Airport ownership and its effects on capacity and price

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Introduction (1/3)

- Why privatize the airports?
  - Government revenues, financing aspects and private enterprise creativity and drive
  - On efficiency grounds (e.g. Condie, 1996) private airports would:
    - Charge more efficient congestion and peak load prices and respond to market incentives for capacity expansions
  - Usually, private airports are subject to economic regulation (e.g. price caps in the UK, rate of return in Germany)
  - …..but this is changing…..many argue that regulation schemes fall short of being optimal

Introduction (2/3)

- it has been argued that regulation may be unnecessary
    - Airports have low price elasticity of demand: allocative inefficiency would not be important
    - Airlines have countervailing power that will put downward pressure on airport prices
    - Most of the problems would be solved if deeper collaboration between airlines and airports was allowed and encouraged
- But, most of the literature is descriptive. Few analytical papers about privatization (two as far as I know: Zhang and Zhang, 2003; Oum et al. 2004)
    - Still, why do we need another one?

Introduction (3/3)

- Public airport problem in previous articles:

$$\max_{P,K} \underbrace{\int_{\rho}^{\infty} Q(\rho)d\rho}_{\text{"Consumer Surplus"}} + PQ - C(Q) - rK$$

- *Q*: Airport's demand *P*: Airport's Price *K*: Capacity
- **But!!** the 'consumers' of airports services are both airlines and passengers
- Airports provide an input. Their demand is a derived demand not a Marshallian one.
- **What I do is:**
- Consider a vertical structure: Airports upstream, airlines' oligopoly donwstream.
- Then solve airlines sub-game, obtain airports' demand, and analyze airports market (effects of ownership on prices and capacities)

A simple airline oligopoly model (1/3)

- Two national airports, demand for roundtrips
- N airlines, identical cost functions, differentiated demands (horizontal non-address differentiation)
- Three-stage game: look for sub-game perfect equilibria
  1. Airports choose K_h (h: airport 1 or 2)
  2. Airports Choose P_h
  3. Airlines choose quantities
- Demand for airline i depends on a vector of full prices, θ:
- Full price of each airline includes:
  - Airline ticket
  - Schedule delay cost (kind of a waiting time)
  - Congestion costs at **both** airports (flight delay: ***D***)

A simple airline oligopoly model (2/3)

- Airlines Cost function

$$C_A^i(Q_i, \mathbf{Q}_{-i}, P_h, K_h) = Q_i\left[c + \sum_{h=1,2}(P_h + \beta D(Q, K_h))\right]$$

- There exists a unique and symmetric Cournot-Nash equilibrium
- Using the FOC and imposing symmetry we get….

$$\Omega(Q, P_h, K_h, N) = (\alpha S + \beta)\sum_{h=1,2}\left(D^h(Q, K_h) + \frac{Q}{N}D_Q^h(Q, K_h)\right) + S\left(g(\frac{Q}{N}) + \frac{Q}{N}g'(\frac{Q}{N})\right)$$
$$+ S^2\left(2B + (N-1)E\right)\frac{Q}{N} + c + \sum_{h=1,2}P_h - AS = 0$$

➔ Implicitly gives airports' demand: $Q\,(P_h, K_h, N)$

and airports' inverse demand $P\,(Q, K_h, N)$ (with $P=P_1+P_2$)

A simple airline oligopoly model (3/3)

- Comparative Statics (in the sub-game only…)

$$\frac{\partial P}{\partial Q} < 0, \quad \frac{\partial P}{\partial N} > 0, \quad \frac{\partial^2 P}{\partial Q \partial N} > 0, \quad \frac{\partial^2 P}{\partial Q^2} < 0, \quad \frac{\partial Q}{\partial N} > 0,$$

$$\frac{\partial Q}{\partial P_h} < 0, \quad \frac{\partial Q}{\partial K_h} > 0, \quad \frac{\partial^2 Q}{\partial P_h^2} < 0, \quad \frac{\partial^2 Q}{\partial P_h \partial K_h} > 0$$

$$\frac{\partial P}{\partial K_h} > 0, \quad \frac{\partial^2 P}{\partial Q \partial K_h} > 0, \quad \frac{\partial^2 P}{\partial K_h^2} < 0, \quad \frac{\partial^2 P}{\partial K_1 \partial K_2} = 0, \quad \frac{\partial^2 P}{\partial K_h \partial N} < 0$$

