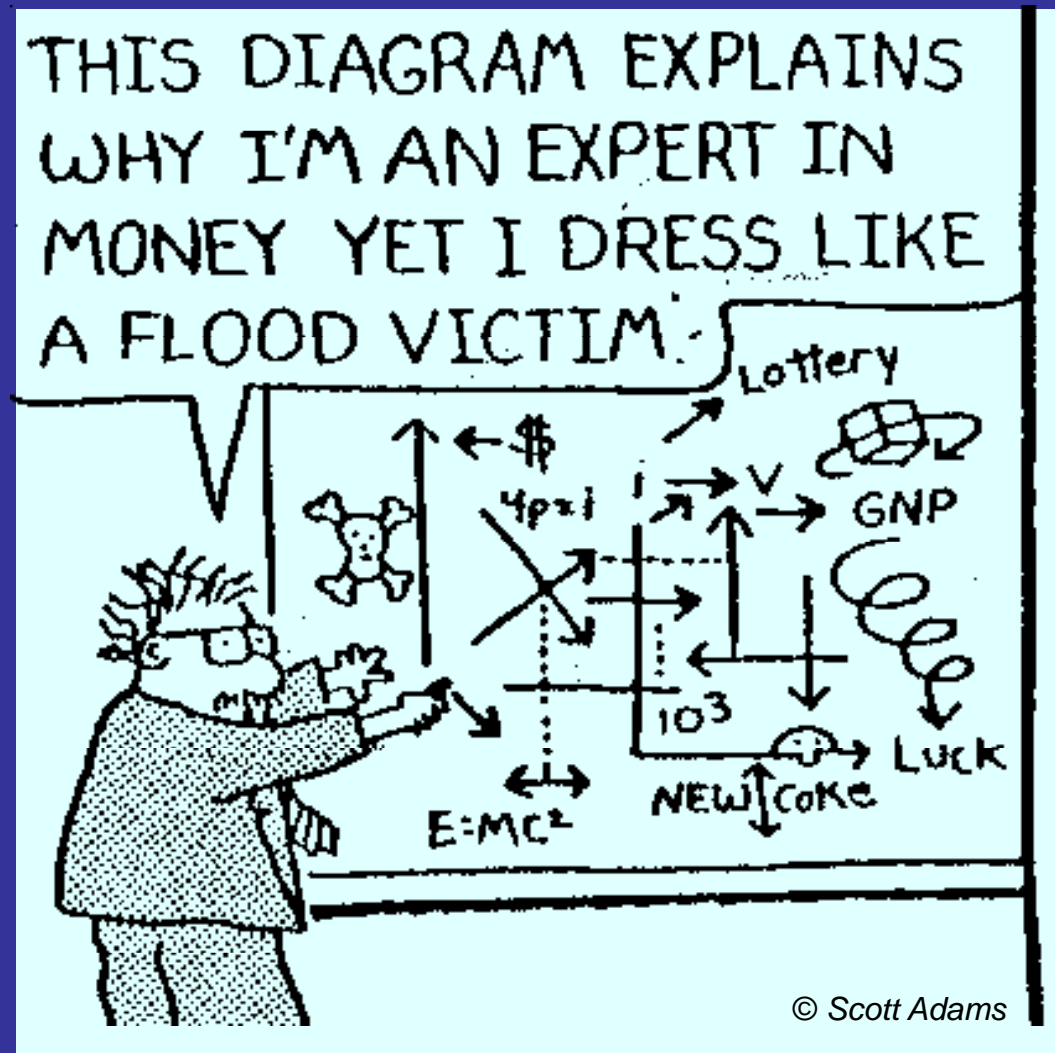


# Biography for William Swan

Chief Economist, Seabury-Airline Planning Group. Visiting Professor, Cranfield University. Retired Chief Economist for Boeing Commercial Aircraft 1996-2005 Previous to Boeing, worked at American Airlines in Operations Research and Strategic Planning and United Airlines in Research and Development. Areas of work included Yield Management, Fleet Planning, Aircraft Routing, and Crew Scheduling. Also worked for Hull Trading, a major market maker in stock index options, and on the staff at MIT's Flight Transportation Lab. Education: Master's, Engineer's Degree, and Ph. D. at MIT. Bachelor of Science in Aeronautical Engineering at Princeton.

([bill.swan@cyberswans.com](mailto:bill.swan@cyberswans.com))



# Airline and Network Evolution

William M Swan

Chief Economist

Boeing Commercial Airplanes, Marketing; Retired

Seabury/APG

Winter 2010

[bill.swan@cyberswans.com](mailto:bill.swan@cyberswans.com)

[Cyberswans.com](http://Cyberswans.com)/"Airline Industry Publications"

# Why Me?

## *I was not always an Economist*

- At MIT aeronautics department
  - LP route planning model
- At American Airlines Operations Research
  - Fleet planning model
  - Revenue Management model
  - Strategic planning
- At United Airlines Research & Development
  - Developed demand estimates for commuter feed
- At Boeing as Chief Economist
  - Did demand and network growth for annual 10-year forecast
  - Participated in various airline bankruptcies (EA, HP, TW ...)
  - Reviewed 20 different start up attempts



# Structure is Destiny

- Structure of costs across airplane sizes
- Distribution of OD market sizes
  - These two make for hubs dominating
- Structure of fares and reservations
- Game theory of competitive pricing
  - These two drive airlines to avoid each other

# The Airplane is Amazingly Similar

- 707 -- first generation jet airplane (1954)
  - Seating 189, charter configuration
  - Speed high sub-sonic
  - Altitude 36,000 ft
  - Range: Transcontinental
  - Body width 12 ft
- 737 - 800
  - Seating 189, charter configuration
  - Speed high subsonic
  - Altitude 35,000 ft
  - Range: Transcontinental
  - Body width 12 ft

# Airplane: 3 Basic Technologies

1. Lift to Drag ratio (L/D)
  - Aerodynamic efficiency (“shape”)
2. Structural Weight Fraction
  - Structural efficiency
3. Fuel Burn (specific fuel consumption SFC)
  - Propulsion Efficiency

# The Significant Changes

- Jets now come from 70-550 seats in size
  - Choice of sizes important
- Ranges now cross the Pacific
  - Range beyond 10,000km not important
    - Too long to sit
    - Not cost efficient
    - Too few markets
    - Too little feed behind or beyond (world is round)
    - The Pacific is not a European pond
- Both size choice and range came in 1970s
  - Higher bypass engines for fuel/range
  - Twin-aisle airplanes for larger sizes
  - This drove changes until fully absorbed in 1980s

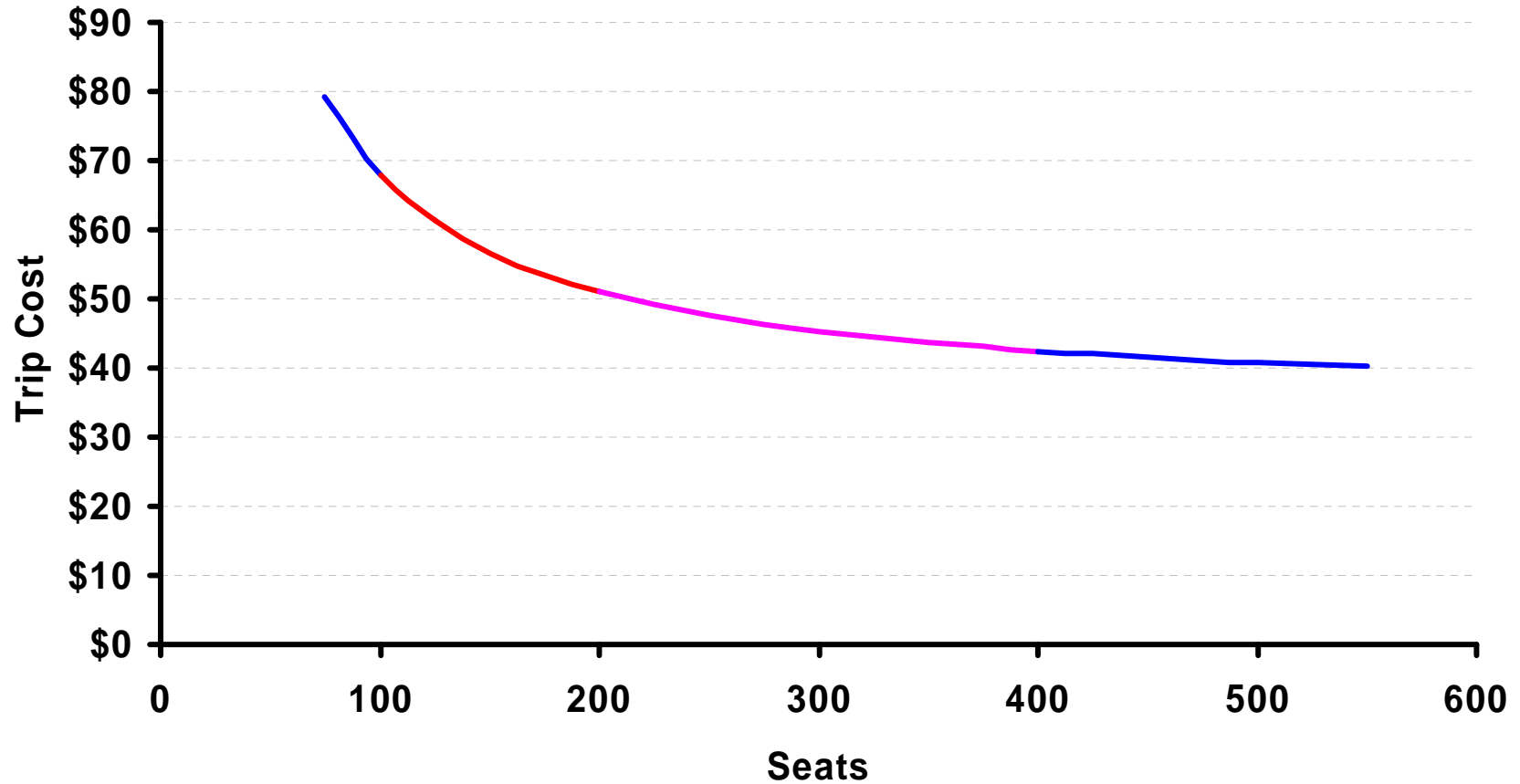
# Concepts to Keep

- The denser the route, the cheaper the seats
- Not the Same as Economies of Scale, version A
  - Scale is bigger airline, wider network
- Not the Same as Economies of Scale, version B
  - Scale is longer flight distance
  - However, longer the distances are cheaper per mile
- Economies of Density have Persisted
  - since jet airplanes:
    - MIT study in 1971
    - AA/UA fleet planning 1986
    - Boeing Study 2001



