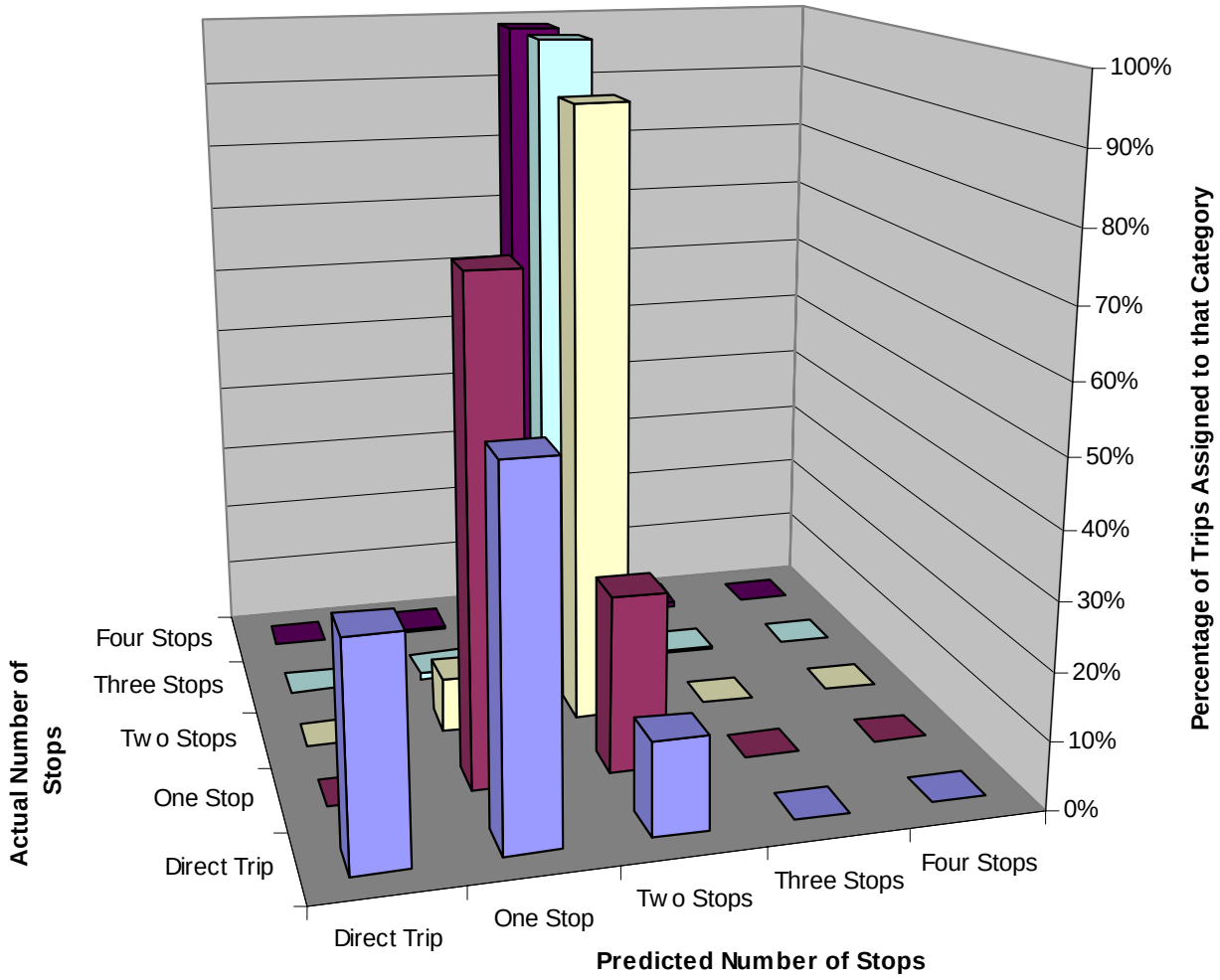
20% take the most common routing (direct)



How Well Does the Model Perform?