- What about the integral of the demand for airports, Q?
  - Using Shepard's lemma, the envelope theorem and Ω=0

$$\int_P^\infty Q(P, K_h, N)\, dP = \text{Airlines Profits}$$
$$+ f\left(CS; \text{Market Power}\right)$$
$$+ g\left(\text{Uninternalized Congestion}\right)$$

Analysis of Airports Market (1/6)

- Five cases are analyzed
  - System of Private Airports (SPA)
  - System of Public Airports (W)
  - Max Joint Profits, Airports and Airlines (JP)
  - Independent Private Airports (IPA, IJP)
  - Budget constrained public airports
- …then, comparisons between them, both analytically and numerically
- We are in a first-best world here!!

Analysis of Airports Market (2/6)

- System of Private Airports (SPA)

$$\max_{Q,K_1,K_2} \pi(Q,K_h;N) = P(Q,K_h;N)Q - 2C(Q) - (K_1 + K_2)r$$

➔ $$P = 2C' + \frac{P}{\varepsilon_P} \quad \text{and} \quad Q\frac{\partial P}{\partial K_h} = r$$

- Also:

$$\frac{d\pi}{dN} = \pi_Q Q_N^{SPA} + \sum \pi_{K_h} K_N^{SPA} + \pi_N = \pi_N = Q^{SPA} P_N > 0$$

➔ The SPA prefer a large N

Analysis of Airports Market (3/6)

- System of Public Airports (W)

$$\max_{Q,K_1,K_2} SW(Q,K_h;N) = \pi + \Phi + CS$$

$$\Rightarrow \qquad P = 2C' + \frac{(N-1)}{N}(\alpha S + \beta)Q\sum_h D_Q^h - \frac{BS^2 Q}{N}$$

$$-Q(\alpha S + \beta)\frac{\partial D(Q,K_h)}{\partial K_h} = r$$

- Preferred N?
- It depends. Two opposing forces: substitutability and schedule delay cost
  - If airlines are very homogenous, preferred N is 1
  - Otherwise, N>1

Analysis of Airports Market (4/6)

- Maximization of Joint Profits: airlines and private airports (JP)
  - Why? Benchmark case for Collaboration and/or airlines' countervailing power, but also Two-Part Tariffs

➔ $$P = 2C' + \frac{(N-1)}{N}(\alpha S + \beta)Q\sum_h D_Q^h + \frac{(N-1)ES^2 Q}{N}$$

$$-Q(\alpha S + \beta)(\partial D / \partial K_h) = r$$

- Preferred N? Similar to public case. It may prefer N=1.
- But recall that SPA preferred a large N!

Analysis of Airports Market (5/6)

Why two airports?

- Independent Private Airports

- Look first at linear prices (IPA)

$$\Rightarrow \quad P = 2C' + 2\frac{P}{\varepsilon_P} \quad \text{and} \quad Q\frac{\partial P}{\partial K_h} = r$$

- Horizontal double marginalization: Complement products!

- Now, joint profits or two-part tariffs each (IJP)

$$\Rightarrow \quad P = 2C' + 2\frac{(N-1)}{N}(\alpha S + \beta)Q\sum_h D_Q^h + 2\frac{(N-1)ES^2Q}{N}$$

$$-Q(\alpha S + \beta)(\partial D / \partial K_h) = r$$

- The horizontal double marginalization also arises here

Analysis of Airports Market (6/6)

- Next, comparisons between cases
- How do we compare?....difficult because simultaneous equations.
- I prove six propositions and use numerical simulation
  - Examples of the propositions

Proposition 1: For a given *K*, the system of private airports (SPA) will induce fewer flights than the public ones or, equivalently, it will charge a higher price.

Proposition 6: JP airports undersupply capacity with respect to the 2nd best social welfare capacities (despite having the same capacity rule).