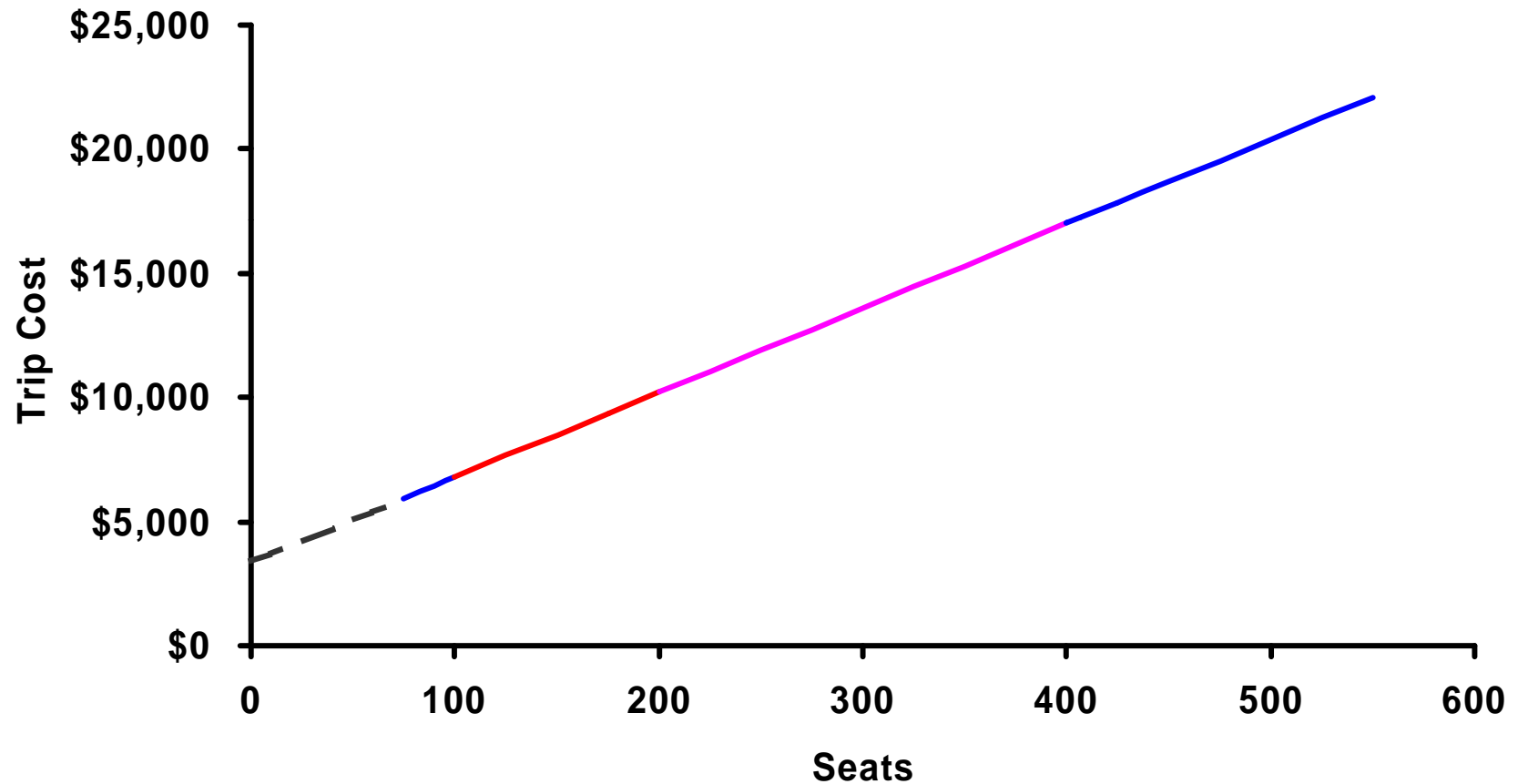
# Big Airplanes are Cheaper per Seat

Conventional Representation (Confusing)

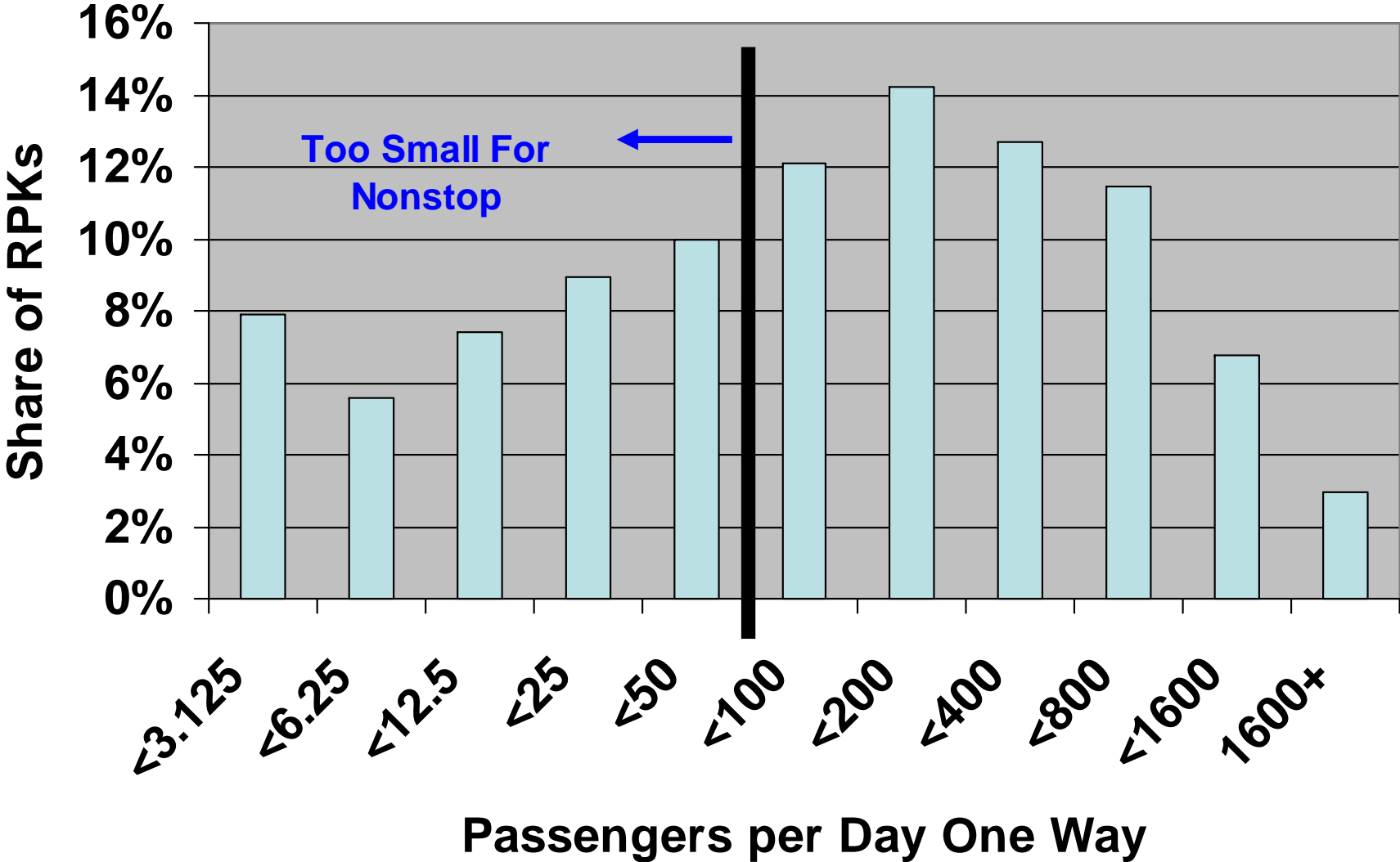


# Underlying Linear Relationship

Well-Adjusted Presentation (Clear)



# Most Markets are Small



# Deregulation Lets Natural Growth Evolve

- Airlines added new nonstop routes
  - Bleeding traffic off old connecting legs
  - Reducing head-to-head competition
  - Making networks thinner but with more links
  - Filling out hubs
- Prices went up in small, short markets
  - It took a while unlearn “long, big” paradigm
  - Smaller communities gained services
  - Hubs began to develop
  - Regional carriers merged with majors
    - They were always loosing money before, anyway