Predictive Performance of Model Across Itinerary Types



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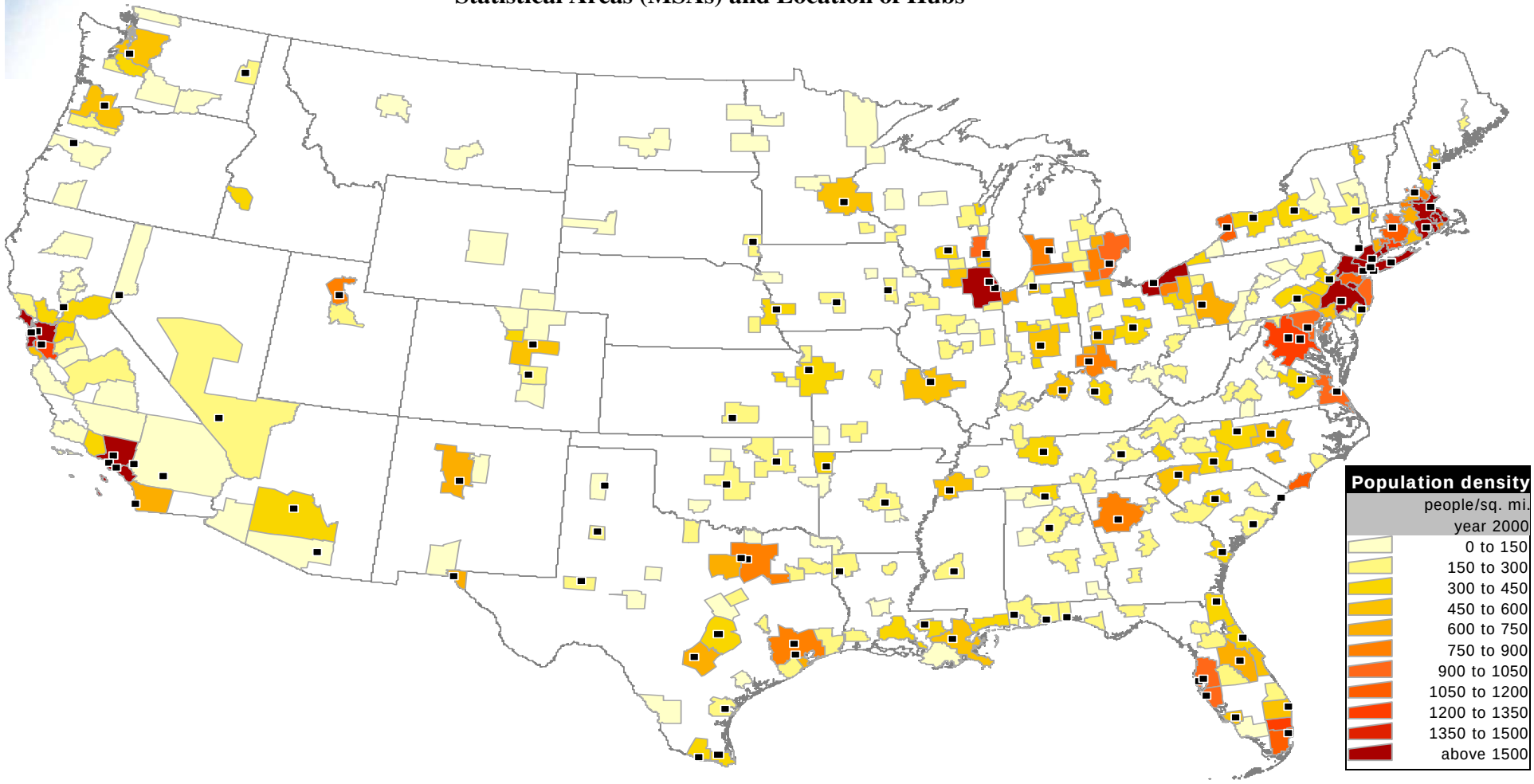
