

# Estimating the Gains from Liberalizing Services Trade: The Case of Passenger Aviation

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# Liberalization and services trade

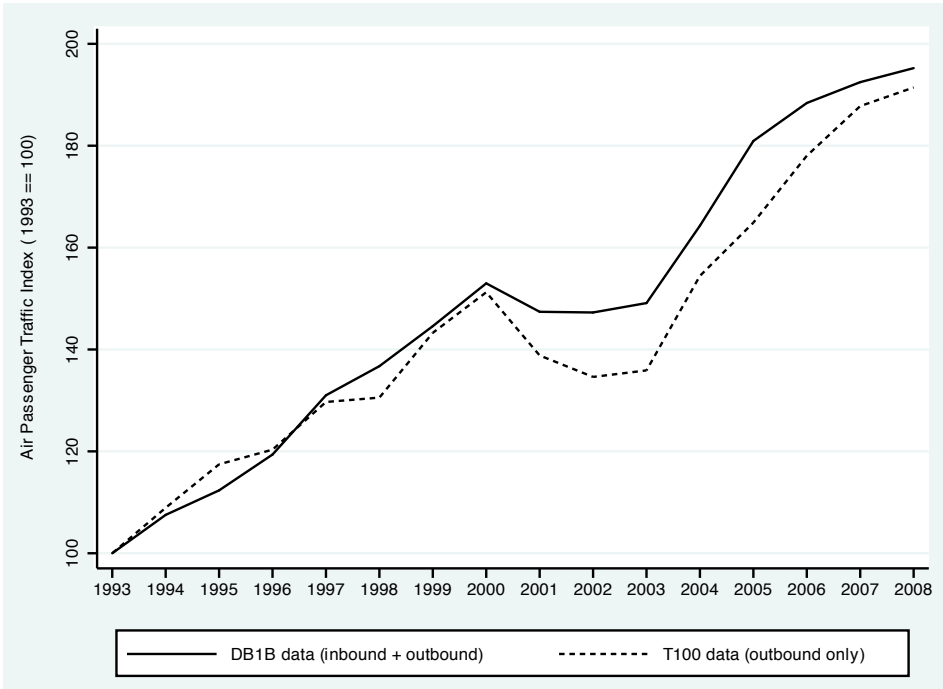
- We **know relatively little** about how services trade is affected by efforts at **liberalization**. Why?
- Measurement:
  - Services trade data are highly aggregated;
  - Values, not P and Q
- Policy change is difficult to quantify
  - Existing rules are complex and focus on regulating the manner in which services are provided.
  - Literature uses indices, relies on cross country comparisons

# We focus on passenger aviation. Why?

- International passenger aviation is important
  - Big (US + EU = \$190bn/year)
  - A key input into
    - merchandise trade (Poole 2009, Cristea 2011)
    - knowledge flows (Hovhannisyan and Keller 2011)
    - Other services (GATS mode 2, mode 4)
- We can specifically characterize how regulations affect the provision of services

# Data on aviation and policy change

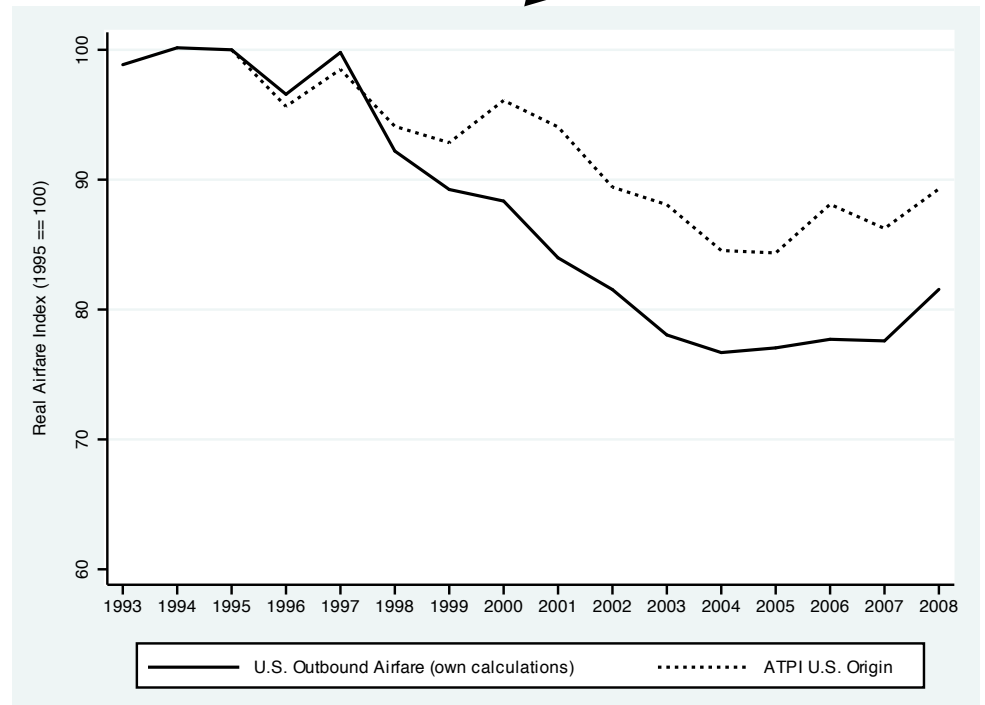
- We have detailed **transactions** data on US passenger aviation, 1993-2008.
  - Prices, quantities for each carrier competing for precisely defined services (IND -> Copenhagen)
- We have a nice source of **policy change**:
  - From 1992-2007, the US signs 87 bilateral “Open Skies Agreements” that liberalize aviation markets.
  - Another 21 agreements signed 2008-2013.



← The quantity of international passengers leaving the US doubles.

While prices fell 15-20%

Were these changes due to liberalization?  
Or other shocks to demand, input prices, technology?



# Outline

- Institutional details of liberalization
- Model of passenger aviation market
  - Carriers choose entry, network formation, and capacity. Set pricing function to adjust to random demand shocks
  - Focus: how do existing regulations distort these choices?
  - Key features
    - Matches important features of this market: price heterogeneity, unused capacity, multiple routings that differ in quality
    - Predictions (ex-ante, ex-post realizations of average prices and quantities) map tightly into our empirics.
- Diff-in-diff estimation: how does liberalization affect
  - Networks, capacity allocation, carrier entry/exit
  - Consumer welfare:  $P$ ,  $Q$ , observed and unobserved quality

# Existing regulatory regime: Bilateral Air Service Agreements

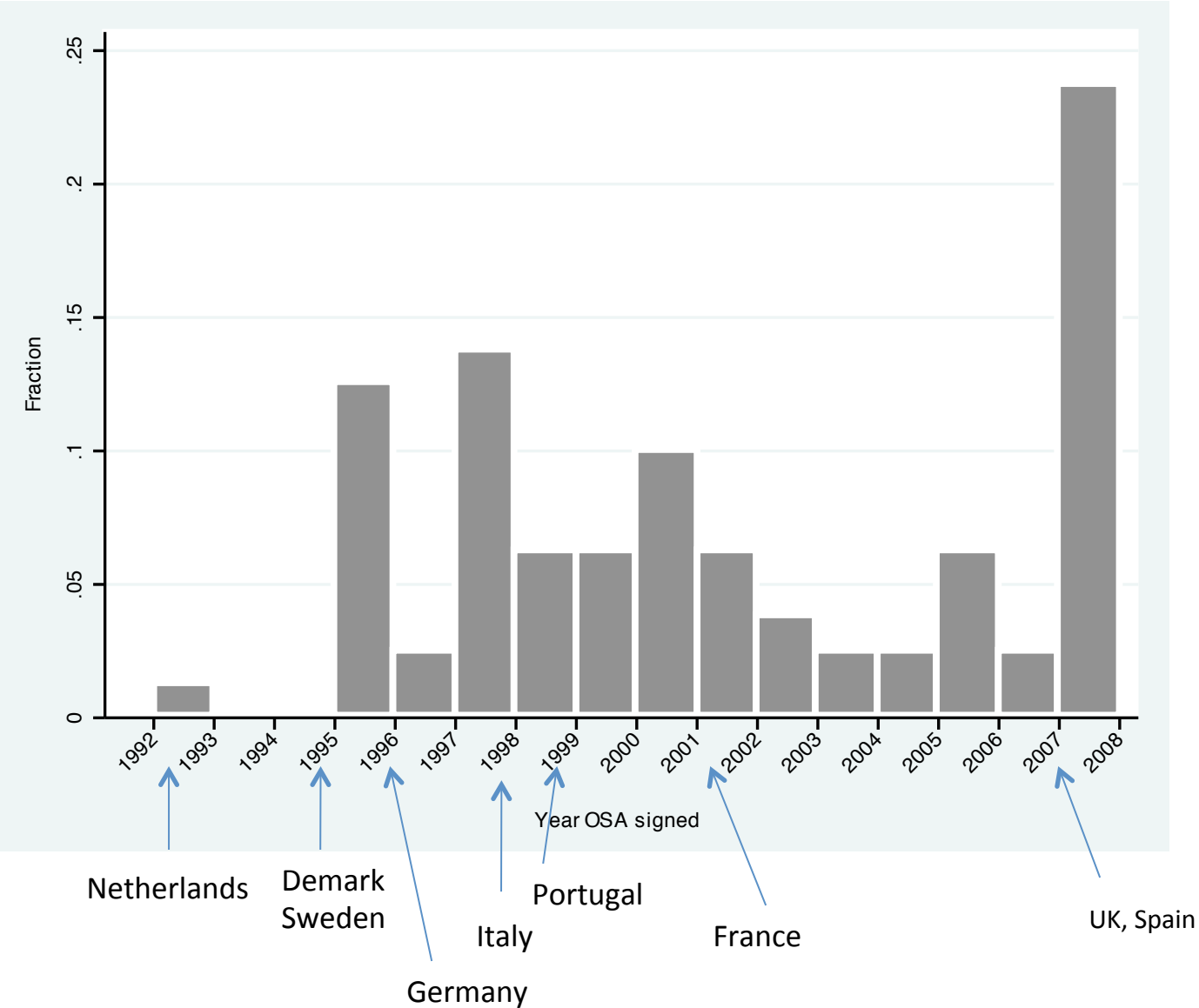
- Early efforts at multilateral agreements failed
  - Aviation is outside General Agreement on Trade in Services
  - In their place: complex web of bilaterals
- US China-Aviation Treaty 1980: Restricts
  - Routes: flights allowed only between
    - LA, SF, NY, Honolulu
    - Beijing, Shanghai
  - Entry: Only 2 carriers per country can offer service
  - Capacity: Carriers can offer two flights per week for a given route
  - Prices: Price changes must be submitted to DC, Beijing for approval two months in advance.

# Bilateral Open Skies Agreements

- Starting in 1992, US begins to sign OSA to liberalize air services with specific partners
- Remove most existing restrictions
  - No limit on carriers, routes, capacity (**our focus**)
  - Price setting at carriers discretion (**...in progress**)
- Aside: OSAs grant new benefits
  - Extensive “beyond” market rights
  - Allow inter-airline cooperation (alliances, codesharing)



# Timing of open skies agreements



Agreements are signed sequentially; order weakly correlated with GDP per capita

Europe spread throughout sample.