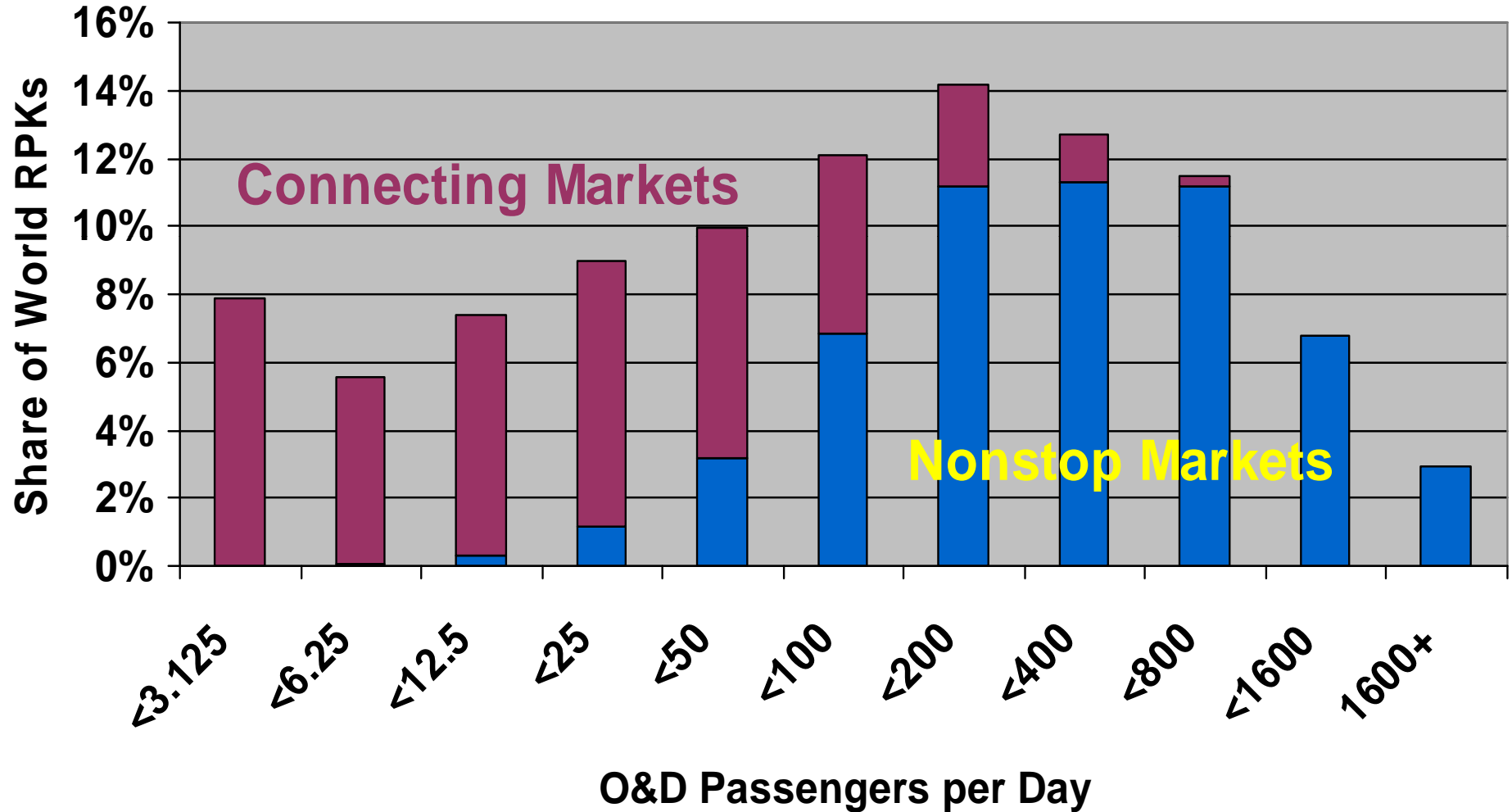
# Industry Growth is Small Markets

- Virtuous Circle:
  - Better services: More Value
    - Faster connections (add 15% demand for online)
    - Fewer Stops (add 15% for each lost stop)
    - Higher frequencies (add 15% for full-day schedule)
  - Lower Costs: Lower Prices
    - Higher traffic volumes mean lower costs
    - Competitive choices eliminate monopoly pricing
- New “small” markets get new services
  - Smaller towns, secondary city airports
  - Grow network from “below”

# Structure is Destiny

- Small Airplanes are expensive, per seat
  - Drive to reach 100 seats short / 200 seats long-haul
- Half of markets too small, must connect
  - Hubs create useful connections

# Half of Travel is in Connecting Markets



# The Main Deregulation Change: Hubs dominate Evolution

- A hub is an airline connecting passengers
  - Flights times to make connections convenient
  - Airline dominates smaller feeder cities
  - Airline competes to larger destination cities
  - Airline likely has some international cities too
- Hubs creates a lot of value
  - Same-day trips all over the world
  - Able to collect fares in proportion to value
- Pattern seems universal
  - Happened in first 10 years in US
  - Happened in first 10 years in Canada
  - Happened in first 10 years in Europe



# Value Created by Hubs

The idea in business is to Create Value

Do things people want at a cost they will pay

Hubs make valuable travel options

Feeder city gets “anywhere” with one connection

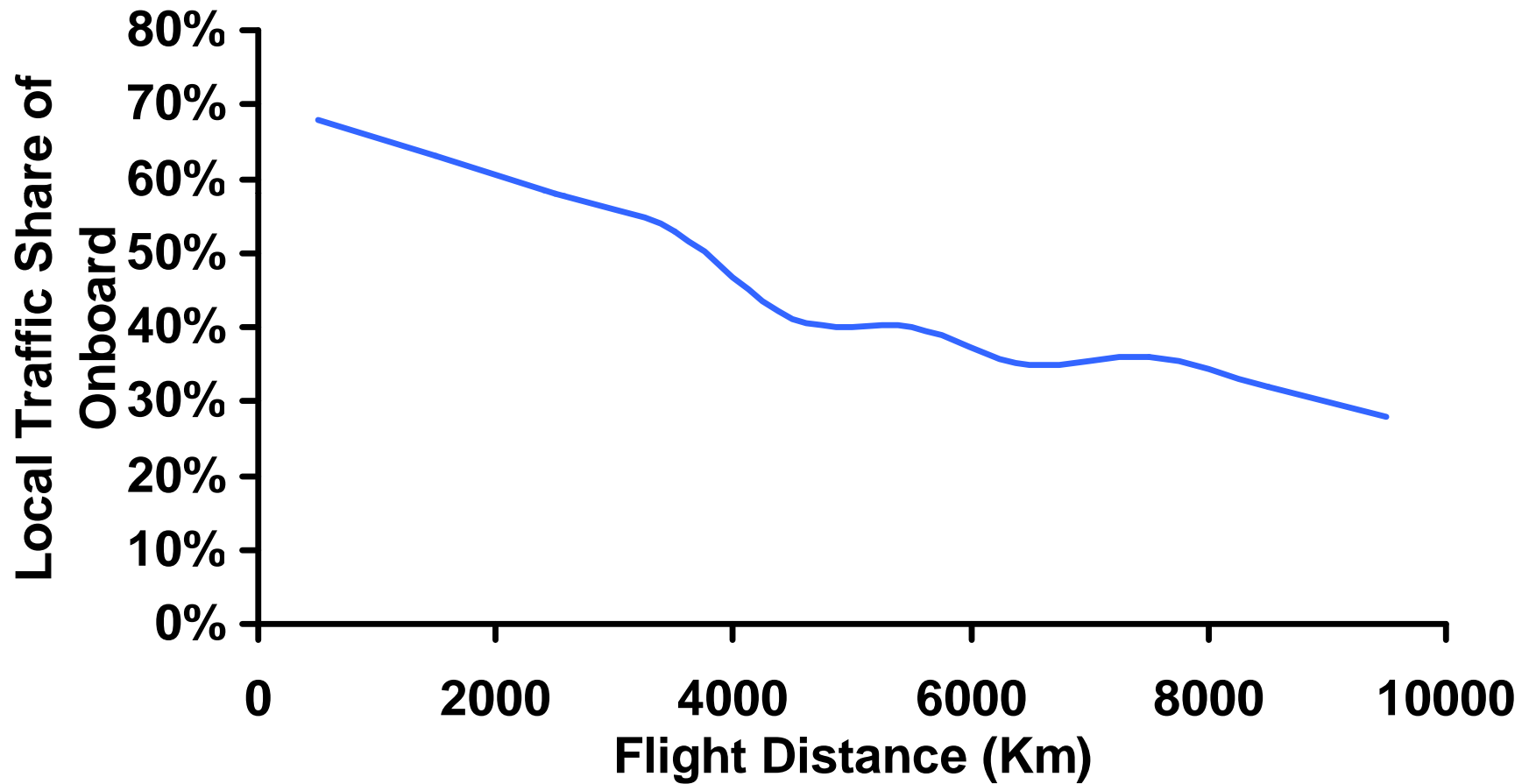
Feeder city can participate in trade and commerce