Results (1/4)

- Selected conclusions from both analytical and numerical results

Parameter values of the numerical simulation

Demand				*Airlines*		*Airports*	
α	40	A	2000	S	100	r	10000
β	3000	B	0.15	N	varies	C’	2000
γ	4	E	0.13	c	36000		

- α, γ : Morrison and Winston (1989)
- β : Morrison (1987)
- S : Swan (2002, aircraft size), Oum and Yu (1997, load factor)
- c : Brander and Zhang (1990) and Oum et al. (1993)

Results (2/4)

- Privatization induces important allocative inefficiencies

$Q^{SPA} = 36 \qquad K^{SPA} = 45 \qquad TSW^{SPA} = 57\ \%$

$Q^{W} = 101 \qquad K^{W} = 110 \qquad TSW^{W} = 100\ \%$

  - The price-elasticity argument does not seem to hold
  - Independent private airports are even smaller

$Q = 19 \qquad K = 26 \qquad TSW = 34\ \%$

ECONOMÍA Y NEC

SANTIAGO DE CHILE, JUEVES 30 DE DICIEMBRE DE 2004

BOLSAS DE VALORES

Índice	Valor	Var. (%)
Ipsa	1.797,45	0,14
Igpa	8.940,62	0,00
Dow Jones	10.829,19	-0,23
Nasdaq	2.177,00	-0,01
Bovespa	26.161,31	0,17

UF

Día	Valor ($)
Miércoles 29	17.313,71
Jueves 30	**17.315,38**
Viernes 31	17.317,05
Sábado 1	17.318,73
Domingo 2	17.320,40

MONEDAS

	Valor	Var. (%)
Dólar observado	559,83	0,03
Dólar interbancario	560,00	-0,14
Euro	761,60	-0,16
Euros por US$	0,735	0,01
Peso argentino por US$	2,975	-0,42

THE WALL STREET JOURNAL AM

Vigilancia del **lavado d** **dinero** en **grandes ban**

B 8

Nuevos cobros en el terminal capitalino:

Acusan arbitrariedades en las tarifas del aeropuerto

Las aerolíneas reclaman que los cambios no apuntan a mejorar el servicio, sino sólo a aumentar los ingresos del concesionario.

FRANCISCO DEROSAS

Cuestionamientos, dudas y acusaciones de grueso calibre marcan hoy las relaciones entre SCL —concesionario del aeropuerto Arturo Merino Benítez (AMB)— y las aerolíneas que operan en Chile, encabezadas por el principal actor del mercado local, LAN.

Las nuevas disposiciones tarifarias —que entran en vigencia el 1 de enero de 2005— gatillaron este entuerto.

Según fuentes de la industria aérea, es totalmente inadmisible que cambios en los cobros por los servicios que el aeropuerto entrega, y que afectarán directamente en el valor final de los pasajes, hayan sido materializados "entre cuatro paredes", sin mediar consulta a las líneas aéreas.

Según un alto ejecutivo de una compañía, establecer obligaciones monopólicas en algunos servicios —como por ejemplo, el abastecimiento de electricidad en las mangas de embarque— es una medida arbitraria que atenta contra la eficiencia de las empresas, que pueden obtener dichas prestaciones en forma mucho más económica.

SCL no quiso tocar el tema, dado que hay un diálogo iniciado entre las partes. (Ver recuadro).

Las modificaciones tarifarias a los servicios que presta SCL surgen en virtud de la firma del Mecanismo de Distribución de Ingresos, "un traje hecho a la medida del concesionario, creado para aumentar los ingresos de la empresa y no para mejorar el servicio", acusa el mismo ejecutivo.

Según el presidente del directorio de LAN, Jorge Awad, el gran tema de fondo es que los cambios impuestos por el MOP y SCL atentan en forma severa contra la eficiencia del mercado.

Además, Awad lamentó que se ponga en juego la "conectividad" aérea entre Chile y el mundo.

El duro conflicto que hoy enfrenta a SCL con las aerolíneas no es más que la punta del iceberg de un drama que ha tenido como protagonistas al concesionario, el Gobierno, la Dirección General de Aeronáutica Civil (DGAC, ligada a la FACh) y las aerolíneas.