NZ 1997, Australia 2008

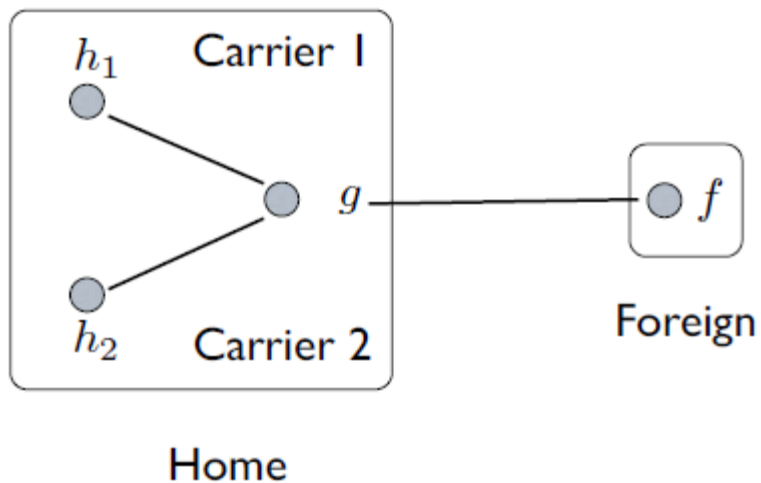
See Table A1

# Endogeneity of OSAs ?

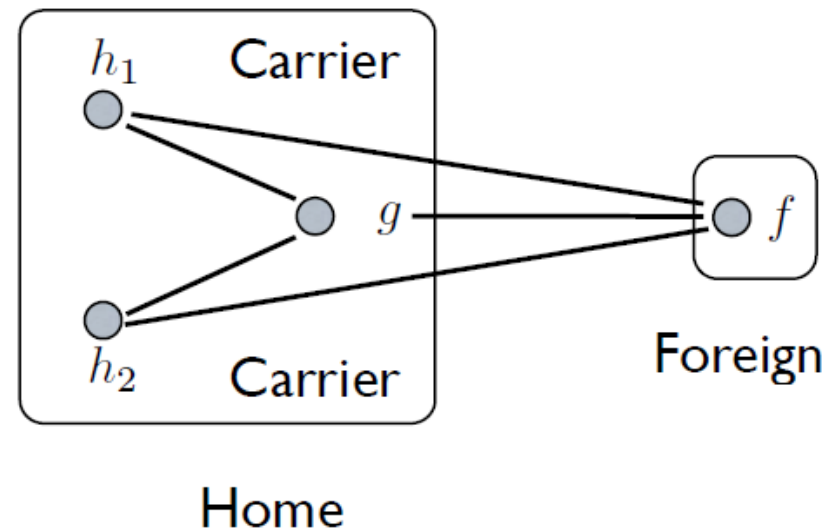
- OSAs are boilerplate agreements, negotiated by State Department
- As of 8/2013 108 countries have signed.
  - Notable exceptions: China, Mexico, Philippines, Argentina
- Why do some countries sign early?
  - No clear statistical pattern in timing of signings.
  - Bob Zoellick USTR (2000-2005) to me: “I have no idea. Likely has more to do with diplomatic issues than economic.”
- Our estimates focus only on signatories.
  - The identification is not who signs, but when each country signs.
  - We take timing as exogenous, conditional on city pair fixed effects, and time varying demand shocks.

# OSA removes route restrictions

## Pre-OSA



## Post-OSA



Pre OSA:

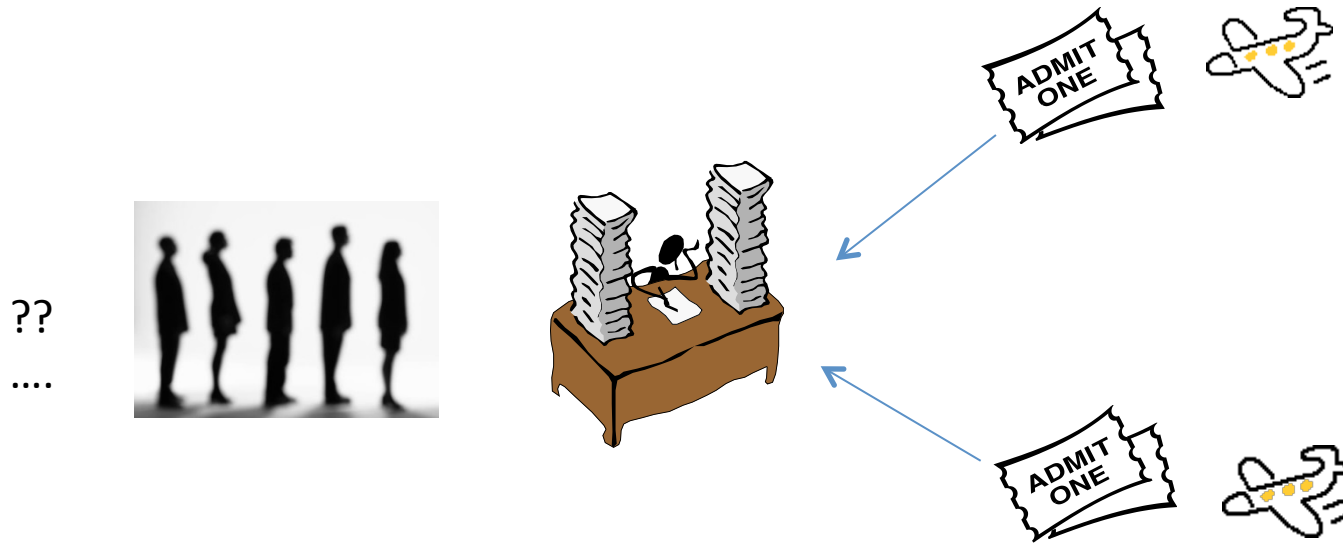
1. Flights can only enter/exit US through gateways (G).
2. To reach other hubs (H), domestic carriers must use indirect flights.
3. Foreign carriers cannot serve hubs.
4. Capacity constraints on gateway may also bind.

# Model: route restrictions, capacity

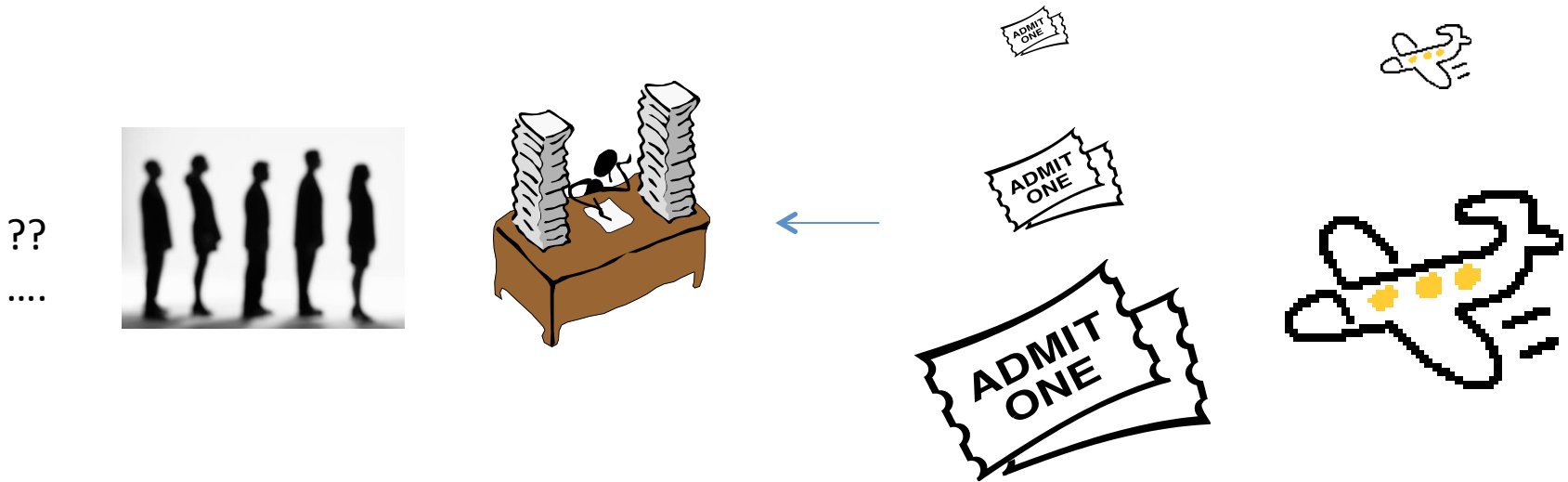
- How do route restrictions affect
  - Marginal cost of production
  - Consumers valuation of flights (directness)
  - Carrier entry/exit on some routes
  - Allocation of capacity between gateways and hubs
- Capacity
  - Route restrictions misallocate capacity across routes
  - Aggregate constraints on flights

# Cost structure

- Carriers offer a fixed capacity at cost per seat
  - $\lambda I$  for international segment
    - Whether direct or as part of indirect flight
  - $\lambda D$  for domestic segment of indirect flights
- Route restrictions increase the capacity cost of offering international flights to hubs.
- Aside: capacity cost are linear
  - could make it nonlinear to reflect fixed costs of establishing hubs, or allow economies of route density.
  - Will be flexible about this in empirics.



1. Customers
  - a. have unit demands, unique reservation values
  - b. queue up in random order at the ticket desk
  - c. purchase lowest (quality-adjusted) price ticket that is below reservation value
  
2. Carriers set pricing schedule without knowing
  - a. The reservation value of a specific customer
  - b. How long the queue is (high or low demand state)
  - c. Where other carriers are in pricing schedule



## Carriers' problem

Stage 1: choose routes and set capacity on a route

Stage 2: offer an ordered ration of ascending ticket prices

Stage 3: realize demand shock ( $e$ ), and sell  $Q(e)$  tickets at varying prices.

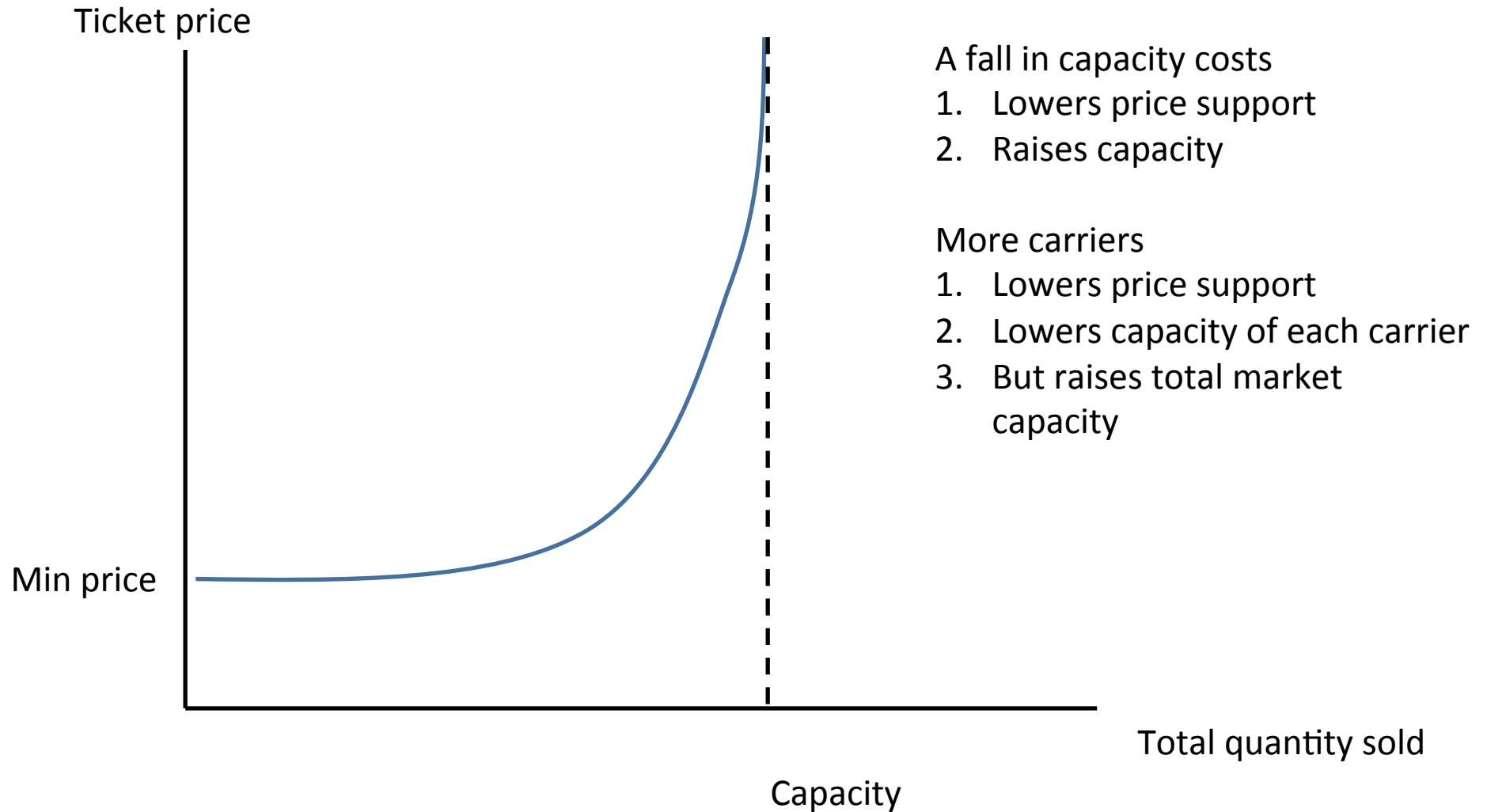
Key: ticket rationing schedule is set in advance, but the ascending order allows the marginal ticket price to respond to varying realizations of demand.