Hubs are cost-effective

Most destinations attract less than 10 pax/day

Connecting loads use cost-effective airplanes

# Connecting Share of Loads Averages about 50%



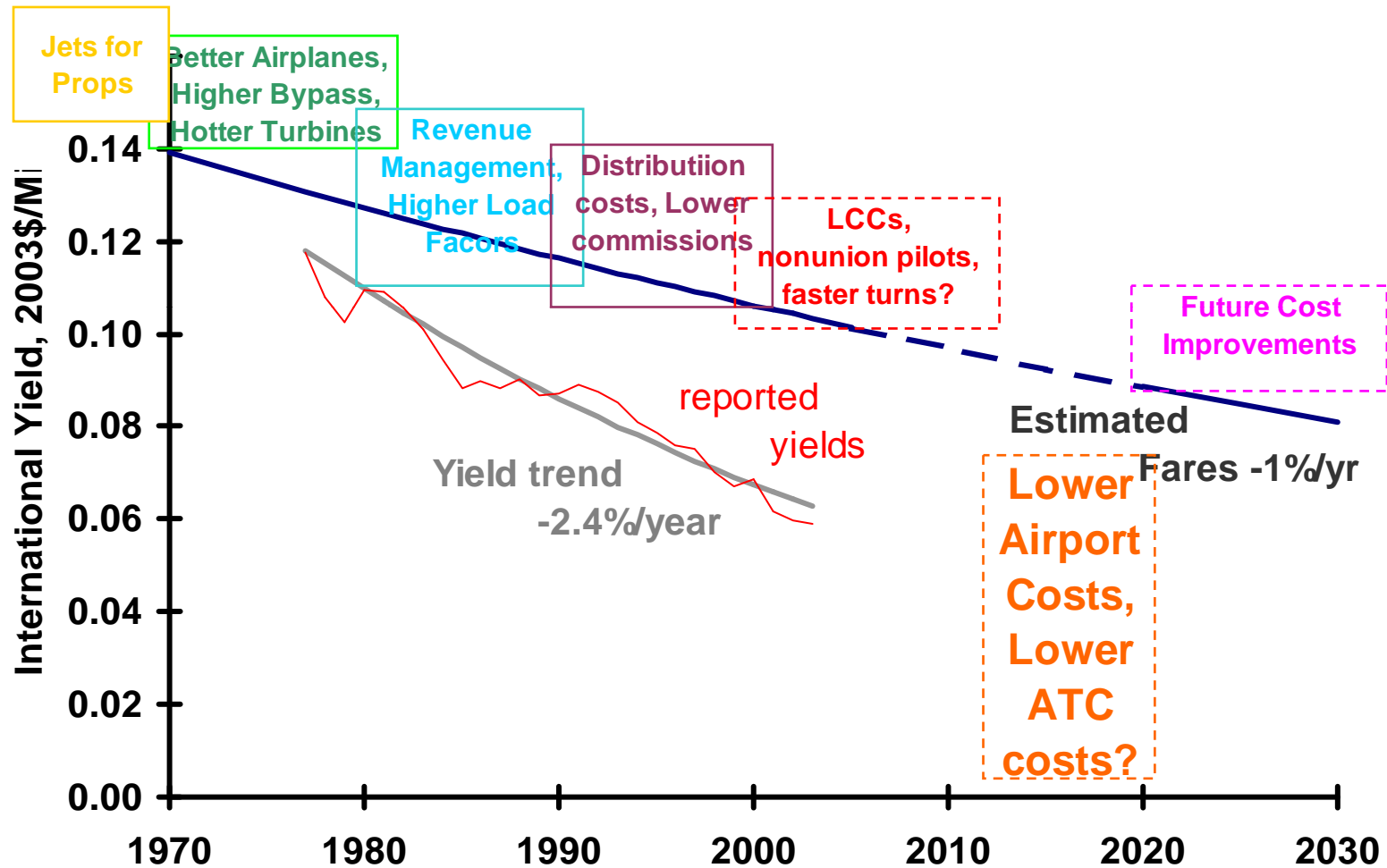
# Structure is Destiny

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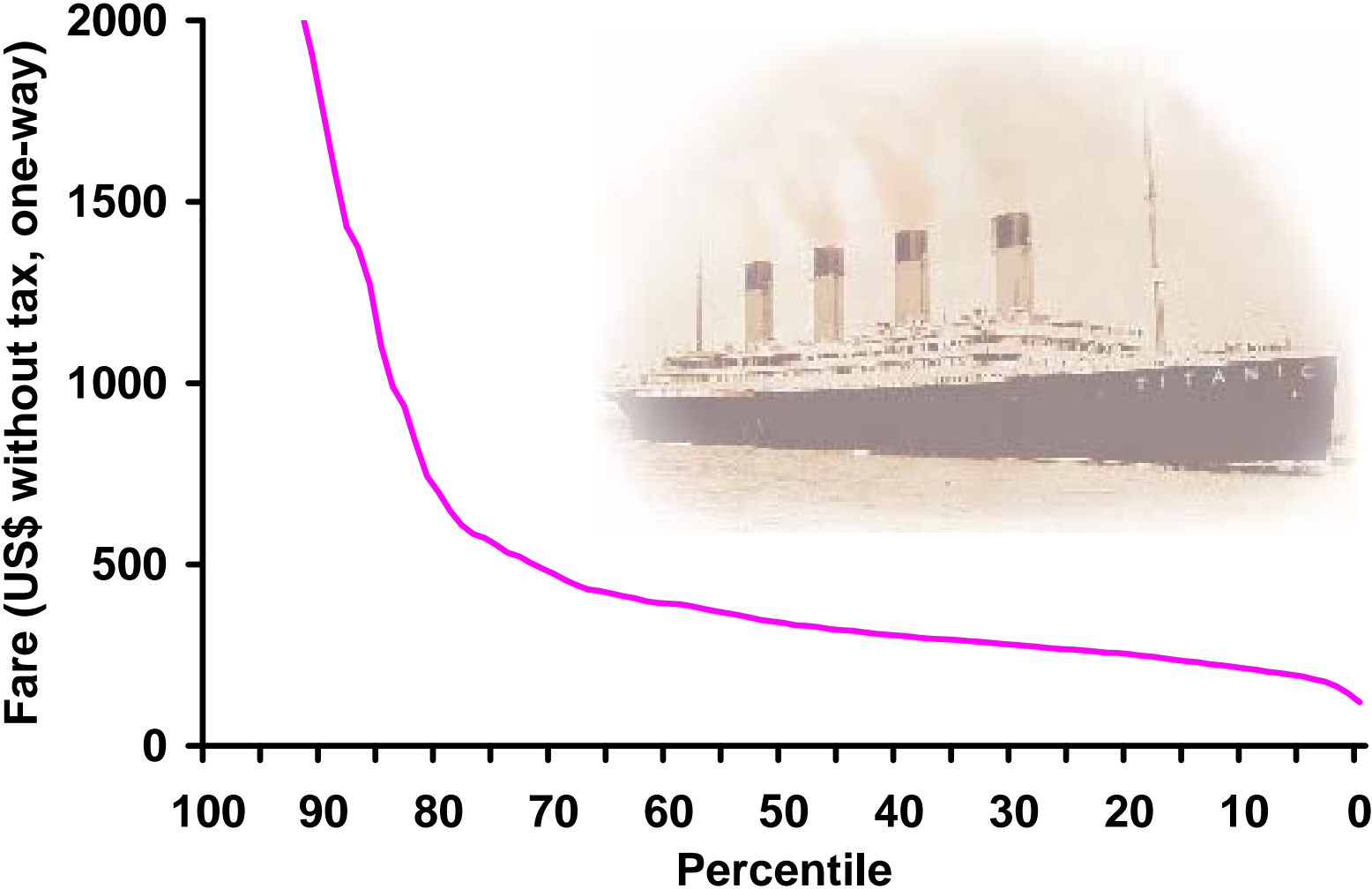
# Ticket Prices

- Two kinds of fares
  - Advance purchase, discount fares
  - Regular, unrestricted, full fares
- Low Cost Carrier (LCC) pricing
  - Erosion of full fare levels, from 3x to 2x
  - Less than meets the eye
- Small, Connecting markets pay more
  - More value
  - Less competition
  - High fares from LCCs, also
- Yield has declined 2-3%/year since 1971
  - Representing a 1% annual decline in fares

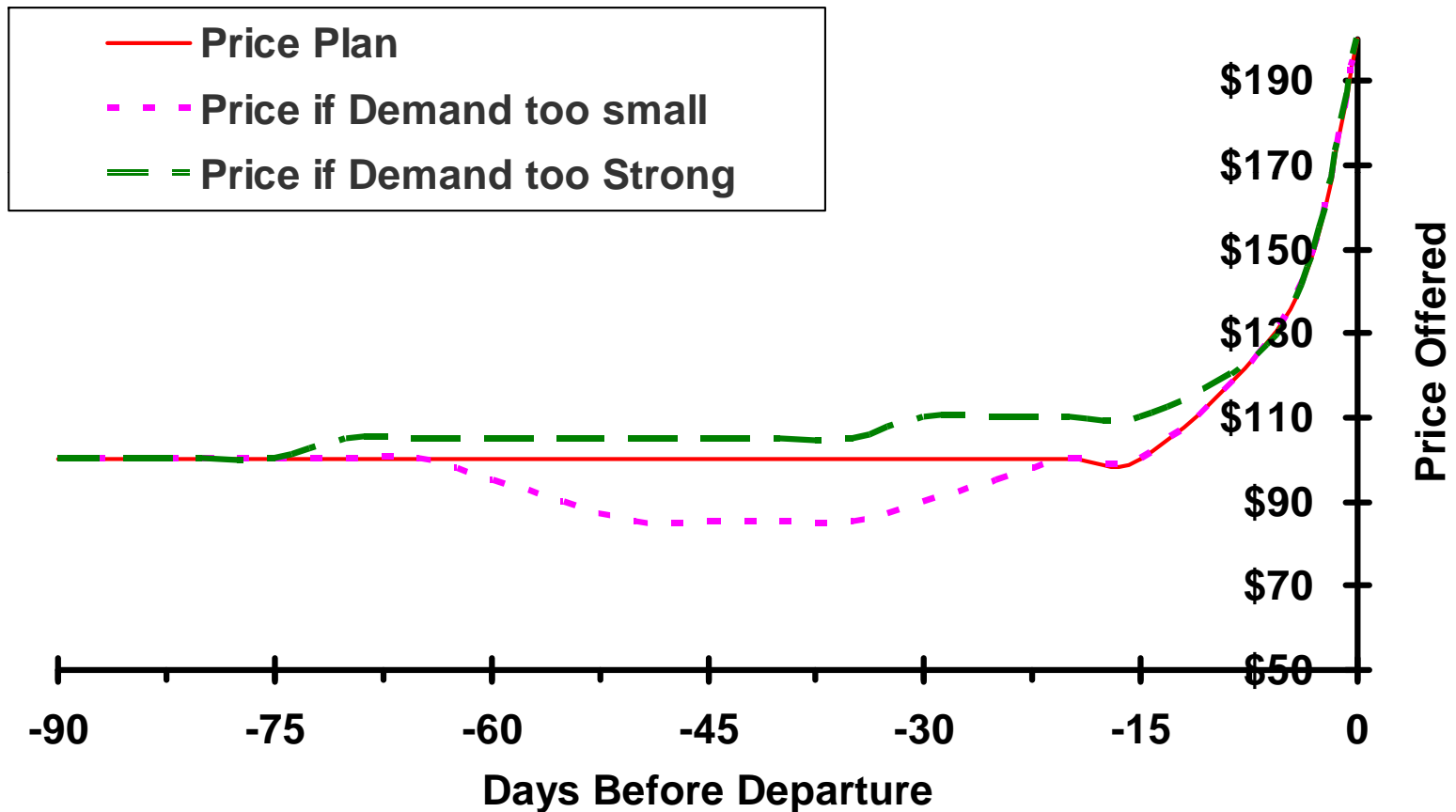
# Cost Reductions Keep Coming



# Fares are a mix of HIGH and Low “Typical” Atlantic Airport-Pair



# LCC's have high fares, in last 2 weeks



# Fares are Higher for Small Markets

*(Includes both Small and LCC Presence Effects)*

For Pax < 10/day

$$\text{Fare} = \$117 + 0.046 * \text{Distance}$$

257 data points; R-square = 0.42

For 10/day < Pax < 100/day

$$\text{Fare} = \$106 + 0.037 * \text{Distance}$$

758 data points; R-square = 0.37

For Pax > 100/day

$$\text{Fare} = \$98 + 0.035 * \text{Distance}$$

671 data points; R-square = 0.34



# Revenue Management

- Revenue Management systems are simple
  - They estimate the high-fare demand
  - They save that many seats
  - They offer the rest of the seats for low fares
- Implementation in a network is messy
- Result: airlines carry all the high fare demand that that they can attract

# What is the Result of Fare Structure?

- First, attracting the high fares is key
- Second, filling the other seats is good
- Consequence: airlines hate to compete
  
- Third, hubs get higher fares, from connections in smaller markets
- Even LCC hubs