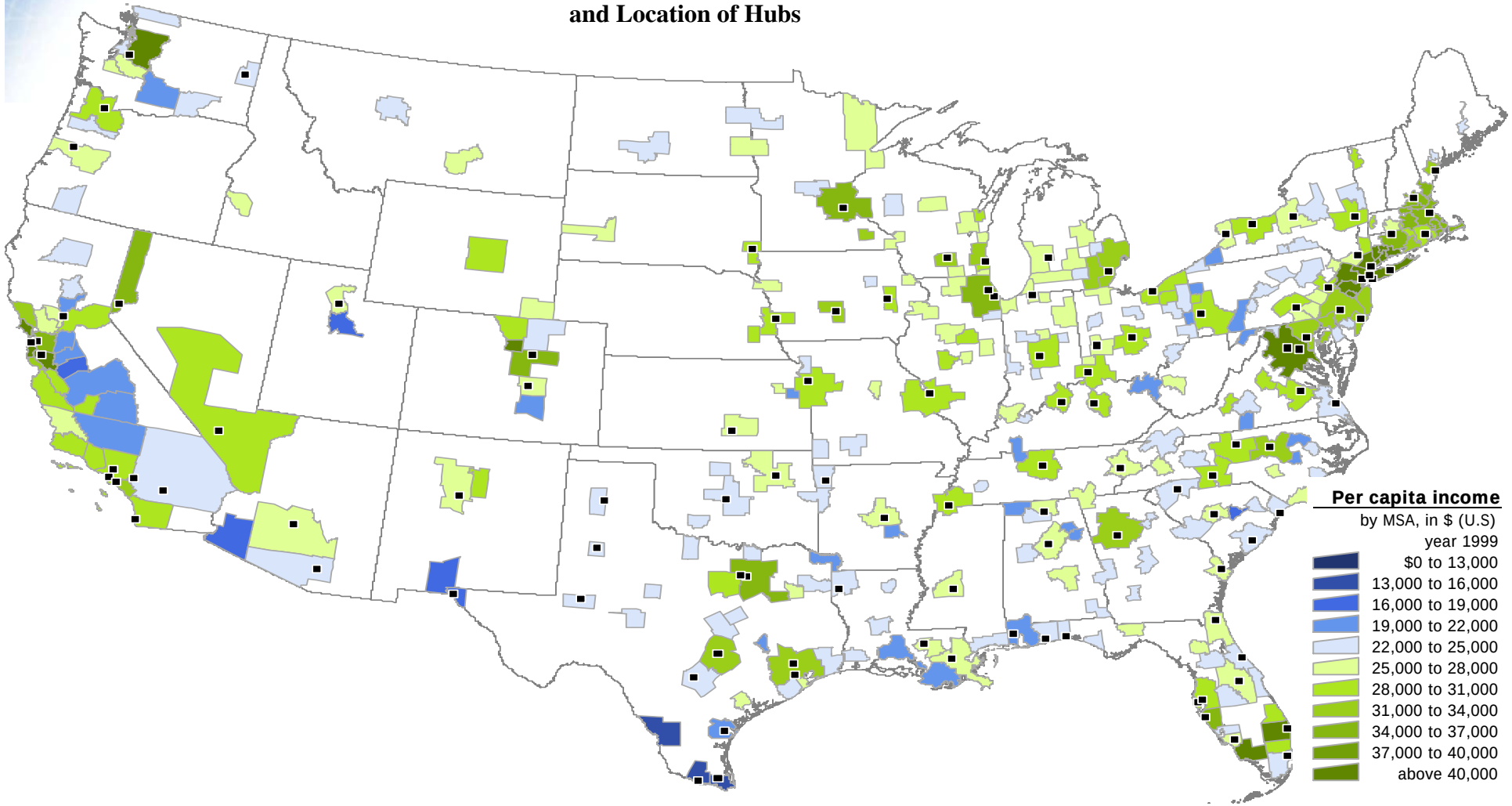
We observe that major US airports are located where the population centers are….