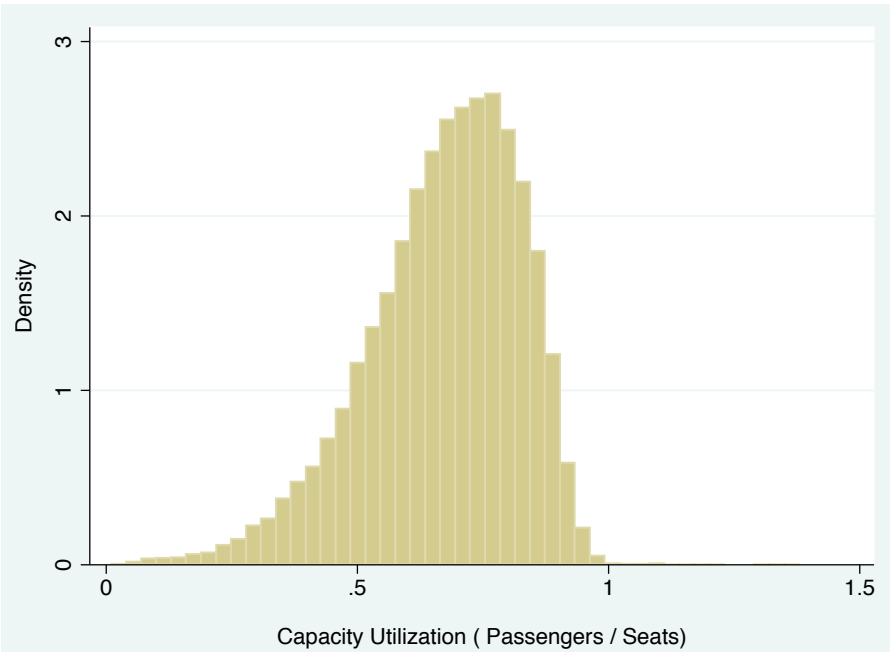
# More formally

- Random demand  $q = eA(p/\alpha)^{1-\epsilon}$ 
  - Consumers have unit demands with heterogeneous value. Demand curve aggregates over these valuations.
  - “e” rotates demand curve; changes the number of consumers at each reservation value.
  - $0 < \alpha < 1$  is price equivalent disutility for indirectness.  $\alpha = 1$  is indifference to taking connecting flights.
- Firms ration ticket offerings
  - Set MR equal across possible demand states.
    - With  $i=1\dots N$  discrete states, offer some  $q_i$  at  $p_i$
  - Continuously distributed e generates a pricing function.



# Single Carrier's Pricing Function



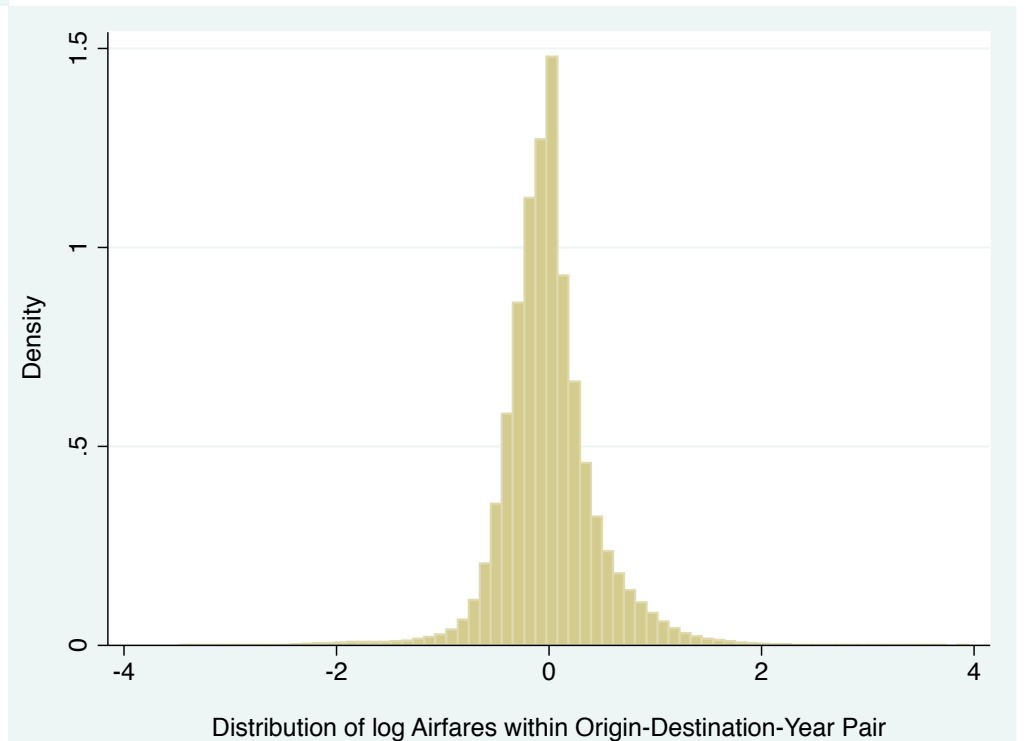


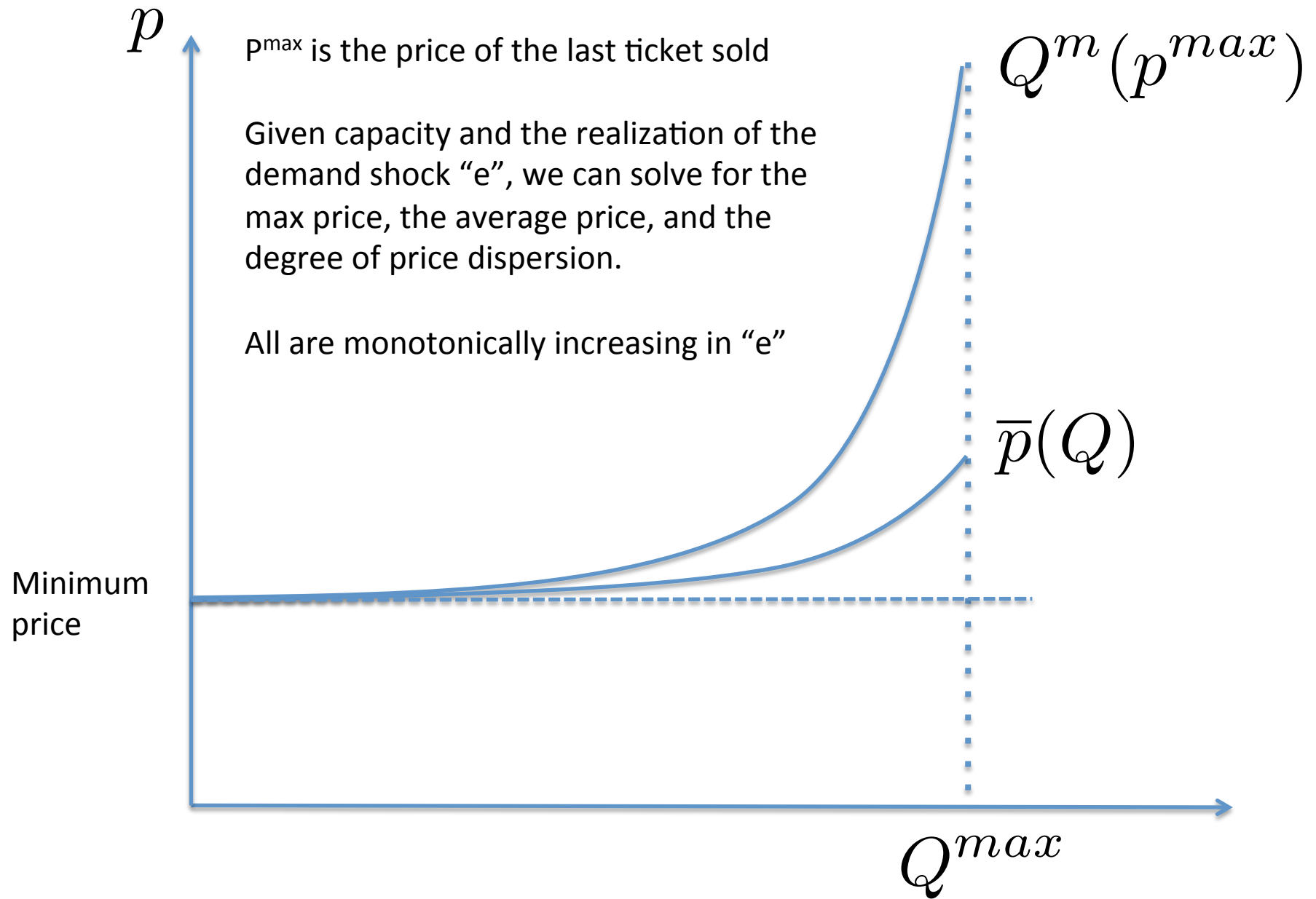
Median capacity utilization on international flights is 69%.

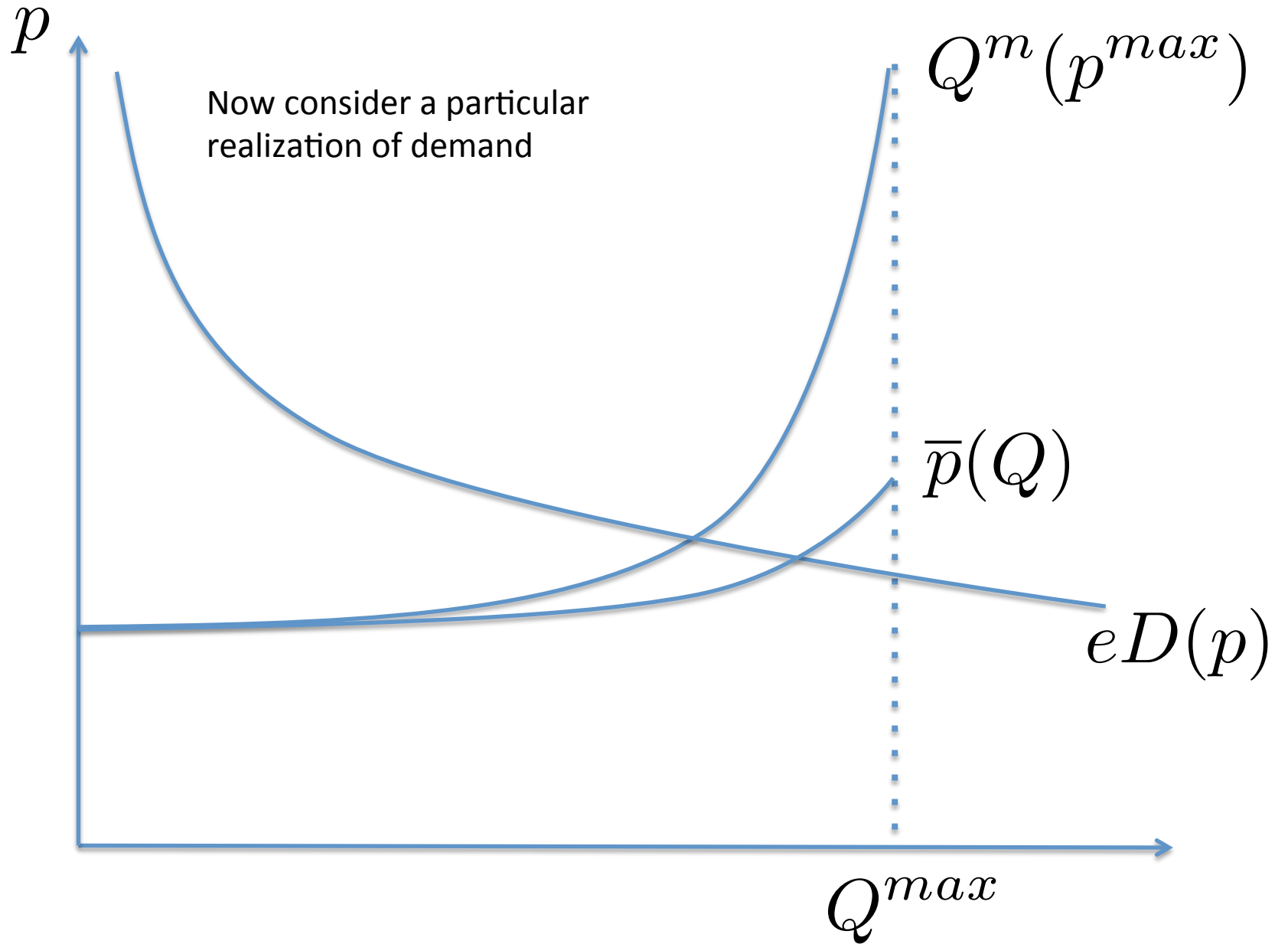
For a given city pair and year, prices vary significantly.