# Airline Competitive Game: Airlines A & Z

- Identical airlines in simplest case
- Two passenger types:
  1. Discount @ \$100, **144** passengers demand
  2. Full-fare @ \$300, **36** passengers demand
  - Average fare \$140
- Each airline has
  - **100**-seat airplane
  - Cost of \$126/seat
  - Break-even at 90% load, half the market

# We Pretend Airline A is Preferred

- **All 180 passengers prefer airline A**
  - Could be quality of service
  - Maybe Airline Z paints its planes an ugly color
- Airline A demand is all 180 passengers
  - **Keeps all 36 full-fare**
  - **Fills to 100% load with 64 more discount**
  - Leaves 80 discount for airline Z
  - Average A fare \$172
  - Revenue per Seat \$172
  - Cost per seat was \$126
  - **Profits: huge**

# Airline Z is not Preferred

- Gets only spilled demand from A
- Has 80 discount passengers on 100 seats
- Revenue per seat \$80
- Cost per seat was \$126
- **Losses: huge**

“not a good thing”

# Preferred Carrier Does Not Want to Have Higher Fares

- Pretend Airline A charges 20% more
  - Goes back to splitting market evenly with Z
  - Profits now 20%
  - Profits when preferred were 36%
    - 25% from having all of full-fares
    - 11% from having high load factor
- Airline Z is better off when A raises prices
  - Returns to previous break-even condition

## A Big Event Nobody Noticed (Post-Deregulation: 1984)

- Peoples Express opened a low cost hub
  - At Newark (EWR) airport, New York City
  - Cheap fares, lousy service
- AA discovered PE
  - Became aware of the extent of PE connects
  - Responded by matching PE fares
    - 70% off full fare (compared to 35% off for SSave)
    - Capacity only available midweek
    - AA clearly the preferred choice at matched fares

# Results of Big Event

- PE went out of business
  - Due to “horrendous peaking of traffic”
  - No midweek loads
- AA found it was making more money
  - 80% average weekly load factors (not 60%)
  - Filling previously empty mid-week seats
  - Selling tickets for half previous discount fares
  - Revenue Management controlling sales
- Paradigm shift:
  - Old way was set fares, get load factor
    - Weak demand means lower load factor
  - New way was set load factor, sell to fill
    - Weak demand means lower average fare



# Summary and Conclusions

- Airlines have strong incentives to match
  - Preferred airline does best matching prices
    - High share of full-fares
    - High load factor in off peak
  - Not-preferred airline does poorly
  - Makes for unstable competition
- A less-preferred airline has a difficult time covering costs
- Preferred airline's advantage is reduced by
  1. Spill – but not much change
  2. Partial preference – some people prefer the other
  3. Time-of-day distribution – good time/bad airline

# How Does This Play out?

- Airlines like to make hubs
- Airlines like to open new routes
- Airlines even like to open new hubs
- Old routes and hubs grow, then plateau

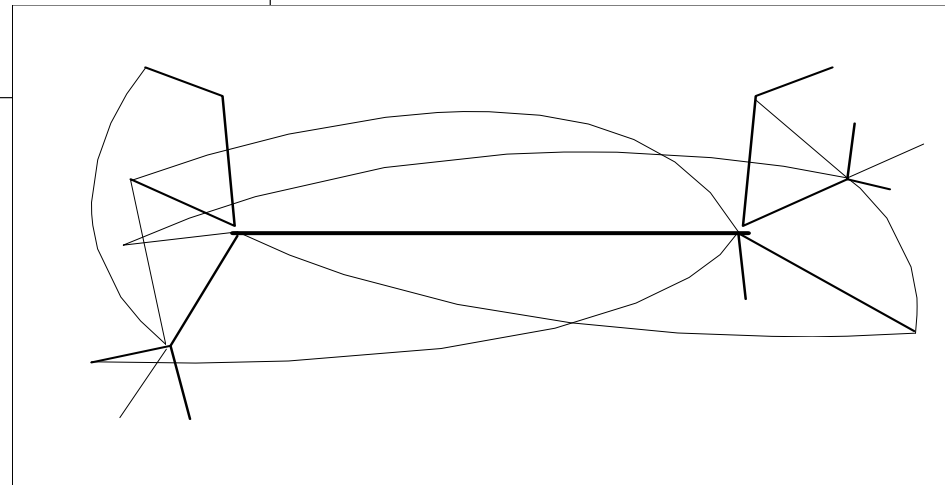
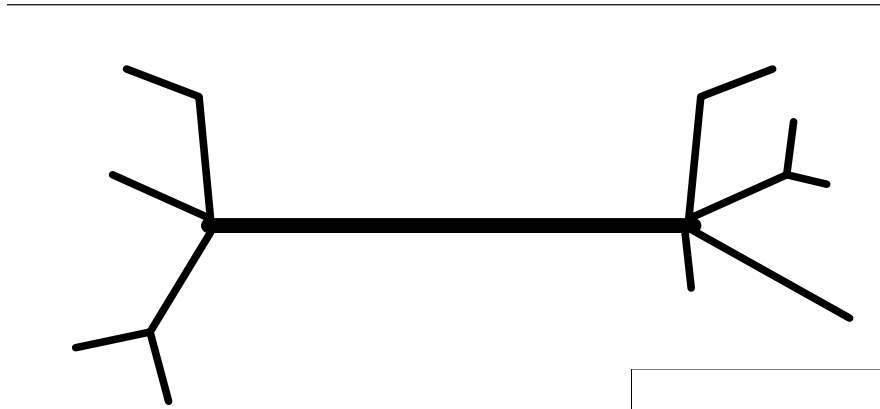
# Networks Develop from Skeletal to Connected

*High growth does not persist at initial gateway hubs*

- **Early developments build loads to use larger airplanes:**
  - Larger airplanes at this state means middle-sized
  - Result is a thin network – few links
    - A focus on a few major hubs or gateways
    - In Operations Research terms, a “minimum spanning tree”
- **Later developments bypass initial hubs:**
  - Bypass saves the costs of connections
  - Bypass establishes secondary hubs
  - New competing carriers bypass hubs dominated by incumbents
  - Large markets peak early, then fade in importance
- **Third stage may be non-hubbed low-cost carriers:**
  - The largest flows can sustain service without connecting feed
  - High frequencies create good connections without hub plan

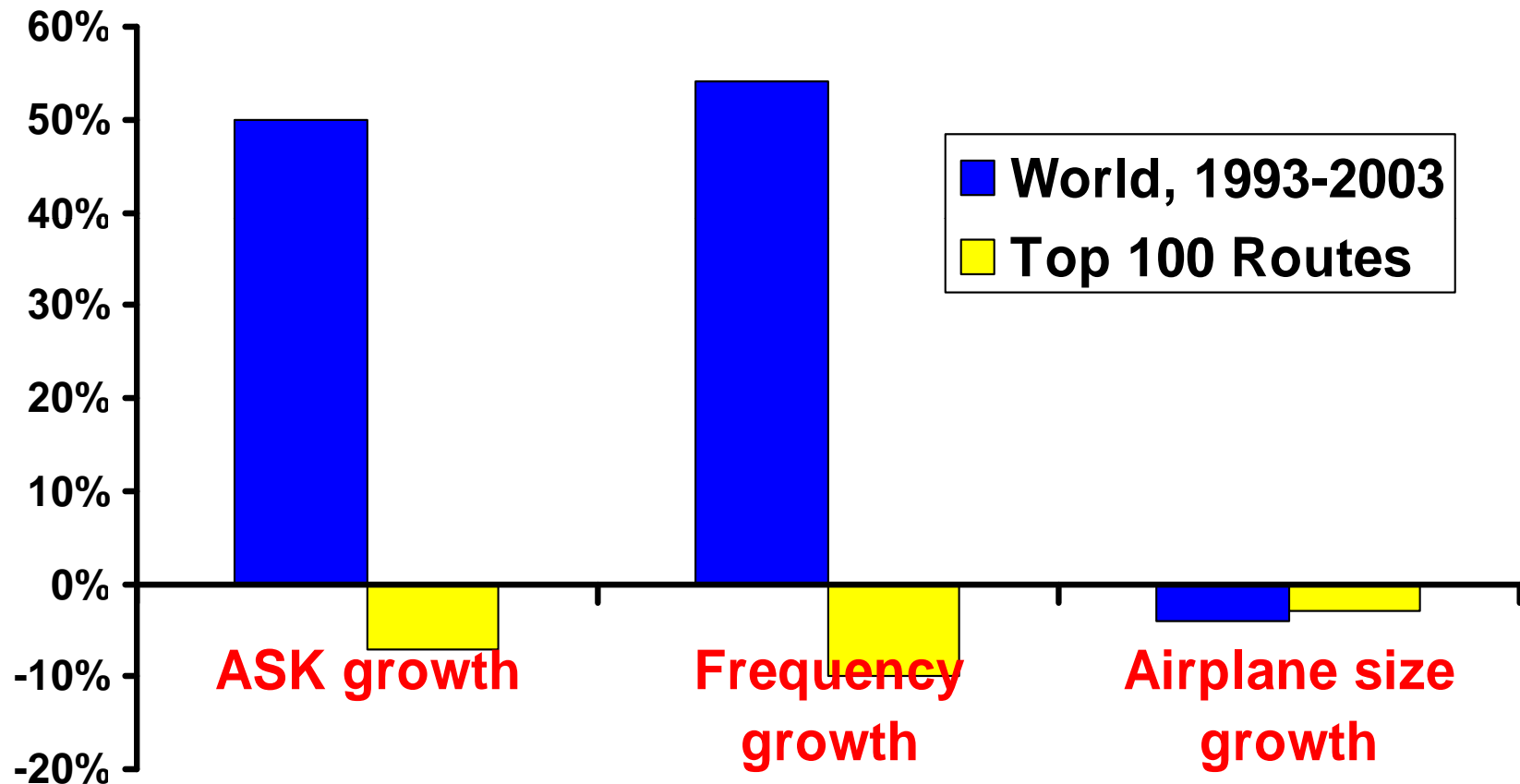
# Skeletal Networks Develop Links to Secondary Hubs