Desde que SCL comenzó a operar el terminal en 1998 ha existido tensión con la DGAC, por la vasta presencia de este organismo en la operación —ineficiente y poco transparente, a juicio del sector privado— de diversos servicios. Algunas asperezas se resolvieron luego de negociar el traspaso a SCL de la operación del Duty Free, mientras la contraparte tiene bajo su cargo operar los equipos de seguridad.

En otro frente, desde hace 4 años que está pendiente un juicio entre LAN y SCL, por una demanda de esta última por supuestos subterfugios usados por la aerolínea para no pagar servicios de *catering* (alimentación).

Acercamientos

En un intento por acercar las distanciadas posiciones, ayer se reunieron los máximos representantes en Chile de la Asociación Internacional de Transporte Aéreo (IATA) y SCL.

Las partes guardaron estricta reserva sobre lo tratado en la reunión, aunque trascendió que se comenzó un análisis "punto a punto" de las polémicas disposiciones tarifarias que comenzarán a regir en AMB a partir del 1 de enero.

Results (3/4)

- JP airports are better, but closer to SPA than W

$Q^{SPA} = 36 \qquad K^{SPA} = 45 \qquad TSW^{SPA} = 57\ \%$

$Q^{JP} = 50 \qquad K^{JP} = 56 \qquad TSW^{JP} = 74\ \%$

$Q^{W} = 101 \qquad K^{W} = 110 \qquad TSW^{W} = 100\ \%$

  - The collaboration argument seems to be overstated

- W airport charges increase with N: congestion effect dominates market power effect as N increases.
- **Delays (SPA) < Delays (W) < Delays (TPT) !** at least up to N=10
- W: subsidies may be very high when N small…
- …budget adequacy of W airports?

Results (4/4)

- Pels and Verhoef (2004): if cost recovery is a problem, set price equal to marginal cost…..but:
  - Here, we need to pay for capacity
  - Two-part tariffs!
- Cost-recovery two-part tariffs TSW = 99.9%
  - Very close to optimality
- If TPT unfeasible, Ramsey-Boiteaux prices. Compare that to private linear prices.

$$Q^{SPA} = 36 \qquad K^{SPA} = 45 \qquad TSW^{SPA} = 57\ \%$$

$$Q^{RB} = 71 \qquad K^{RB} = 81 \qquad TSW^{RB} = 91\ \%$$

$$Q^{W} = 101 \qquad K^{W} = 110 \qquad TSW^{W} = 100\ \%$$

Final Comments (almost)

- Methodological:
  - Models that recognize the vertical structure are needed
  - Bad news for regulators and managers of public airports
  - Prod. differentiation and schedule delay cost
- Policy:
  - Privatization is quite unattractive here, particularly if done in an airport by airport basis (but…..)
- Furthermore, the insights apply to many other cases as well

Where do we go from here?

- Competition between airports: in two ways
  - Geographic competition: address models
  - Network competition: Route structure choice models
- Sequential Peak-Load pricing
- Actual policies: Information **is** incomplete, X-inefficiency
- Other aspects that may be examined
  - Effect of concession revenues
  - lumpy capacity

Thanks!

Questions?

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The Airline Market

- Two-stage game: look for sub-game perfect equilibria
  1. Airports choose P and K
  2. Airlines choose quantities.
- Two national airports, demand for roundtrips
- N airlines, identical cost functions, differentiated demands (horizontal non-address differentiation)
- Demand for airline *i* depends on a vector of full prices, θ:

$$q_i(\boldsymbol{\theta}) = q_i(\theta_i, \boldsymbol{\theta}_{-i})$$

$$\theta_i = t_i + g(Q_i) + \alpha\big(D(Q,K_1) + D(Q,K_2)\big)$$

- q_i : demand Q_i : number of flights per period t_i : ticket price
- $g(Q_i)$: Schedule (frequency) delay cost α : pax value of time
- ***D*** : Flight Delay ***Q*** : Total number of flights