Density Distribution in Metropolitan Statistical Areas (MSAs) and Location of Hubs

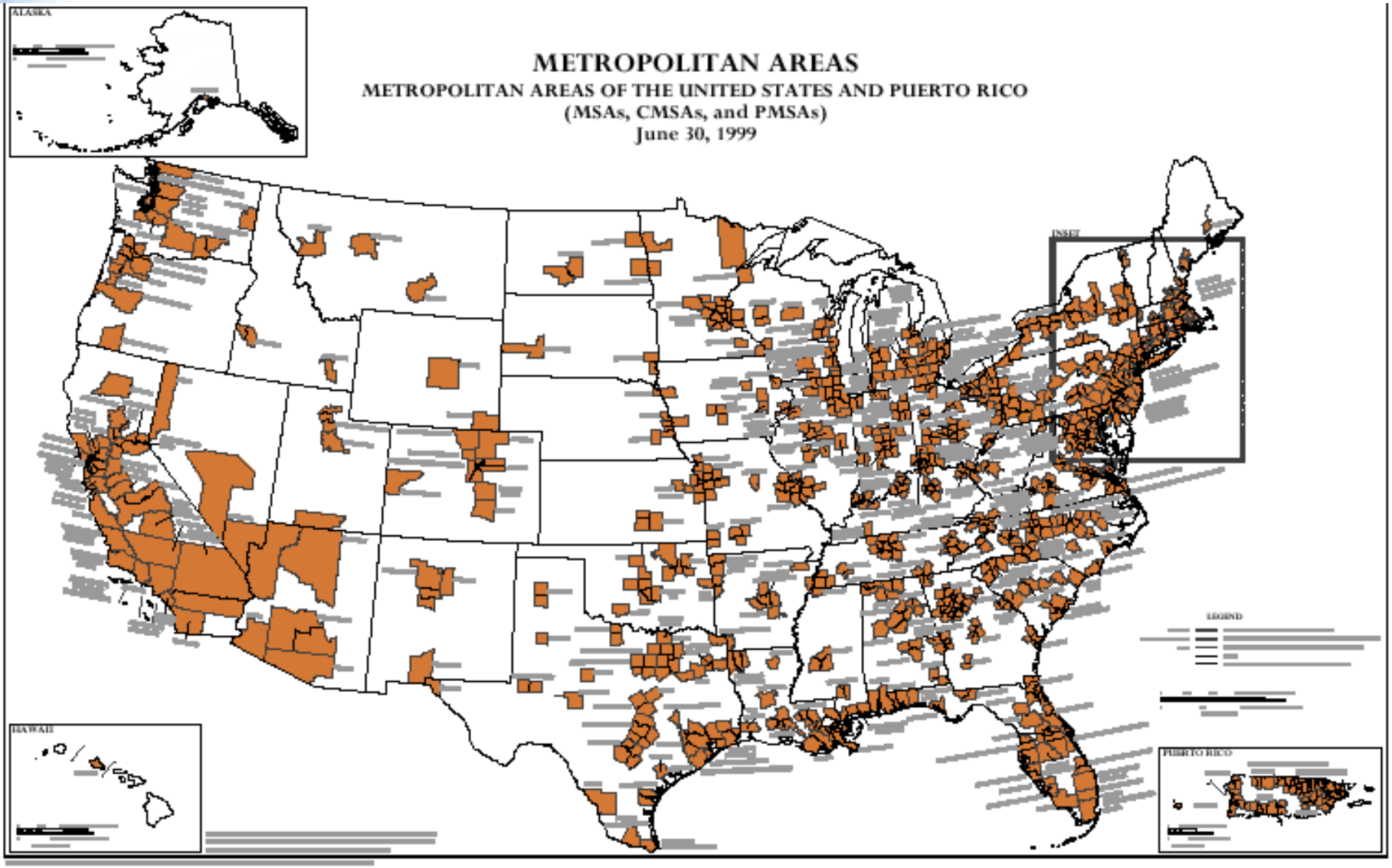


and….higher the per capita income, the greater the likelihood of major airports