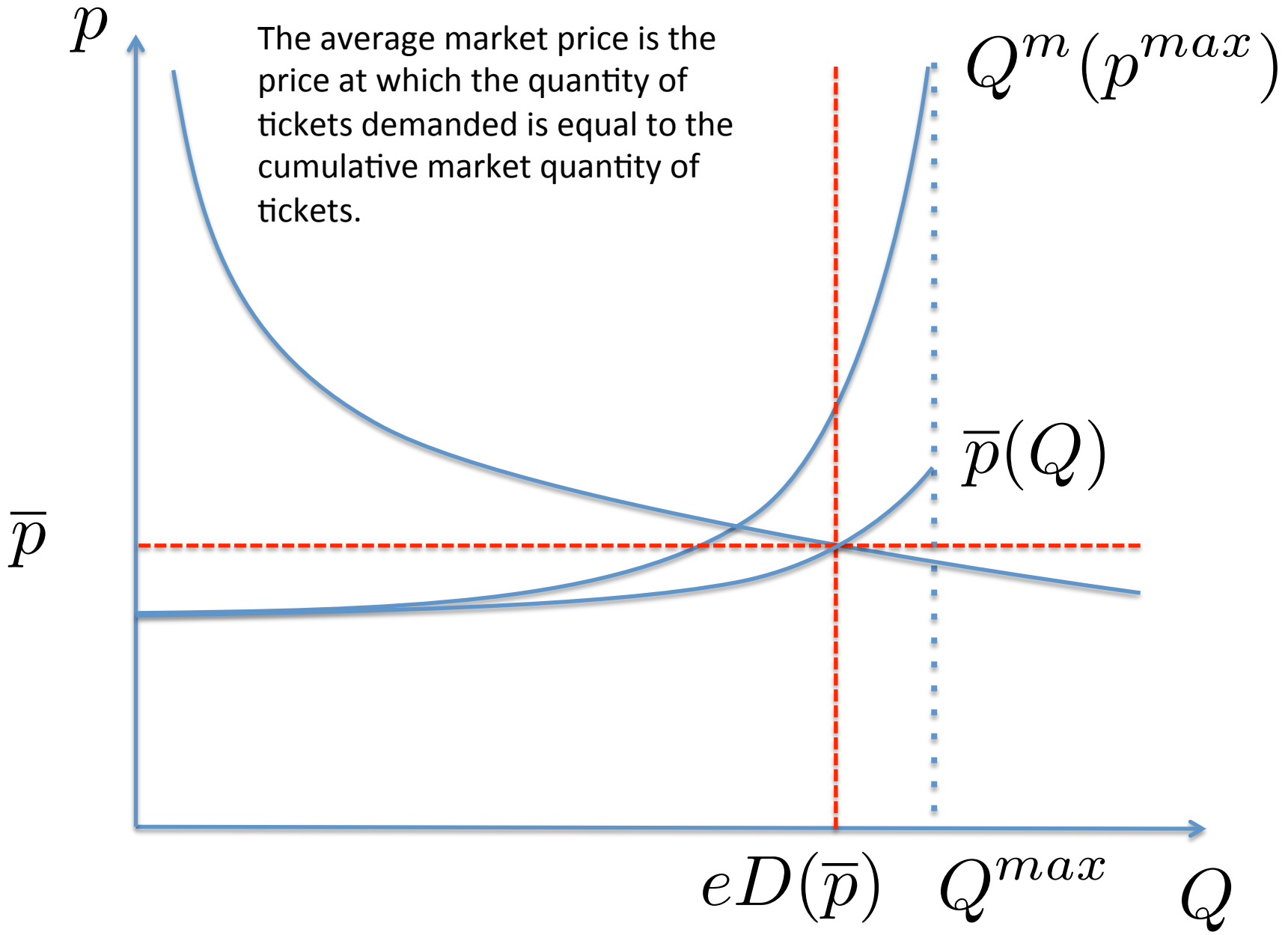
Stdev/mean = 0.43 log points.

90/10 = 0.93 log points.



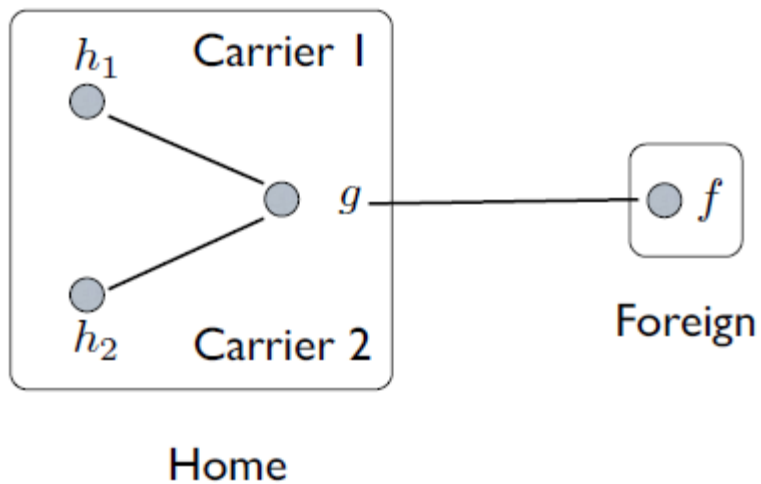




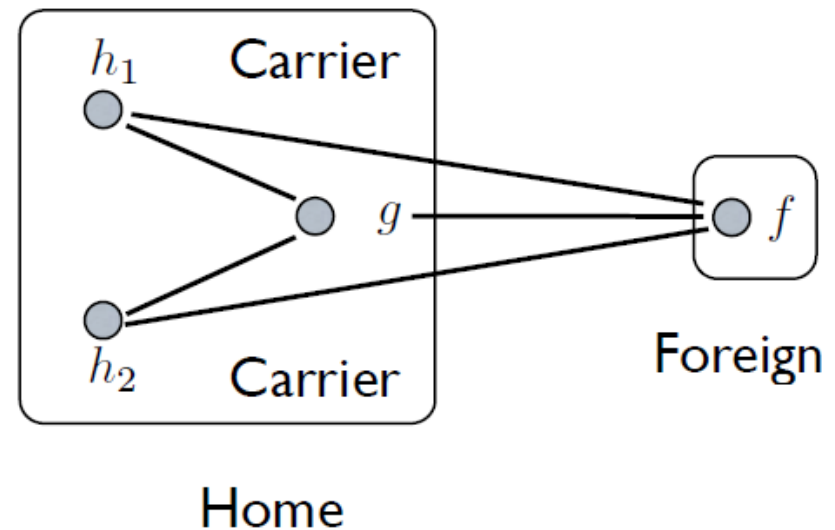


# OSA removes route restrictions

Pre-OSA

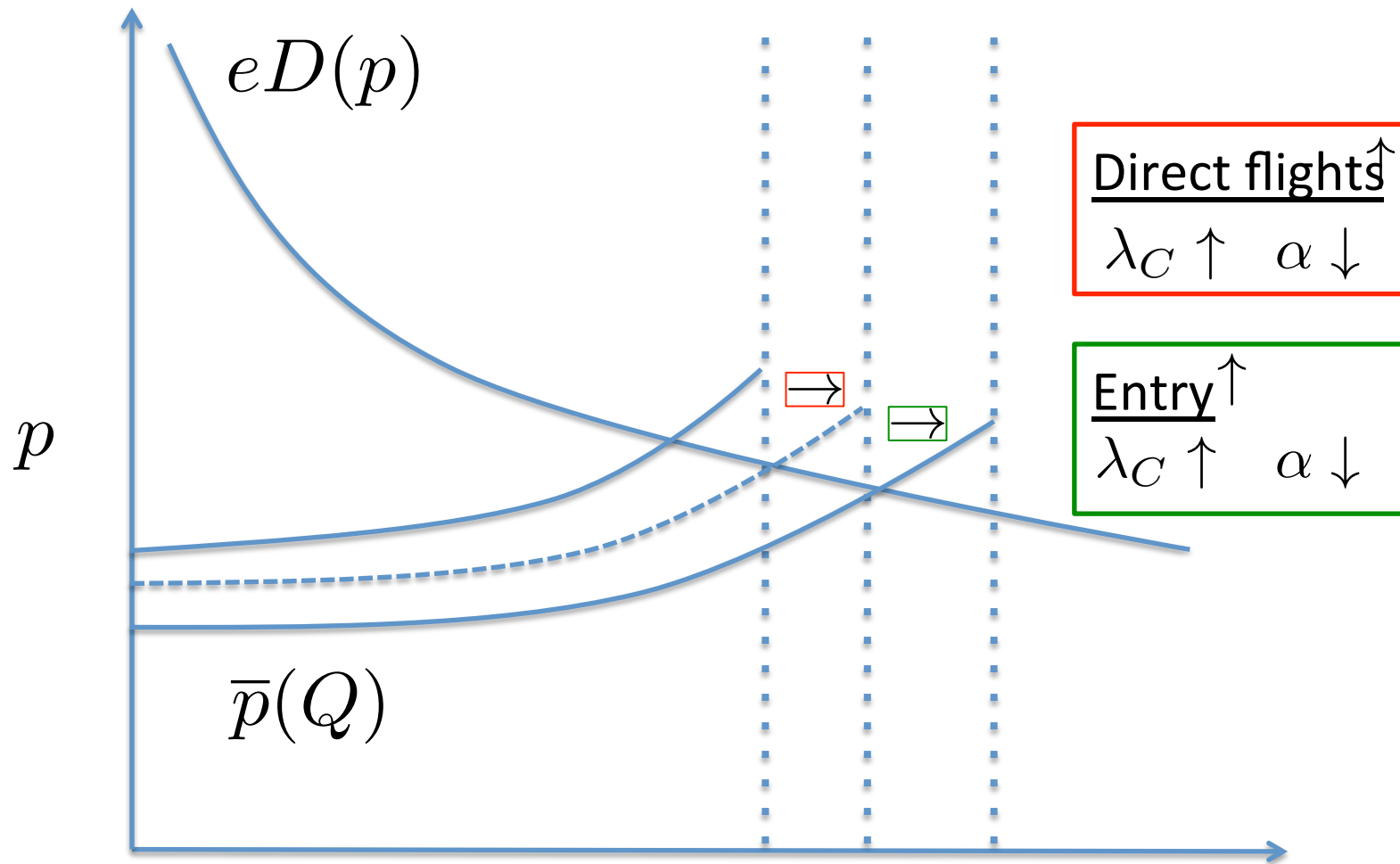


Post-OSA



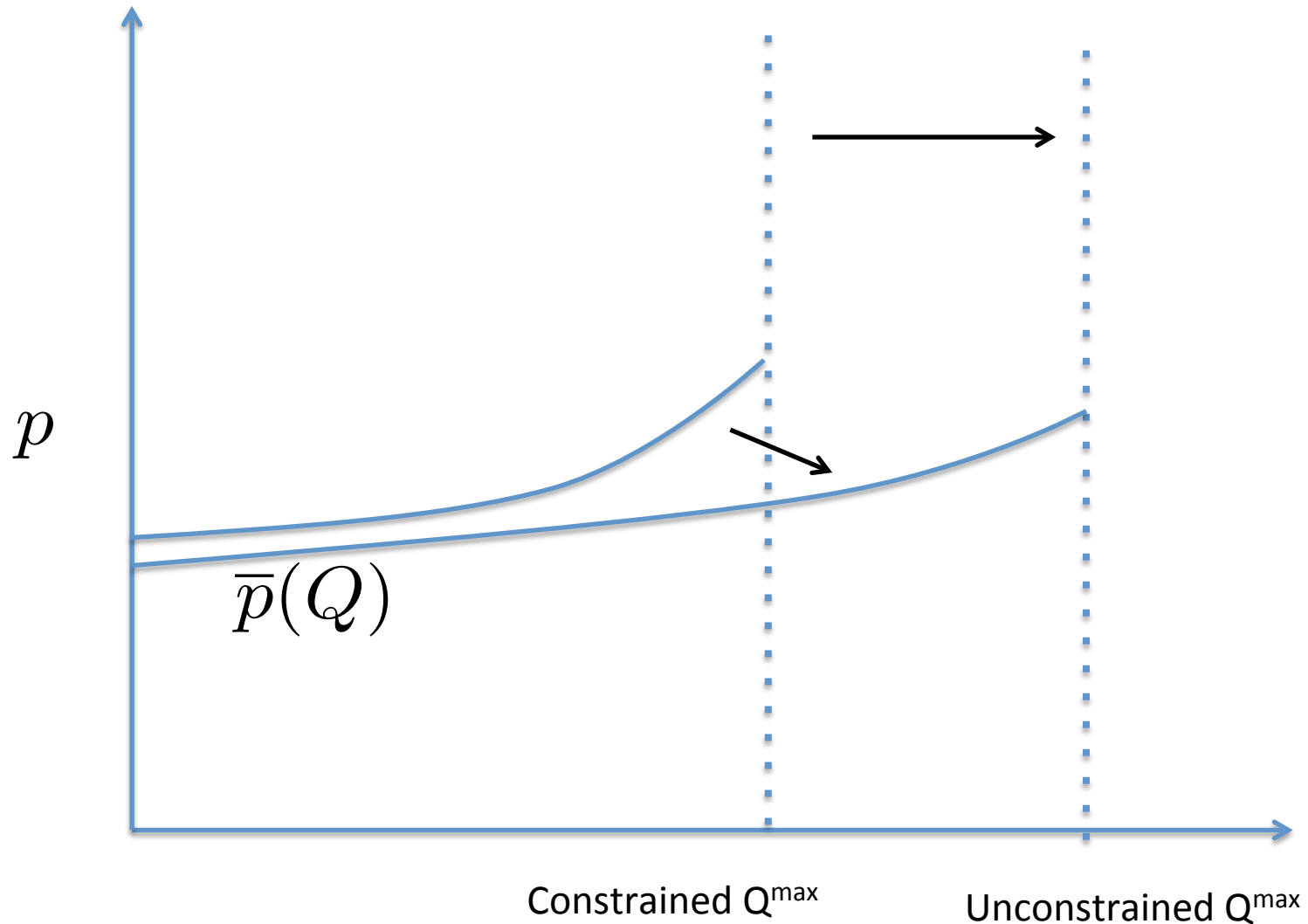
Pre OSA: can only enter/exit US through gateways (G). To reach other hubs (H), domestic carriers must use indirect flights. Foreign carriers cannot serve hubs. Capacity constraints on gateway may also bind.