## Early Skeletal Network

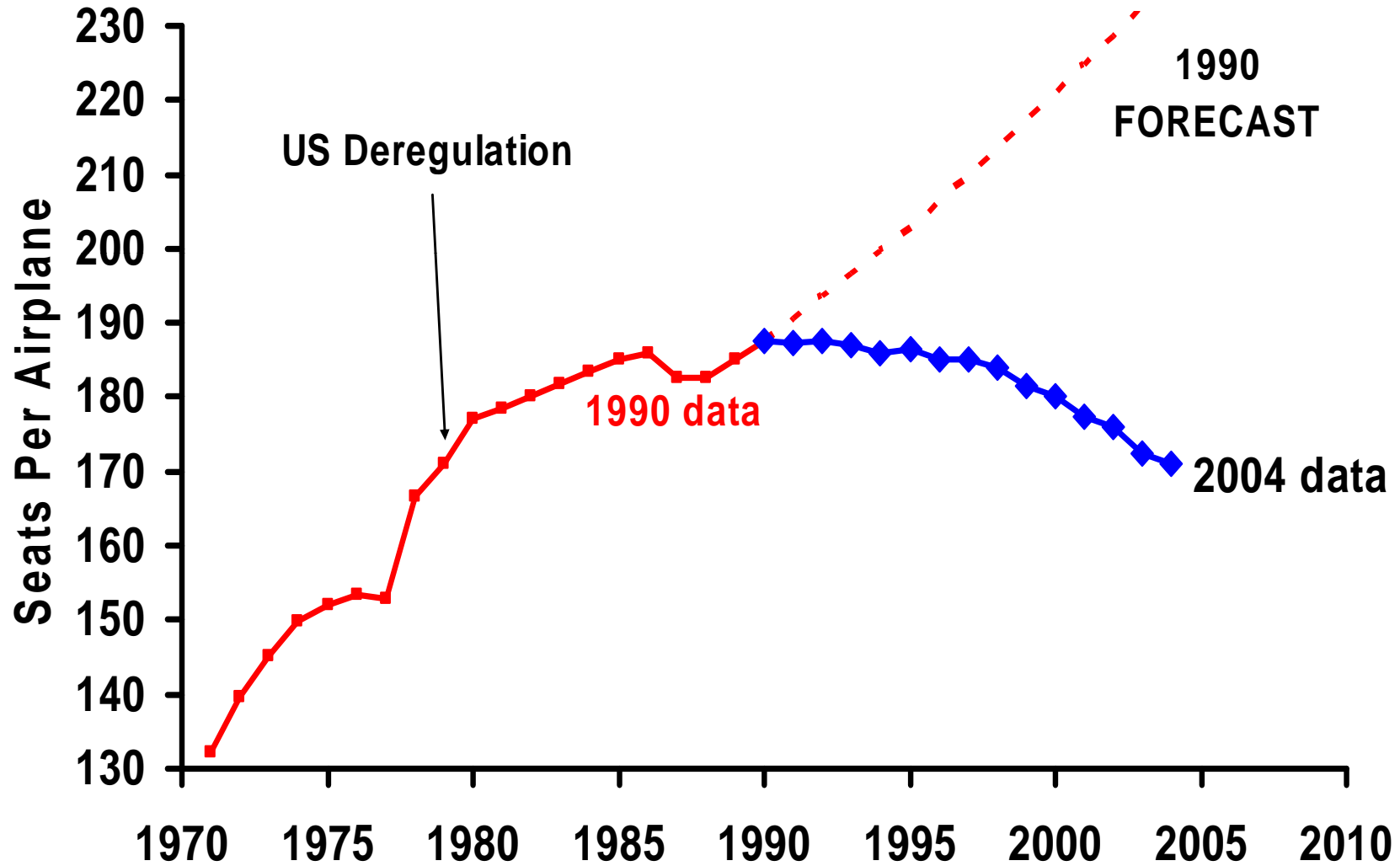


Later Development bypasses Early Hubs

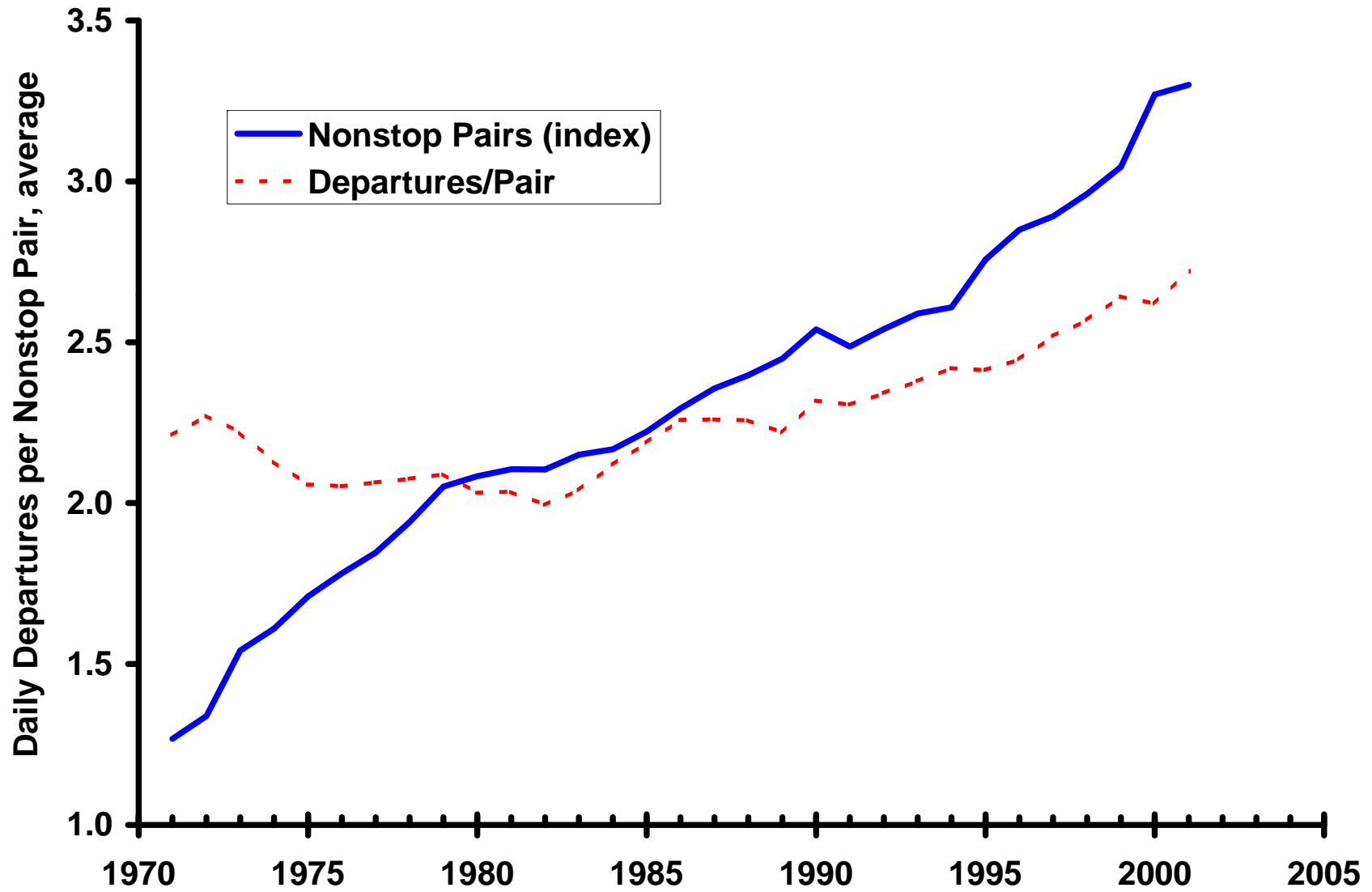
# Largest Routes are Not Growing as bypass flying diverts traffic



# Forecasters in 1990 Were Confused



# What We Missed: New Routes



# Why Secondary Hubs?

## Airlines Hate Competition

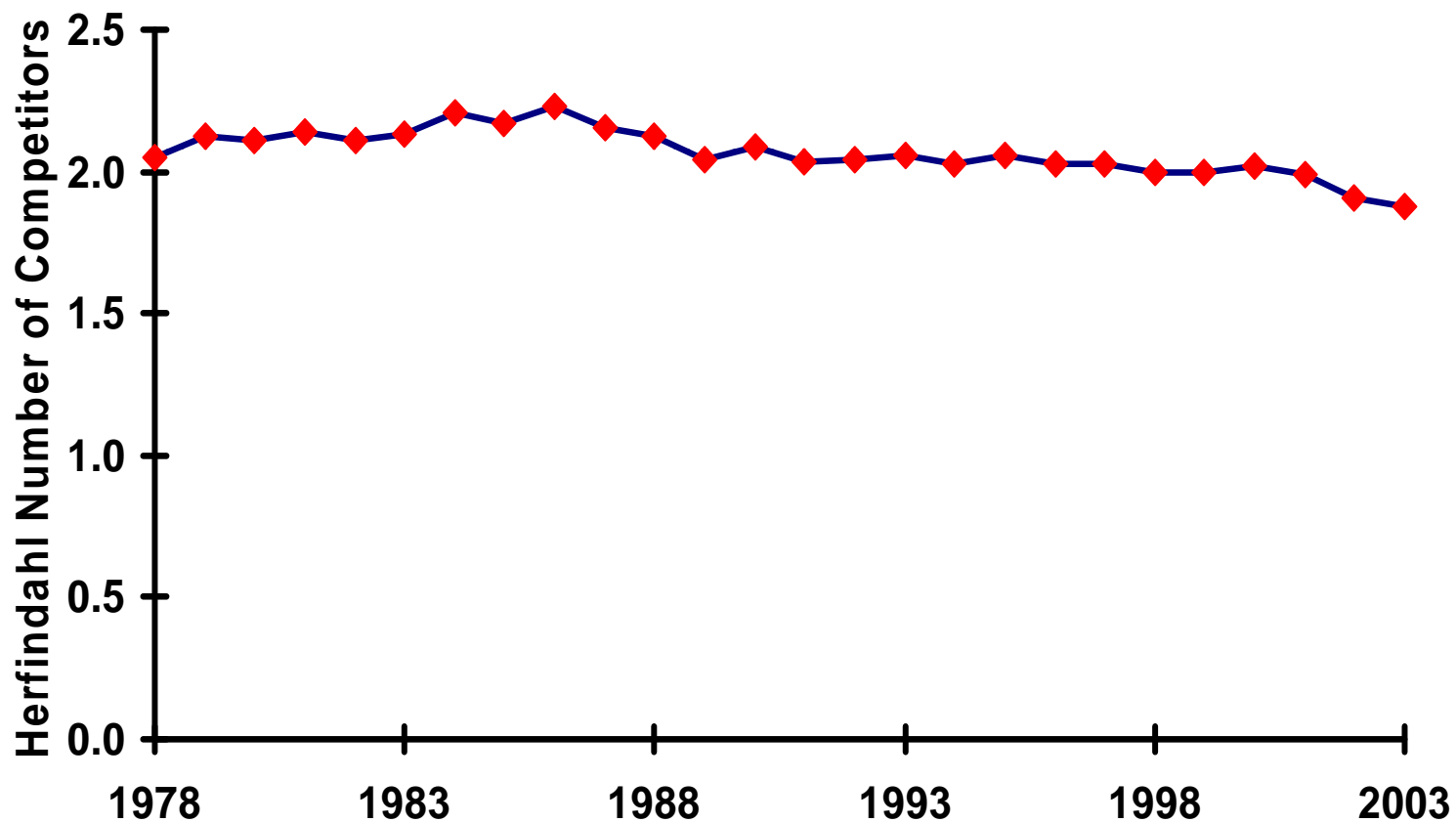
- Avoid “head-to-head” whenever possible
  - Preferred carrier wins big
    - Gets first choice of premium fare demand
    - Gets full loads during off peaks
    - Leaves 2<sup>nd</sup> choice carrier low yield, high peaking
  - Result: Lots of new routes