Income Distribution in MSAs and Location of Hubs

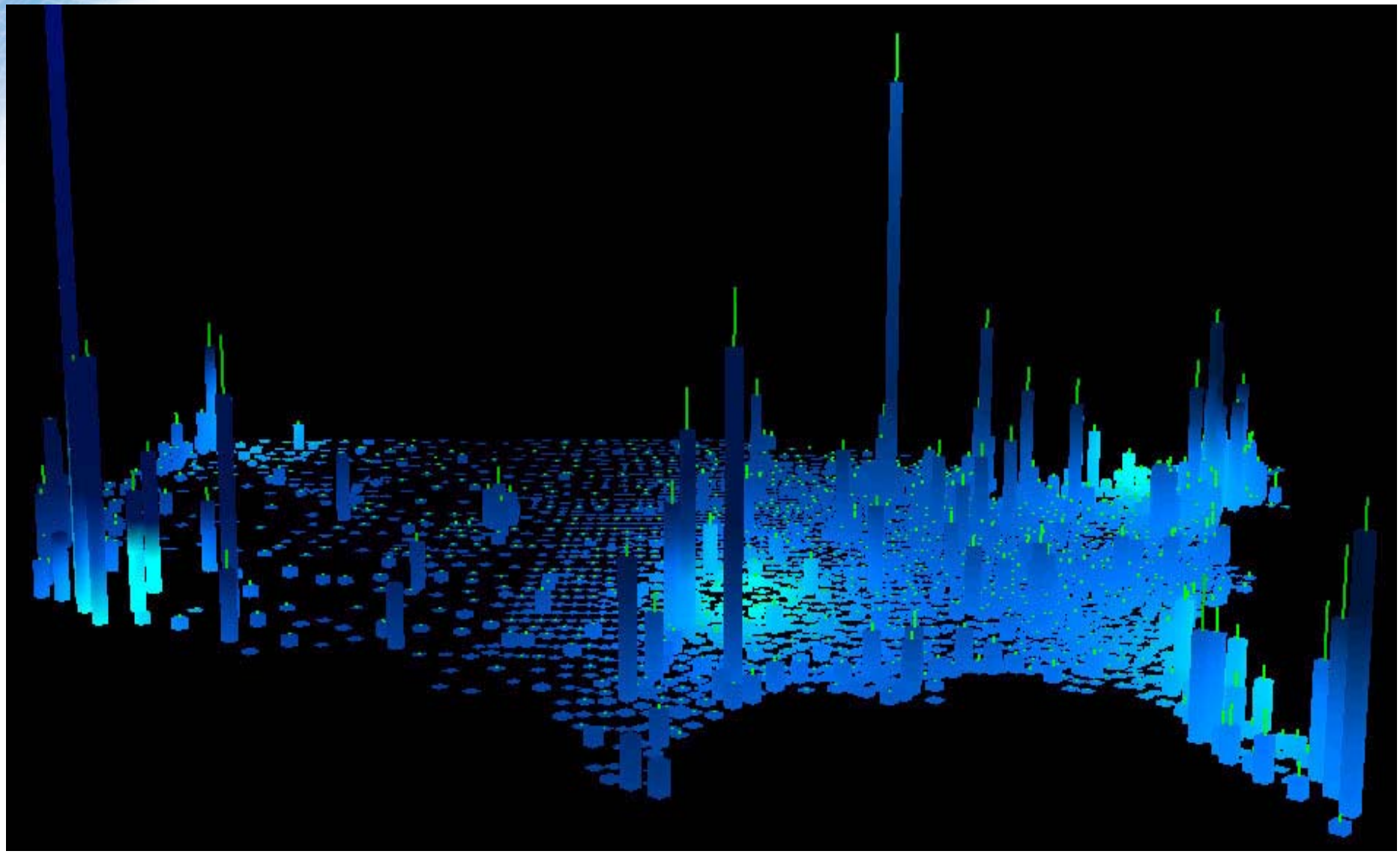


Aviation activities result from economics and demographics: Metropolitan areas as engine of growth