# Liberalization Effects on Non-Gateway Hubs



Allowing direct flights, foreign entry: raises capacity and  $Q$ ; lowers average prices

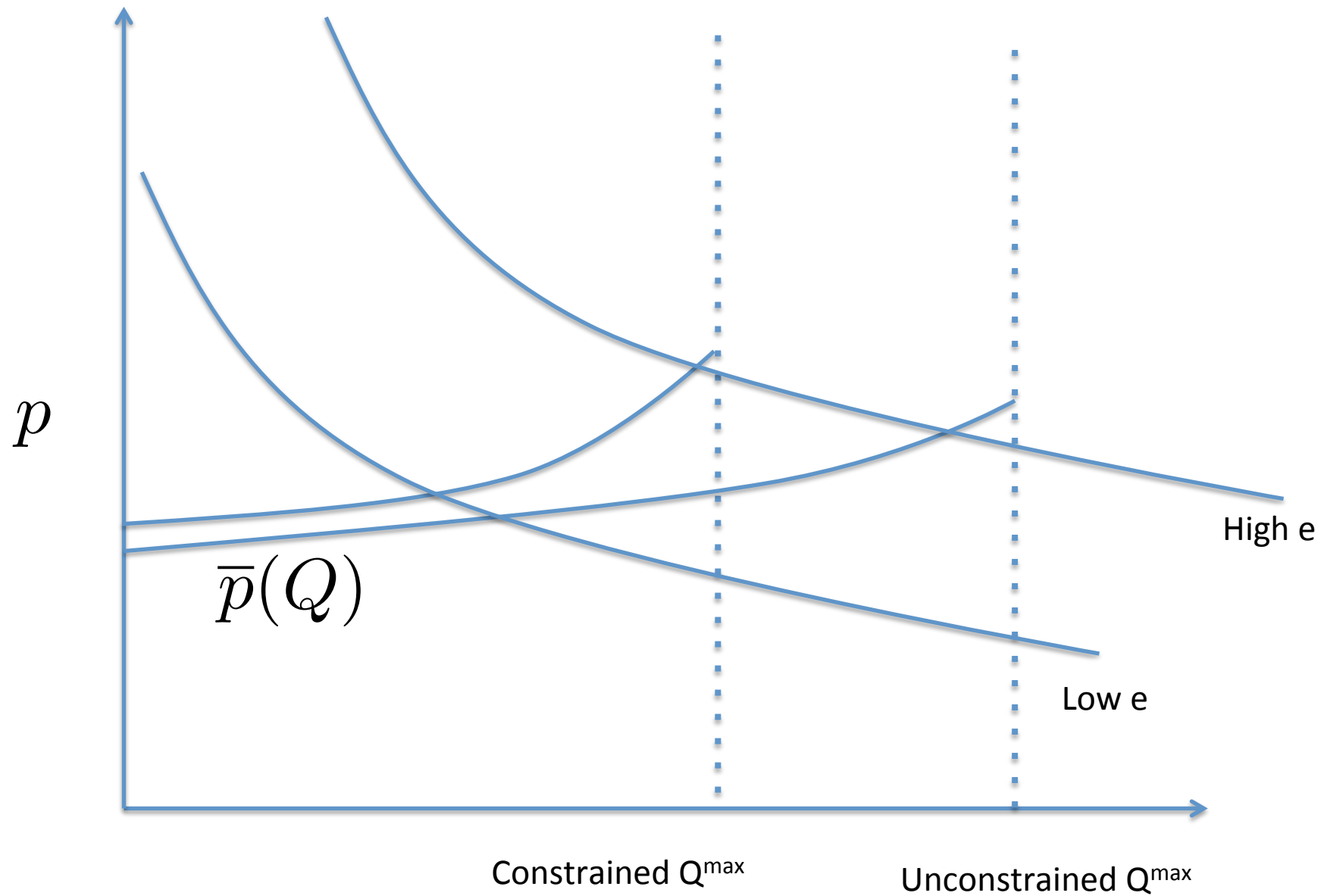
# Liberalization Effects on Gateways



Relaxing capacity constraints increases capacity, lowers average price



The impact on  $p$ ,  $q$  depends on the ex-post demand state



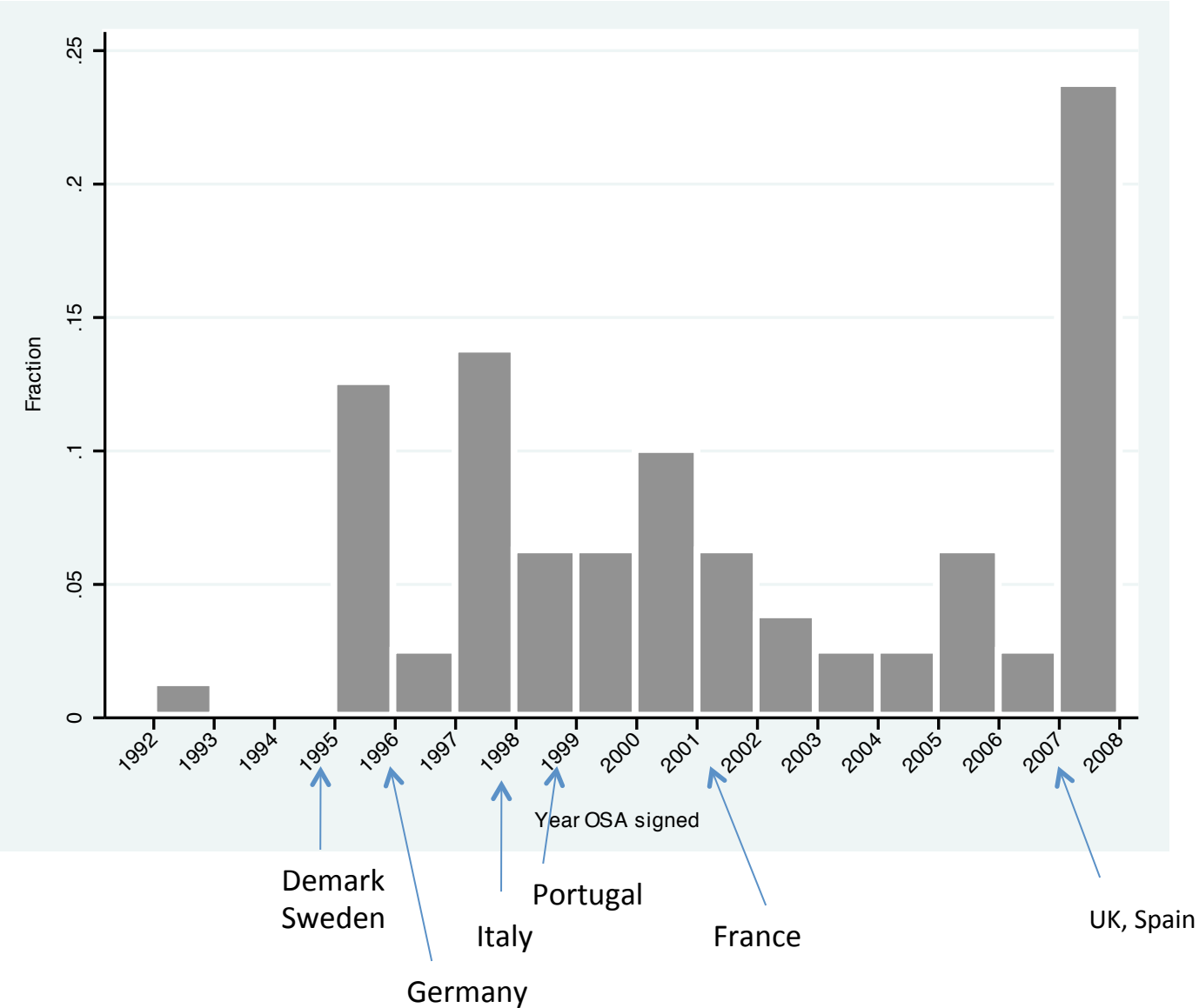
# Empirics: diff in diff.

- Evidence for key channels of the model
  - Passenger growth through expansion of new routes
  - Reallocation of capacity and carriers pre/post
- Consumer welfare
  - estimate changes in prices, quantities, quality (explicit, implicit).
  - Combine these into changes in quality-adjusted prices after liberalization. Vary by city type.

# Data

- T 100 International Segment Data
  - Traffic data by route (city-pair) x carrier
  - All non-stop flight segments crossing the US border
  - Number of passengers, departures, available seats
- Origin-Destination Passenger Survey
  - *Transaction* data: 10% sample of int'l airline tickets
  - air fare, service characteristics (fare class, distance flown, # segments, transit airports)
  - all segments of the itinerary and carrier(s)

# Timing of open skies agreements



Agreements are signed sequentially; order weakly correlated with GDP per capita

Europe spread throughout sample.

NZ 1997, Australia 2008

See Table A1

# Estimate the impact of OSA on traffic

Difference-in-difference estimation for the number of passengers traveling to destination  $j$  in quarter  $q$  of year  $t$

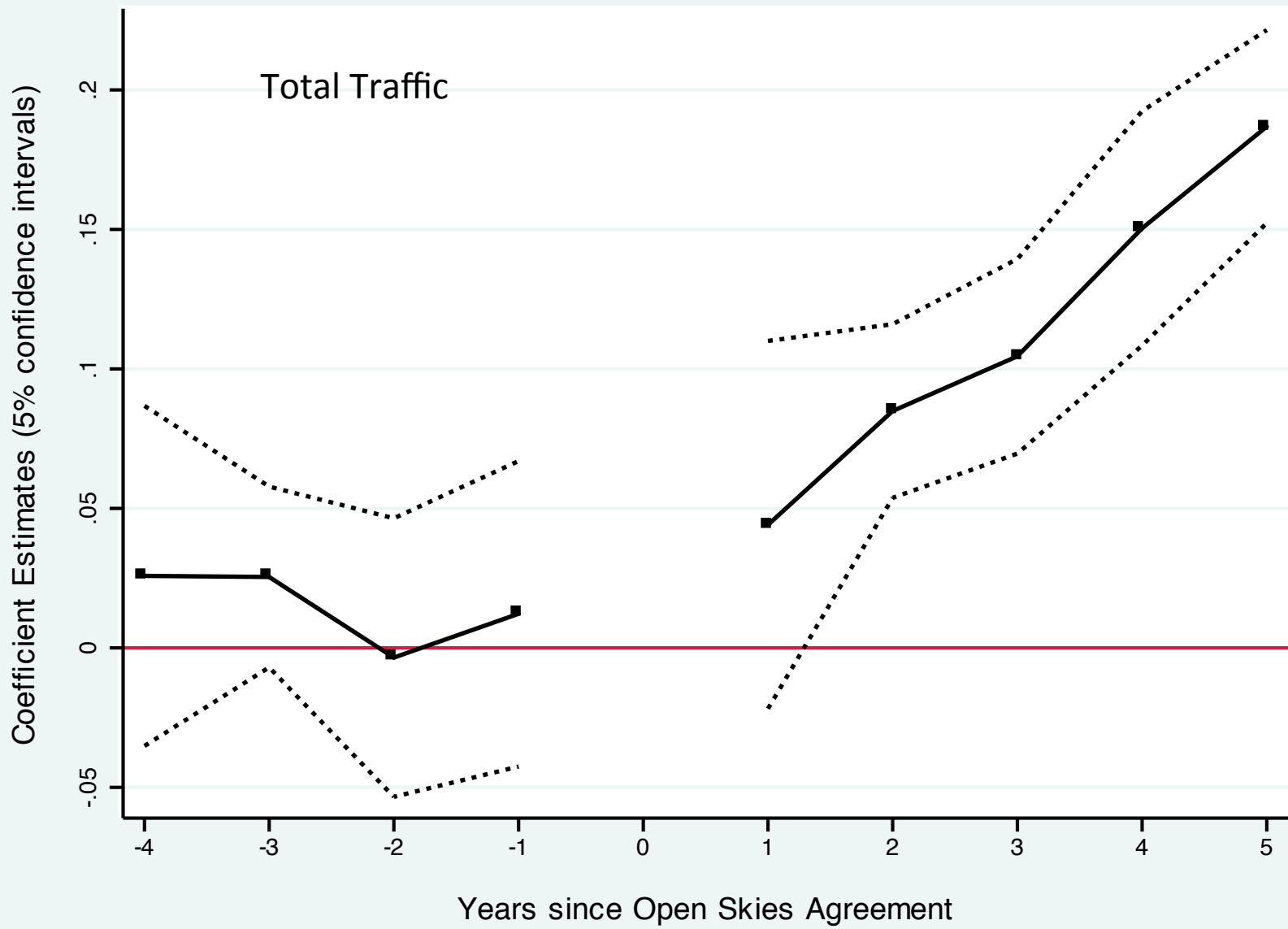
$$\ln Z_{j,qt} = \beta_1 OSA_{j,t} + X\beta + \alpha_{jq} + \alpha_t + \varepsilon_{j,t}$$