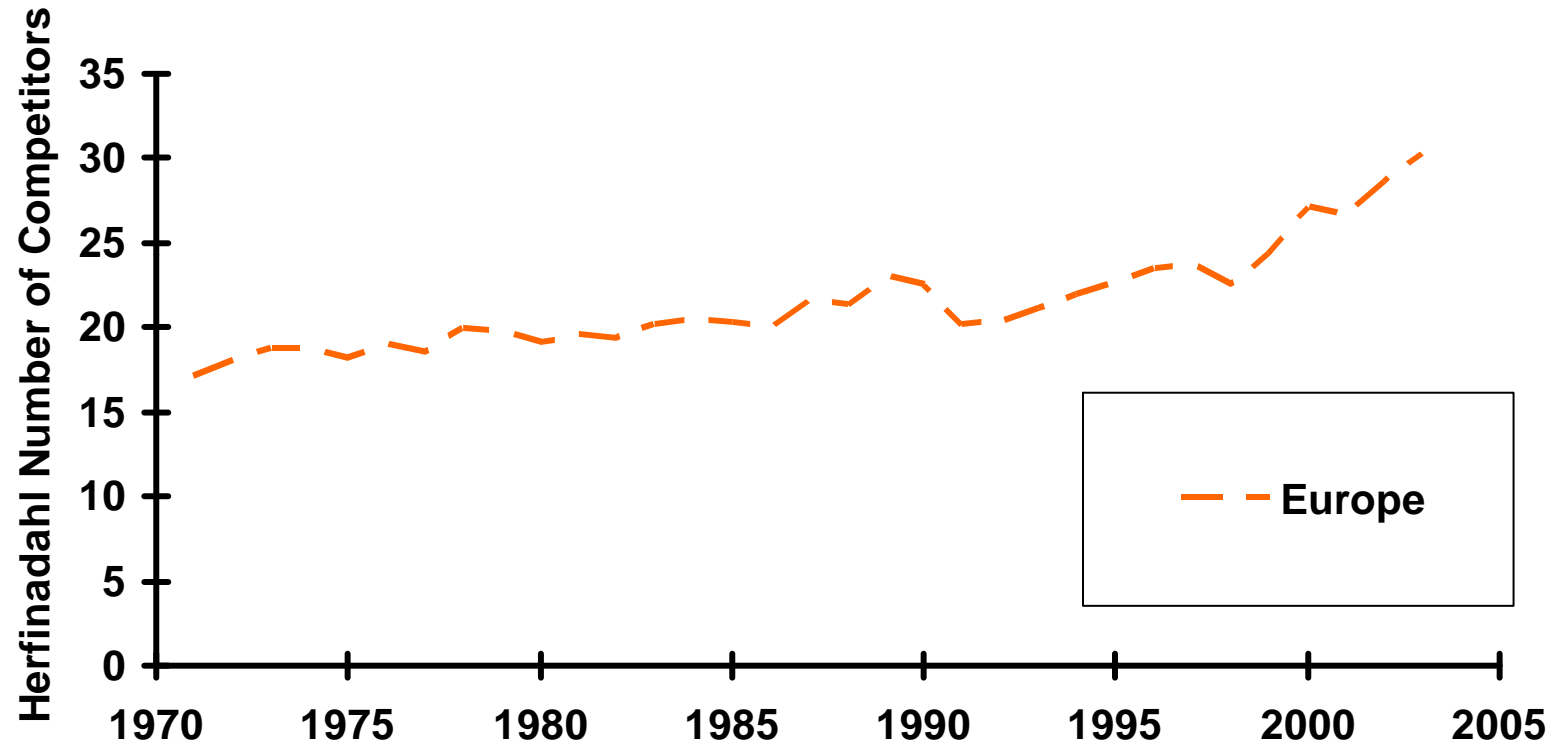
# Passengers' Perspective

## World Average Number of Competitors

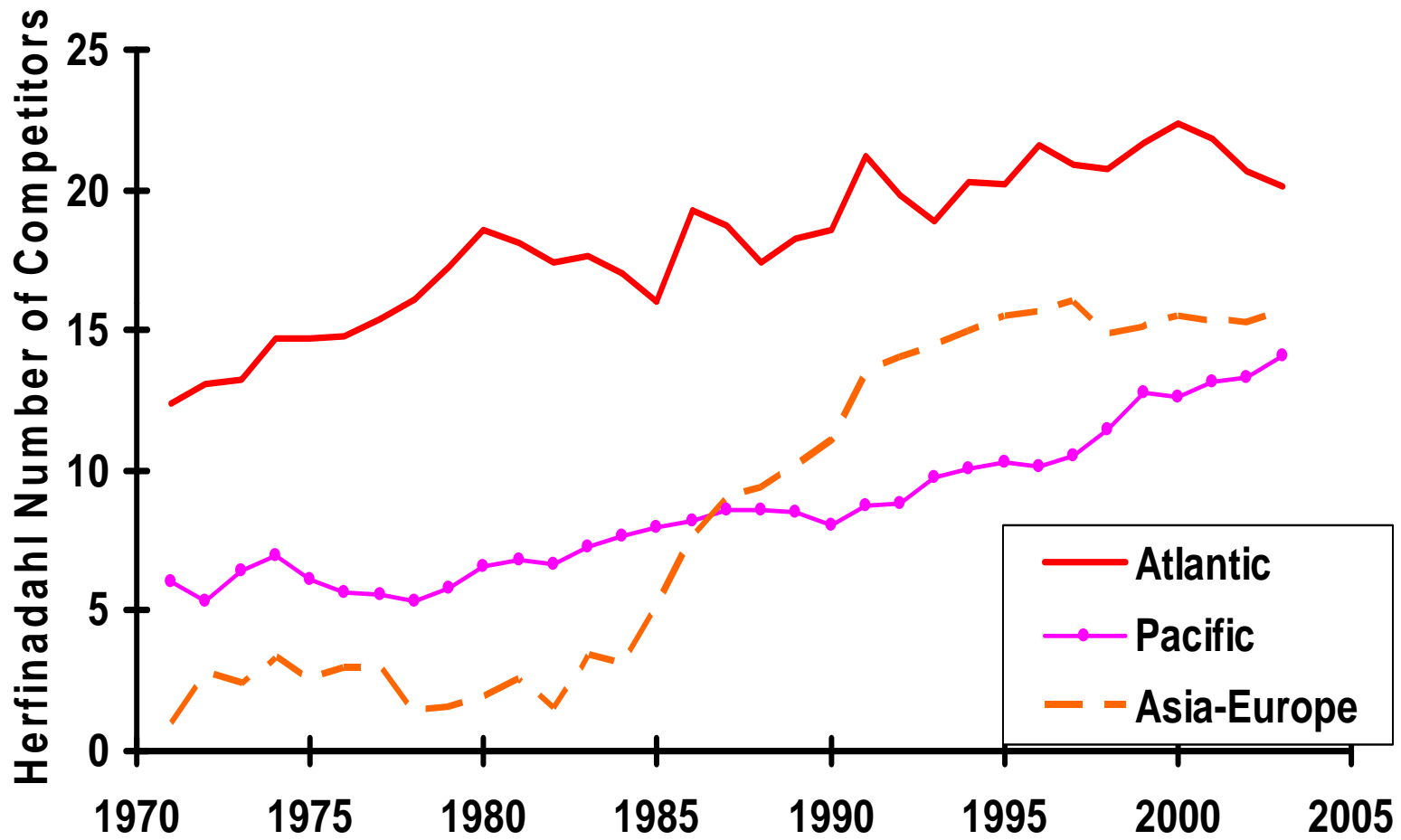
### Small Decline based on Airport Pairs



# Increasing Regional Competition



# Rising Competition in Long-Haul Flows



# Southwest and LCCs

## New Airlines from Deregulation

- 19 out of 20 start-ups failed
- WN (Southwest) succeeded
- America West (hubbed) survived (+AirTran)
- LCCs had 20% cost advantage from labor
- WN had “shuttle technology”
  - Engineered for loading and unloading
  - Reliability from high frequency
  - Incidental connections high (30%)
  - Business airline: not “cheap,” Just good
  - Good employee relations; reasonable wages

# The 2nd Big Event Nobody Noticed

(Post-Deregulation in 1998)

- Airlines were paying \$3/segment booking fees
  - Computer reservations systems owned by AA, UA
  - Travel agents hooked to mainframes
    - Agents got 8-15% booking fees
    - Agents got bribes to sell AA, UA, DL....dominant networks
- Southwest refused to pay fee
  - Was thrown off reservations systems
  - Continued to sell on internet
  - No drop in Southwest business
  - No one noticed
- Majors' Res systems no longer in control