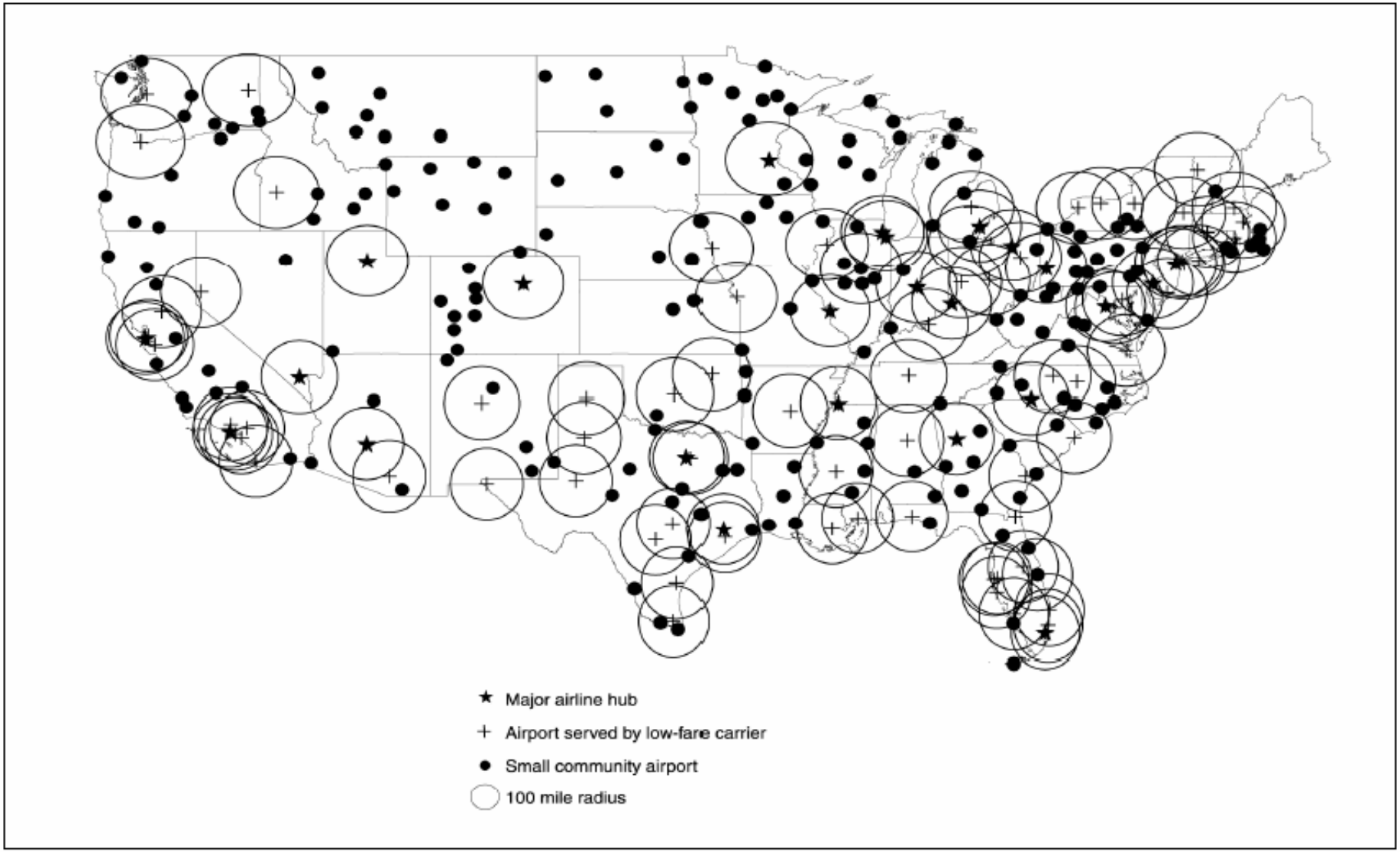
Source: http://landview.census.gov/geo/www/mapGallery/ma_1999.pdf