$Z$  is a a measure of passenger traffic

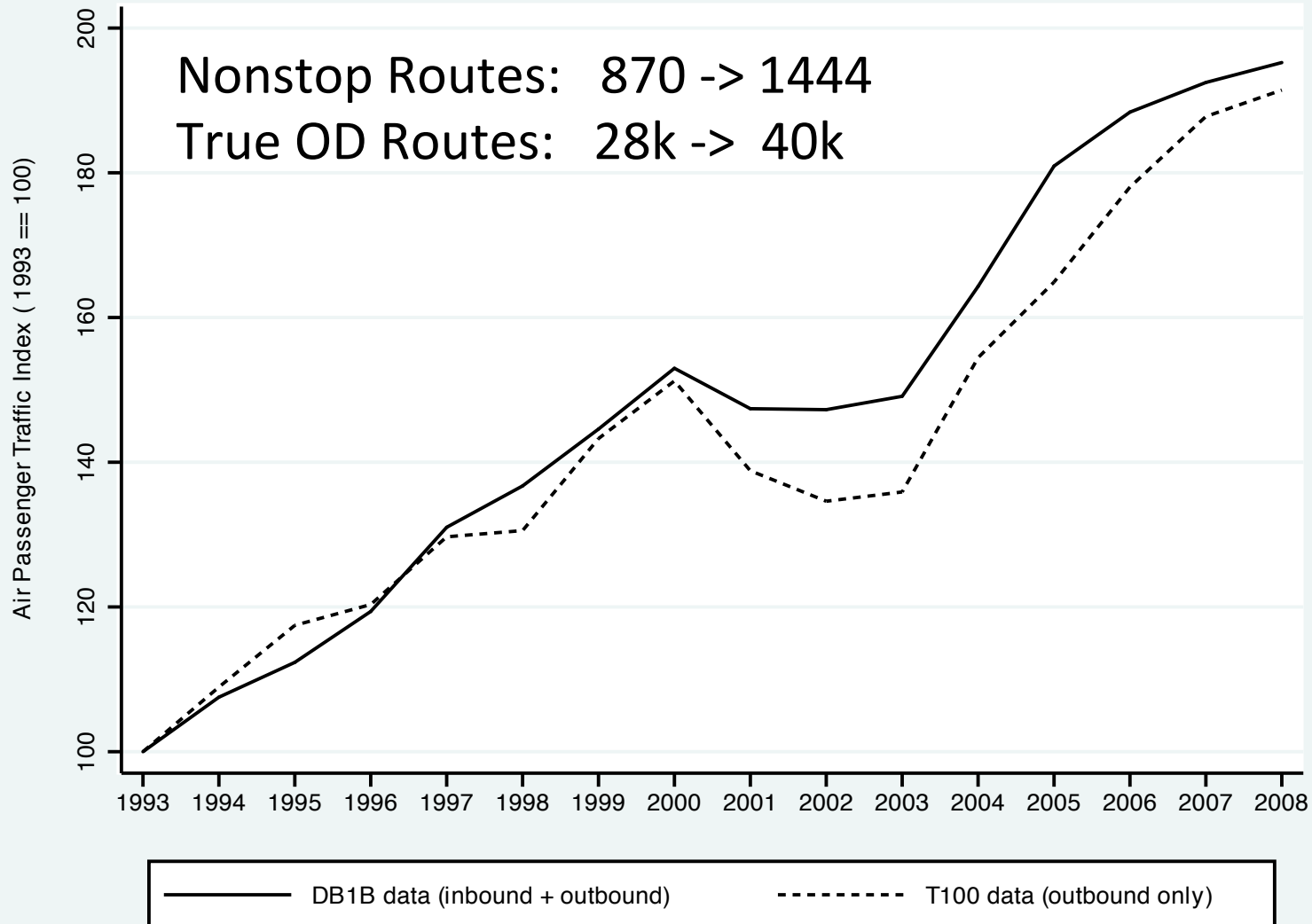
Controls: income, population, destination-quarter FE, 9/11 crisis; Asia crisis and Caribbean trends.

## To pick up effect of OSA

- Dummy:  $OSA = 1$  for any year that agreement is in effect
- Or, interact OSA dummy with vector  $D(-3)$  to  $D(+5)$  for the age of the OSA agreement allows us to identify pre-existing trends, lagged effects of signing



# Air Passenger Traffic



**Table 2: Aviation Liberalization and Margins of Passenger Growth and Capacity**

	Total Passengers	Margins of Passenger Growth				Capacity Growth	
		Simple Route Count		Common routes defined relative to T-3		Total Seats	Share Seats Old Gateway
		<i>Extensive</i>	<i>Intensive</i>	<i>Extensive</i>	<i>Intensive</i>		
<b>Panel A</b>							
OSA	0.071**	0.105***	-0.034	0.038**	0.034	0.054**	-0.064***
Observations	4036	4036	4036	4036	4036	4,034	4,034
R-squared	0.512	0.305	0.234	0.304	0.341	0.370	0.433
<b>Panel B</b>							
Year OSA == 5+	0.172***	0.202***	-0.030	0.065***	0.107**	0.160***	-0.132***
Observations	4036	4036	4036	4036	4036	4.529	4,034
R-squared	0.518	0.311	0.236	0.308	0.346	[5.627]	0.452

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Robust standard errors in brackets

Rise in new routes (extensive margin)

1. **Simple counts** => Number of routes rises; passengers per route fall.
2. **Weighted counts** (ala Feenstra 94): Increase traffic through extensive is 38% to 54% total growth.



**Table 2: Aviation Liberalization and Margins of Passenger Growth and Capacity**

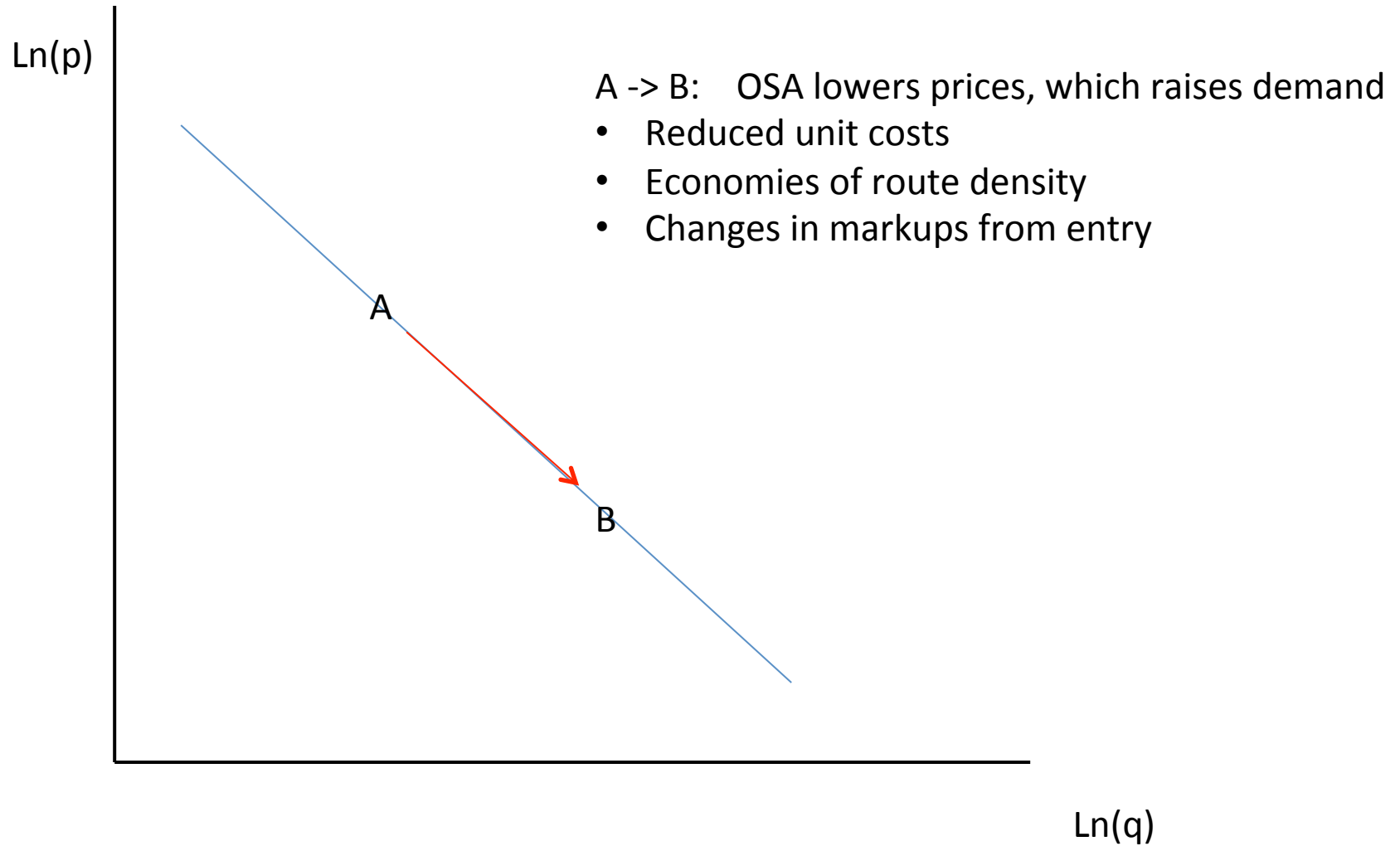
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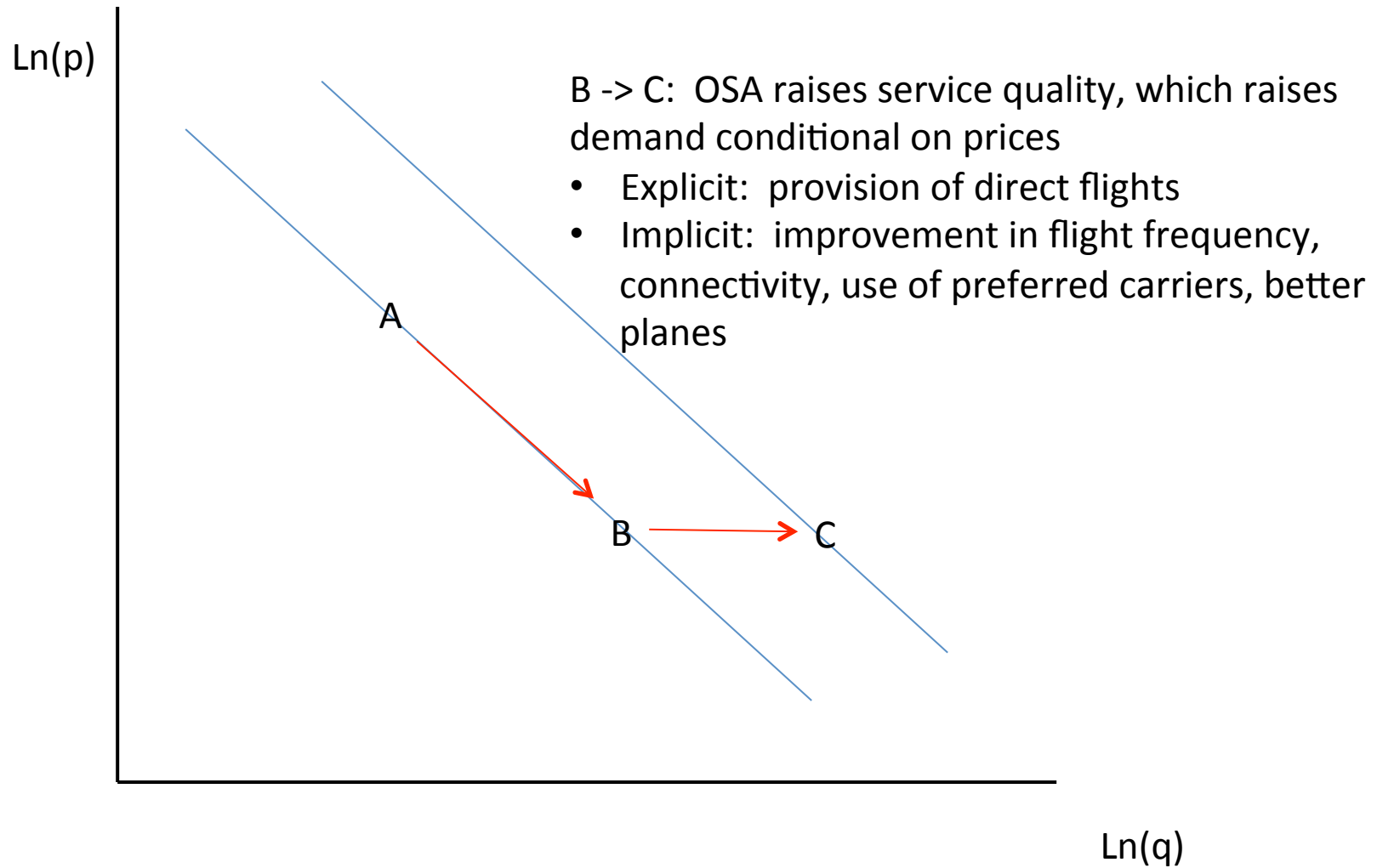
OSAs:

1. Expand **total capacity** (16% five years out)
2. Reallocate capacity away from old gateways toward new entry points. **Share of old gateways in total seats** falls 13%

# OSA effects on quantities



# OSA effects on quantities



# Organizing the O-D Ticket Sample

- Use O-D ticket data to estimate changes in prices, quantities, number of segments for a “true” origin-destination in year  $t$ .
- Start from about 40 million tickets: Aggregate all tickets with same origin-destination within a given year  $t$ 
  - We might have 10 different ways to get from Indy to MEL, on many different carriers. Median odt has 400 tickets.
  - Quantities = total tickets for that o-d-t
  - Prices = (pax weighted) average ticket price for o-d-t.
  - Segments = (pax weighted) average number of segments o-d-t
- Keep track of intermediate routings:
  - countries that have not yet liberalized can benefit if passengers route through liberalized neighbors.

# Price Equation

- Key variables:
  - Passenger quantities (IV: population in O, D)
  - Number of segments flown (exog wrt prices)
  - Measures of liberalization:
    - OSA Combine =  $\max(\text{OSA}, \text{OSA connect})$
    - OSA connect = dist share of tickets routing thru OSA neighbors
- Controls
  - Diff in diff: fixed effects for origin-destination, time
  - Per capita incomes in origin MSA, destination country, Asia crisis, Caribb trend.
  - Route-time varying cost shocks: insurance costs, jet fuel prices \* distance measures (nonstop and actual distance, squared)

	Dependent variable: Ln Airfare				
	(1)	(2)	(3)	(6)	(7)
	OSA	OSAconnect	By Type Gateways	Countries w/ Direct Routes	Drop EU
OSA	0.005** [0.002]				
OSA Combined		-0.021*** [0.002]	-0.018*** [0.002]	-0.018*** [0.002]	-0.031*** [0.002]
OSA Combined * Pre-OSA Gateway			-0.021*** [0.006]		
Osa Combined * Large Hub			-0.011*** [0.003]		
Ln Pax	-0.105*** [0.008]	-0.104*** [0.008]	-0.104*** [0.008]	-0.101*** [0.008]	-0.079*** [0.007]
Ln Flight Segments	0.170*** [0.009]	0.173*** [0.009]	0.173*** [0.009]	0.178*** [0.009]	0.220*** [0.010]
Partial Liberalization (dummy)	-0.016*** [0.003]	-0.029*** [0.003]	-0.029*** [0.003]	-0.027*** [0.003]	-0.026*** [0.003]
Observations	470,597	470,597	470,597	452,261	317,247
R-squared	0.184	0.185	0.185	0.183	0.226
First Stage F-Test	1023	1031	983.3	1017	1035
Partial R-squared	0	0	0	0	0

Small cities: prices drop 1.8%; large cities 2.9%; gateways: 3.9%

Consistent with the view that gateways were capacity constrained pre OSA

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A rise in population increase the passengers on a route and lowers costs: consistent with economies of density or a competition effect. (Don't confuse with "e" shocks)

Increasing flight segments raises costs.

# Quantity equation

- Key variables:
  - Airfare, number of segments (explicit quality)
    - IV: jet fuel prices \* distance measures (nonstop distance; distance and dist squared)
  - Measures of liberalization:
    - OSA Combine =  $\max(\text{OSA}, \text{OSA connect})$
    - OSA connect = dist share of tickets routing thru OSA neighbors
- Controls
  - Diff in diff: fixed effects for origin-destination, time
  - Population, incomes, state level exports, Asia crisis. Caribb trend
- OSA variable measures implicit quality: increase in passengers conditional on prices, other demand shifters.



	Dependent variable: Ln Pax				
	(1)	(2)	(3)	(6)	(7)
	OSA	OSAconnect	By Type Gateways	Countries w/ Direct Routes	Drop EU
OSA	0.022*** [0.005]				
OSA Combine		0.139*** [0.006]	0.133*** [0.006]	0.140*** [0.006]	0.146*** [0.006]
OSA Combine * Pre-OSA Gateway			-0.082*** [0.016]		
OSA Combine * Large Hub			0.042*** [0.008]		
Ln Airfare	-1.302*** [0.057]	-1.291*** [0.057]	-1.267*** [0.057]	-1.306*** [0.064]	-0.912*** [0.046]
Ln Flight Segments	-0.616*** [0.176]	-0.657*** [0.180]	-0.650*** [0.179]	-0.820*** [0.186]	-1.686*** [0.197]
Partial Liberalization (dummy)	0.017** [0.007]	0.047*** [0.006]	0.045*** [0.006]	0.044*** [0.006]	0.077*** [0.007]
Observations	470,597	470,597	470,597	452,261	317,247
R-squared	-0.077	-0.069	-0.057	-0.076	0.126
F-Test of ivs (airfare)	668.7	679.5	676.7	577.3	849.2
F-Test of ivs (number segments)	448.6	438.5	437.4	425.3	299.9
Robust standard errors in brackets					
*** p<0.01, ** p<0.05, * p<0.1					

Price elasticity = -1.2. In line with literature.

Valuation of directness: taking a connecting flight equivalent to raising prices by 50%

	Dependent variable: Ln Pax				
	(1) OSA	(2) OSAconnect	(3) By Type Gateways	(6) Countries w/ Direct Routes	(7) Drop EU
OSA	0.022*** [0.005]				
OSA Combine		0.139*** [0.006]	0.133*** [0.006]	0.140*** [0.006]	0.146*** [0.006]
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Robust standard errors in brackets					
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Quantity growth: Small cities 13.3%; large cities 17.5%; gateways: 5.1%

Condition on p, segments, OSAs raise consumer valuations of travel, do so most strongly on most constrained routes.

# Number of segments equation

- Dep variable: the average number of segments in o-d-t.
- Key variables:
  - Passenger quantities (IV: population in O, D)
  - Measures of liberalization:
    - OSA Combine =  $\max(\text{OSA}, \text{OSA connect})$
    - OSA connect = dist share of tickets routing thru OSA neighbors
- Controls
  - Diff in diff: fixed effects for origin-destination, time
  - Per capita incomes in origin MSA, destination country, Asia crisis, Caribb trend.

	Dependent variable: Ln Flight Segments				
	(1)	(2)	(3)	(4)	(8)
	OSA	OSAconnect	By Type Gateways	By Type Gateways	Drop EU
OSA	-0.004*** [0.001]				
OSA Combine		0.012*** [0.001]	0.009*** [0.001]	0.012*** [0.001]	0.006*** [0.001]
Osa Combine * Pre-OSA Gateway			0.003 [0.003]	-0.004 [0.003]	
Osa Combine * Large Hub			0.011*** [0.002]		
Osa Combine * Large Hub (T100)				-0.045*** [0.003]	
Ln Pax	-0.060*** [0.007]	-0.065*** [0.007]	-0.065*** [0.007]	-0.065*** [0.007]	-0.078*** [0.006]
Partial Liberalization (dummy)	-0.011*** [0.001]	-0.004*** [0.001]	-0.004*** [0.001]	-0.004*** [0.001]	-0.001 [0.001]
Observations	470,597	470,597	470,597	470,597	317,247
R-squared	0.090	0.082	0.085	0.085	0.077
F-Test of ivs	348.0	365.5	375.4	365.5	498.1

There is a modest increase in average number of flight segments, except for cities where direct service is offered for the first time. There segments decrease 3.3%

Why not all large hubs? There are 40 cities that FAA characterizes as large hubs. Not enough traffic to create direct connections even after constraints are lifted.

# Combining the effects

- P, Q, SEG depend on OSA and on each other.
- To calculate total derivative of P, Q wrt OSA...

	Consumer Welfare Effects of OSA				
	Pooled Estim.	Pre-OSA Gateway	Large Hub	Large Hub T100	Small City
<i>Cummulative Demand Effects:</i>	0.192	0.112	0.241	0.299	0.183
Of which:					
Direct Effect:	0.139	0.051	0.175	0.175	0.133
Indirect Effect via Connectivity:	0.000	-0.003	-0.003	0.034	0.002
	0.053	0.064	0.069	0.089	0.049
<i>Piece Equiv. of Demand Effects:</i>	-0.108	-0.037	-0.133	-0.162	-0.105
<i>Cummulative Cost Effects:</i>	-0.041	-0.050	-0.053	-0.069	-0.038
Of which:					
Direct Effect:	-0.021	-0.039	-0.029	-0.029	-0.018
Indirect Effect via Quantity:	-0.020	-0.012	-0.025	-0.031	-0.019
Indirect Effect via Connectivity:	0.000	0.001	0.001	-0.009	-0.001
<b><i>Total price effect of OSA:</i></b>	<b>-0.149</b>	<b>-0.087</b>	<b>-0.187</b>	<b>-0.231</b>	<b>-0.142</b>
<b>Average Price Effect at U.S. Level</b>					
<i>City Population Shares as Weights</i>				-0.144	
<i>City Passenger Shares as Weights</i>				-0.143	

OSAs lower quality adjusted prices by 8.7 % (pre OSA gateways) to 23.1% (large hubs where direct service is offered for the first time post OSA

Quantities rise 11.2% (gateways) to 30% (new hubs)

# Summary

- Regulation of aviation markets constrain capacity, routes, entry.
- We study how these constraints distort competition and the channels through which markets respond after liberalization.
- We build a novel model of capacity constrained price competition with uncertain demand. Includes entry, networks, quality.
  - The model delivers price dispersion within and across carriers, and unused capacity in equilibrium.
- Equilibrium described by tractable average price and market demand curves
  - yield (relatively) simple comparative statics, and map tightly into useful empirical objects.

# Summary (cont.)

- Empirics: use diff-in-diff strategy to examine sequential bilateral liberalization of aviation markets.
- OSA's:
  - expand route offerings; reallocate capacity toward constrained routes.
  - Lower prices, raise (explicit, implicit) quality.
  - Benefits are largest for most constrained cities.
  - Non-signatories also benefit from the ability to connect through OSA countries.