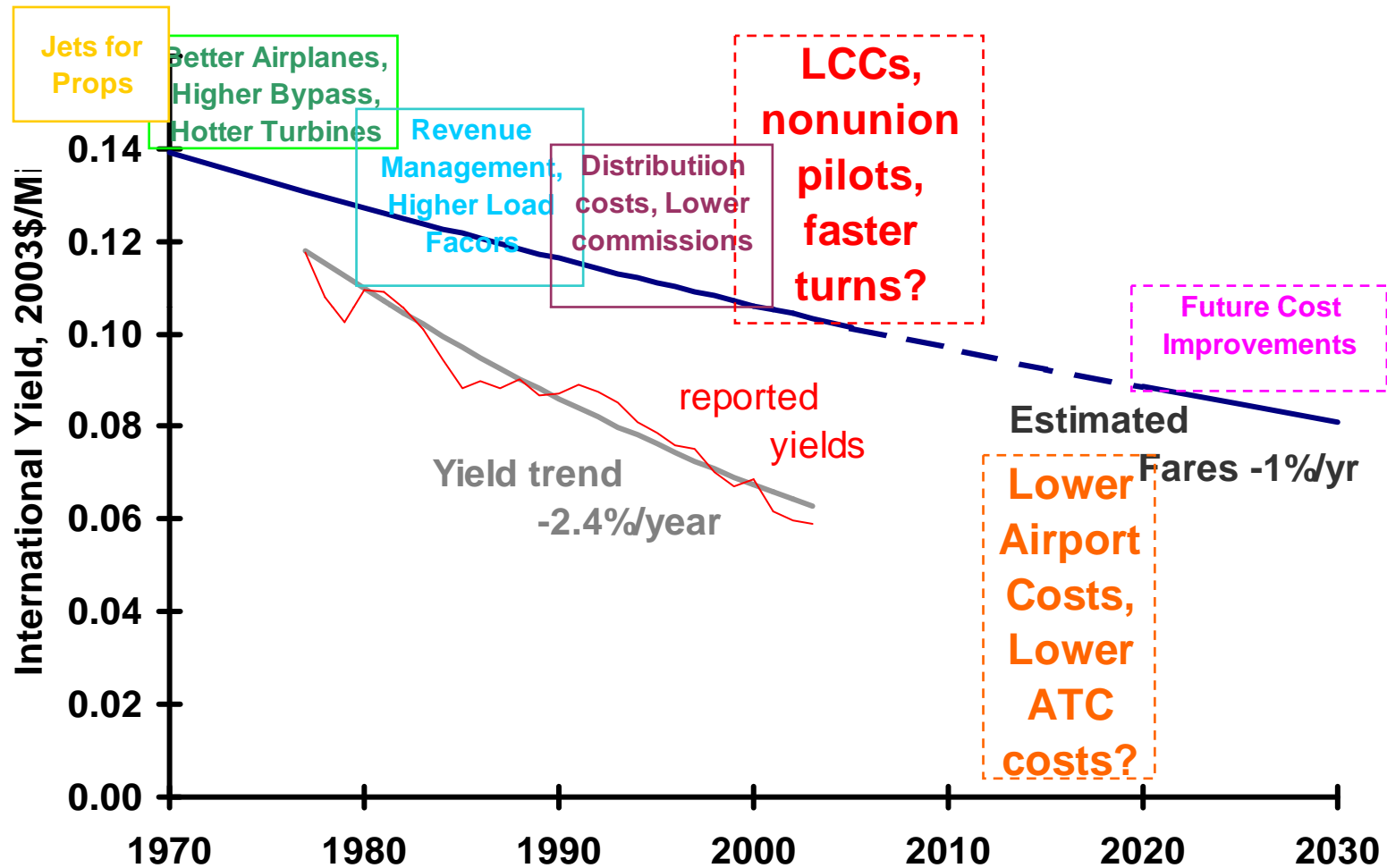
# Consequences of 2<sup>nd</sup> Event: It was Easier to Start and LCC

- Start ups no longer had to pay majors
  - Previous Res System profits greater than airline's
  - Majors owned Res Systems
  - *Majors no longer controlled cost of entry*
  - Majors lost full information about competitor's prices
- Later consequence: Competitive Pricing
  - Direct-to-airline bookings made prices hard to monitor
  - Internet intermediaries compared multiple airlines sites
  - Cost of information on prices greatly reduced
  - *Now only 18 out of 20 start-ups fail = twice the successes*
  - Majors unable to extract rents to pay pilots' premiums

# The LCC/HCC War

- Airline Industry is forever young
  - Birth and death process
    - 38% of ASK service 20 years back, airline gone
    - 28% of today's ASKs with new airlines
    - Index of competition flat to rising
- HCCs have adapted
  - Labor rates down: wages, rules, retirement
  - Service quality, costs, and prices down
- LCCs will migrate services
  - Higher quality: boarding, onboard, reliability
  - More connections at higher prices
  - More price differentiation
  - Higher connecting share
- Who can tell which is which?

# Cost Reductions Keep Coming





# Evolution: Birth and Death

- 38% of the air travel 20 years ago
  - Was flown by carriers that do not exist today
- 28% of the air travel today
  - Is flown by carriers that did not exist 20 years ago
- Competition is greater now
  - By any reasonable technical measure
  - But only slightly greater. Almost unchanged
- Conclusion: A healthy industry requires
  - Failure of badly run airlines
  - Failure of most new start-up airlines
  - Success of some new start-up airlines
- Overall employment and services should grow

# Three Kinds of Hubs

- International hubs driven by long-haul
  - Gateway cities
  - Many European hubs: CDG, LHR, AMS, FRA
  - Some evolving interior hubs, such as Chicago
  - Typically one bank of connections per day
- Regional hubs connecting smaller cities
  - Most US hubs, with at least 3 banks per day
  - Some European hubs, with 1 or 2 banks per day
- High-Density hubs without banking
  - Continuous connections from continuous arrivals and departures
  - American Airlines at Chicago and Dallas
  - Southwest at many of its focus cities
  - Even Ryan Air

# EVERYBODY has a Hub

- US majors are 50% connecting
  - Higher, if you count revenues or profits
- The famous LCC, Southwest, is 1/3 conx
  - Sells connecting & Through tickets
  - Uses connects for discount fill traffic
- Ryan Air is 15% connecting traffic
  - They try but fail to discourage it

# What Evolves?

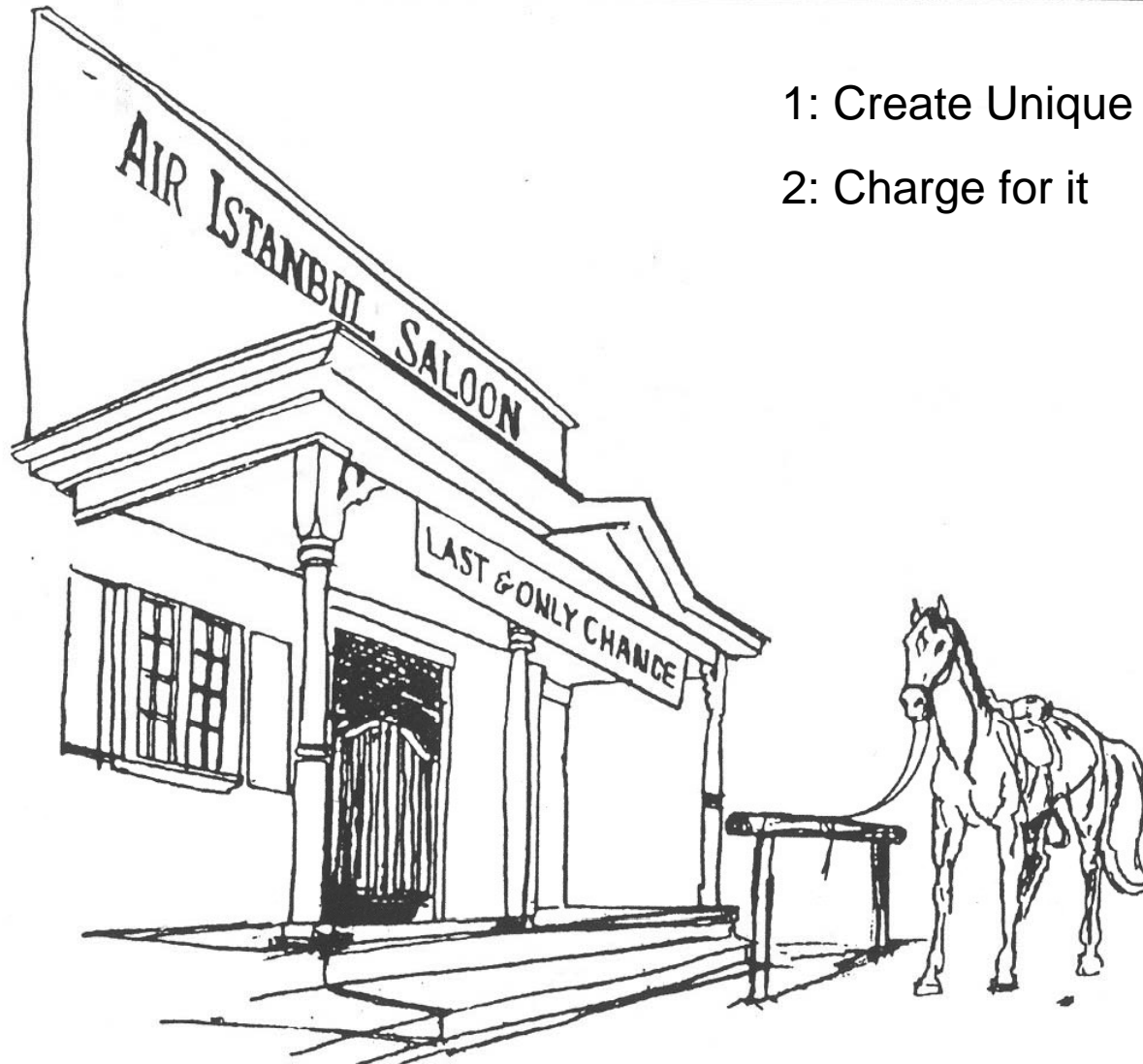
- Hubs
- Secondary hubs
- New routes
- Continued cost improvements
- Birth and death of airlines
- Airplane size mix seems static
- Competition increases, but slowly

# Wining Strategy: be The One Horse in a “One-Horse Town”

---

1: Create Unique Value

2: Charge for it



**William Swan:**



**Data Troll**

**Story Teller**

**Economist**



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