Uneven density results from uneven economic and demographic activities



Source: http://www.manifold.net/press/us_pops_scrn.jpg

Airports and airlines serve peoples' needs



GAO Report #02-432: *Air Service Trends at Small Communities since October 2000*

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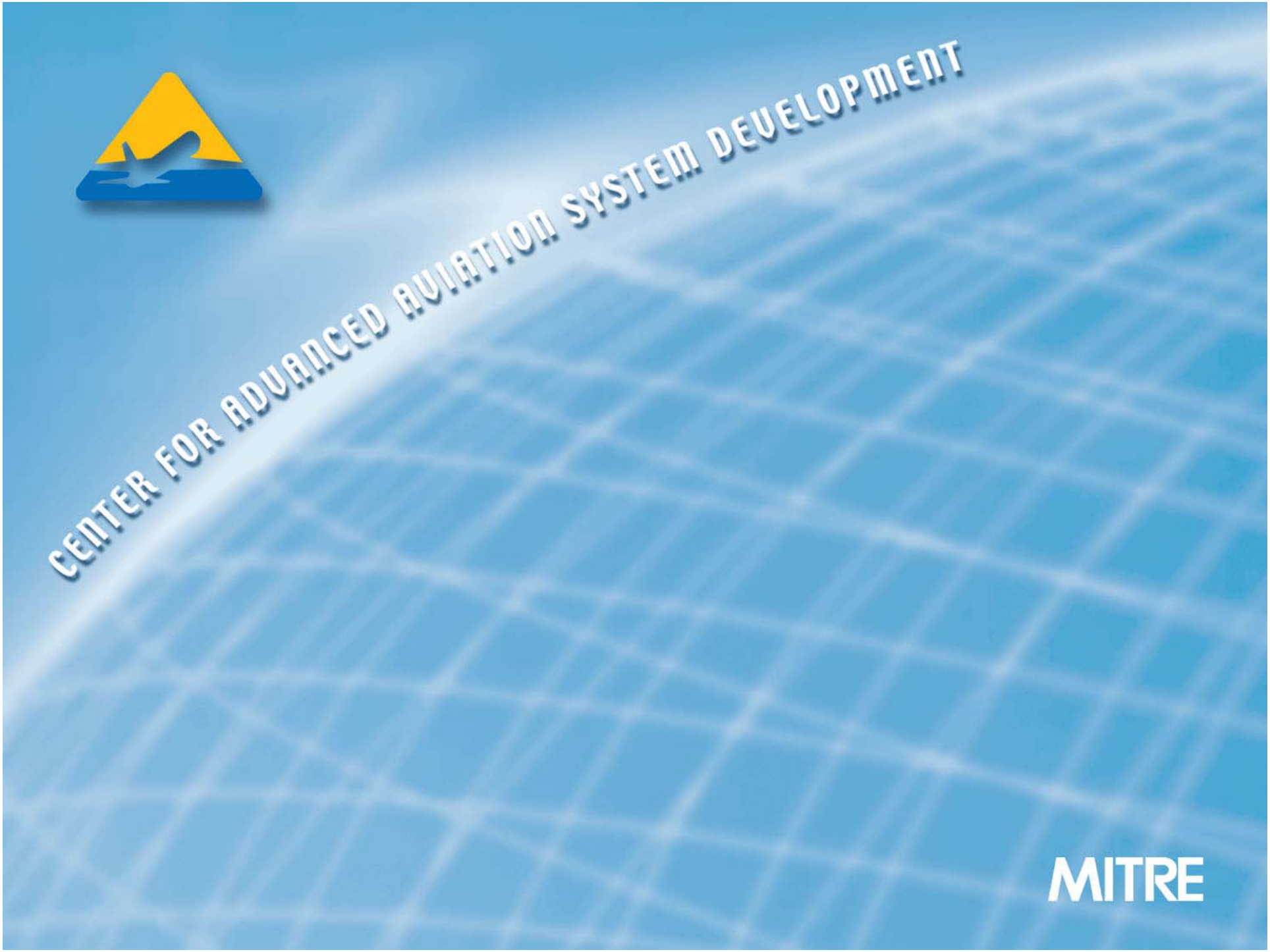
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