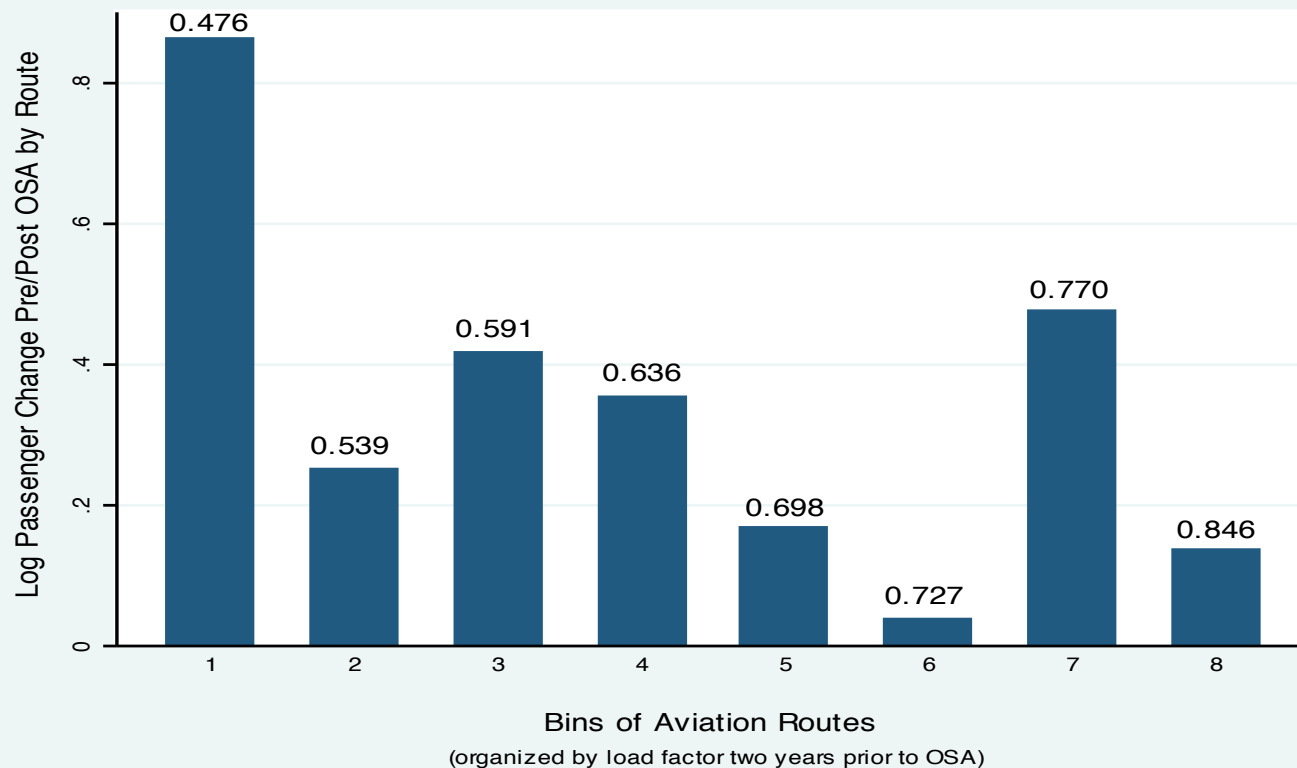
# Future Work

- How does advance notification on pricing
  - Distort optimal pricing and capacity utilization?
  - Redistribute welfare across high/low valuation fliers?
- Why are multiple routings valuable?
  - Examine the correlation structure of demand shocks across routes.
  - Expanding set of routes is like offering a more complete class of financial assets to span possible states of nature.

# Extra Slides

# Is $D(qty)$ due to relaxed capacity constraint?

- Pre-OSA Load factor never exceeds 85%. Median 63.6%
- Load factors rise post-OSA.
  - Elasticity of load factor wrt OSA = 0.026.



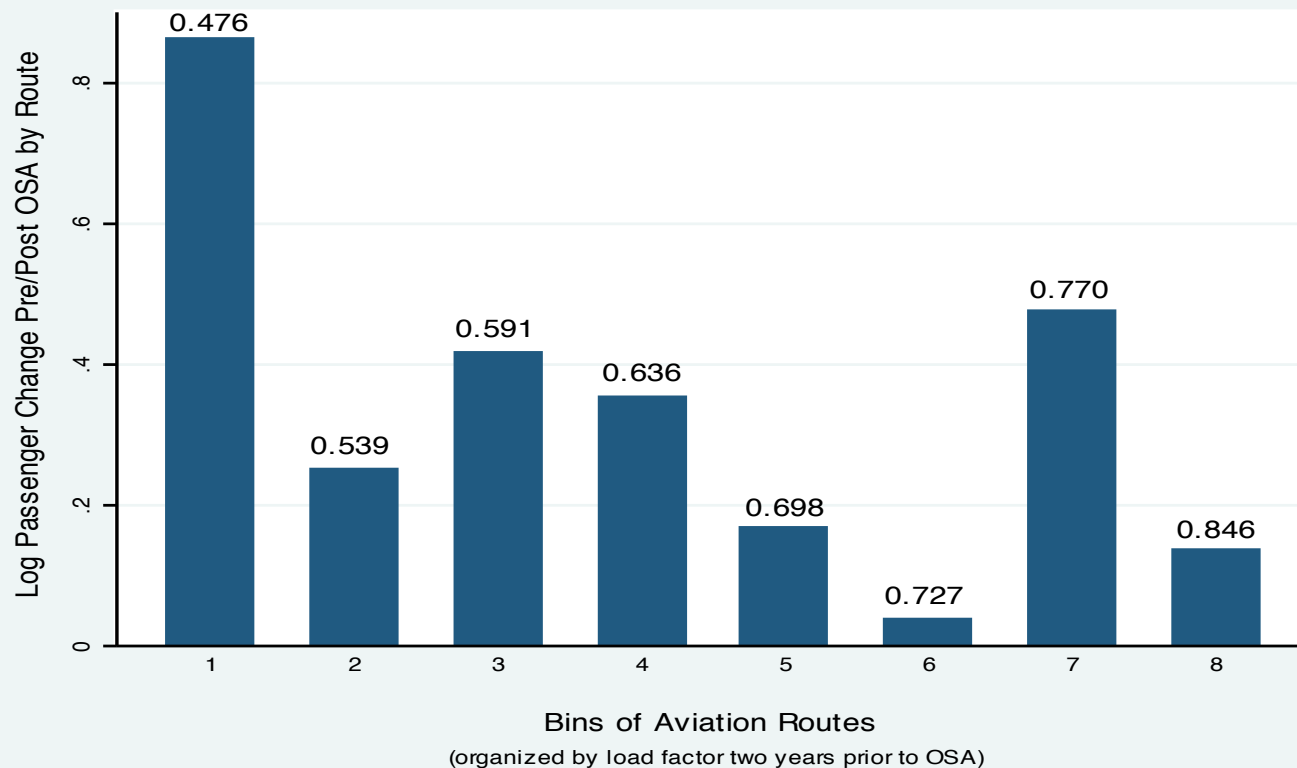
Organize routes into 8 bins by pre-OSA load factors.

Number is max load factor in that bin

Height of bar is log change in passengers post-OSA

# Pre OSA capacity constraints not binding

- Pre-OSA Load factor never exceeds 85%. Median 63.6%
- Passenger growth is highest where load factors were lowest



Organize routes into 8 bins by pre-OSA load factors.

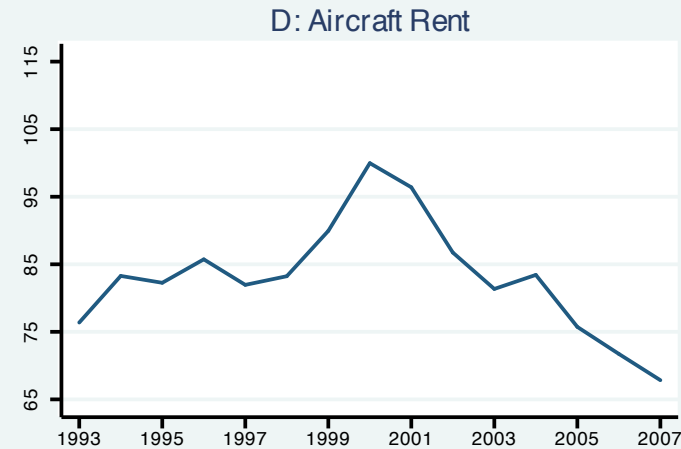
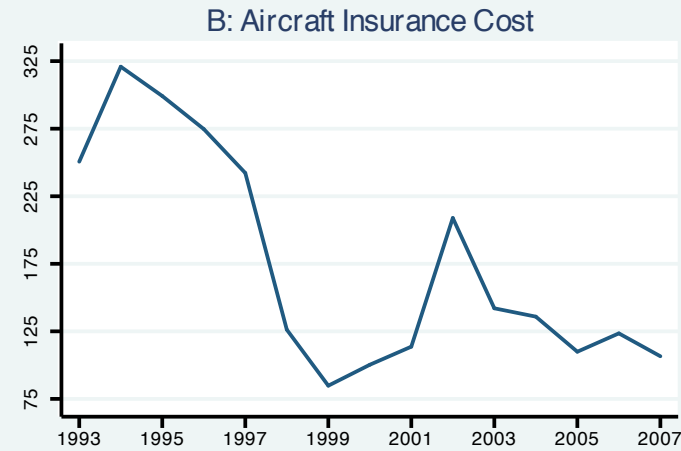
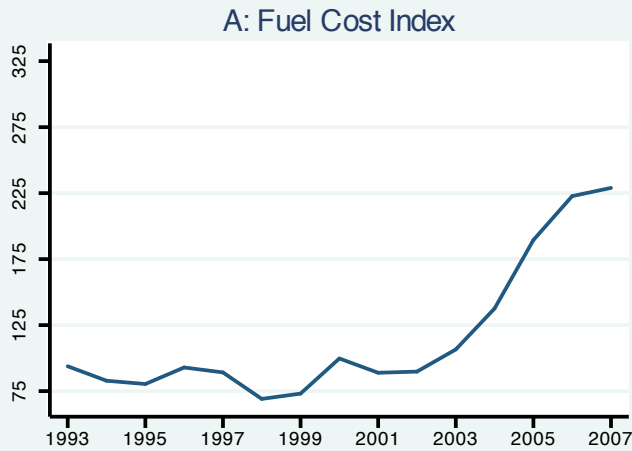
Number is max load factor in that bin

Height of bar is log change in passengers post-OSA

# Cost shifters: ATA data

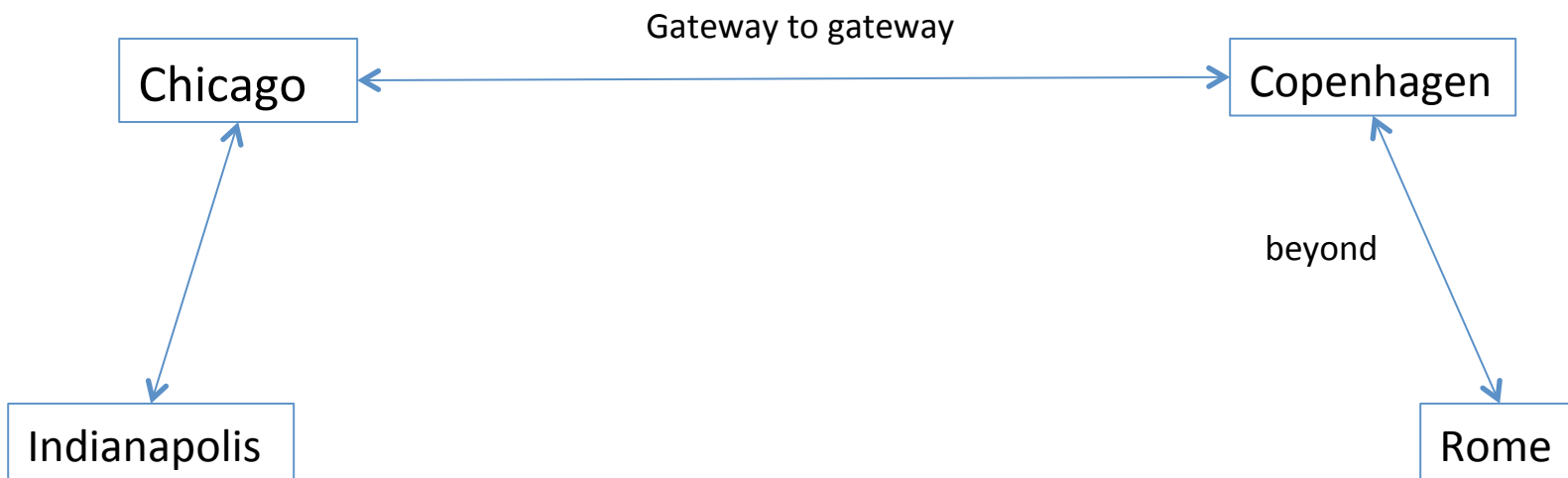
Fuel ranges from 9-27% of total cost in this period

Real Cost Index (1995 == 100)



Route x  
Time  
varying

Time  
varying



# Theory literature

	Standard Oligopoly models	Bertrand-Edgeworth capacity games	Bertrand-Edgeworth with random demand	Cristea, Hummels, Roberson
Network formation/ Carrier entry	Lots of papers  Multiple carriers require Cournot, or diff'd Bertrand			X
Oligopoly price competition s.t. capacity constraints		e.g. Kreps-Schienkman	Dana (1999)	X
Unused capacity Heterog pricing	No.		Eden (1990) Dana (1999)	X
Heterogeneous Firms (indirect)				x