The Airline Market

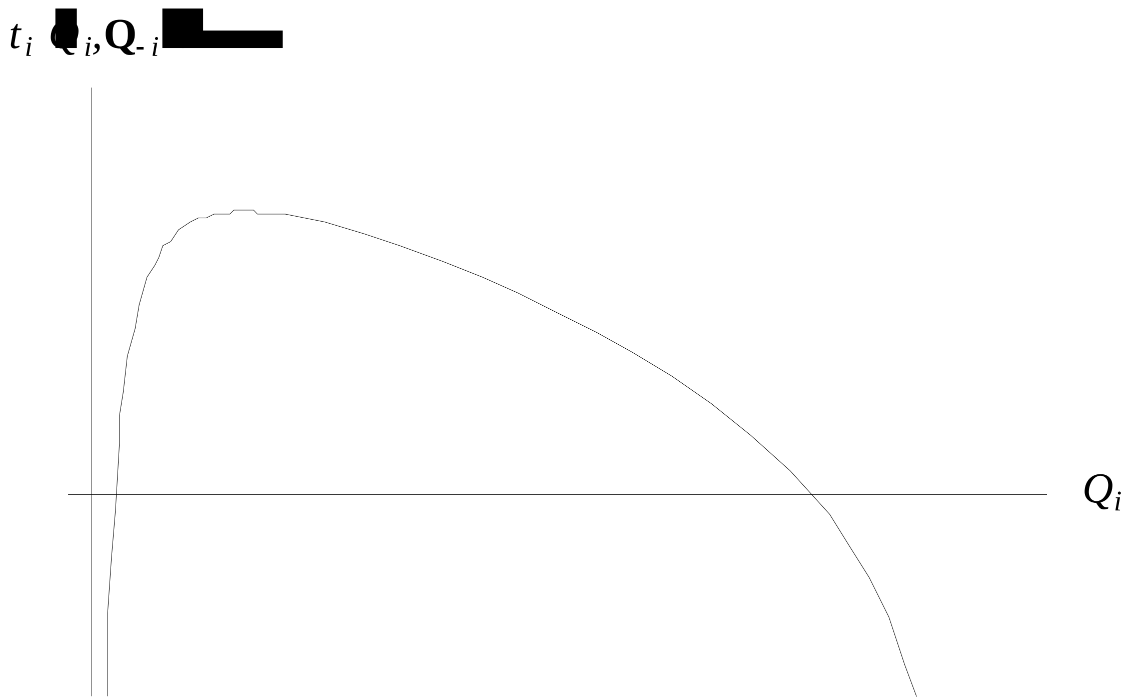
- Linear symmetric demands, outputs are substitutes:

$$q_i(\boldsymbol{\theta}) = a - b\theta_i + \sum_{j\neq i}^{N} e\theta_j \qquad \theta_i = A - B\cdot q_i - \sum_{j\neq i}^{N} E\cdot q_j \qquad , \quad B>E>0$$

- Why this model? Vives (1985): If *g* = *D* = 0, there is a unique equilibrium and market power decreases with *N*.
- In the airport literature:
  - Always homogenous Cournot
  - Never schedule delay cost
- Why is N exogenously given?
- Assumption: Fixed proportions $q_i = Q_i \times \underbrace{\text{Aircraft Size} \times \text{Load Factor}}_{S}$

➔ $$t^i(Q_i, \mathbf{Q}_{-i}) = A - SBQ_i - \sum_{j\neq i}^{N} SEQ_j - g(Q_i) - \alpha\big(D(Q,K_1) + D(Q,K_2)\big)$$

The Airline Market



Residual inverse demand faced by airline *i*

- Cost function

$$C_A^i(Q_i, \mathbf{Q}_{-i}, P_h, K_h) = Q_i\left[c + \sum_{h=1,2}(P_h + \beta D(Q, K_h))\right]$$

The Airline Market

- Profit function:

$$\phi^i(Q_i, \mathbf{Q}_{-i}, P_h, K_h) = \left[AS - BQ_iS^2 - \sum_{j\neq i} EQ_jS^2 - c - \sum_{h=1,2} P_h \right] Q_i - SQ_ig(Q_i)$$
$$-(\alpha S + \beta)\sum_{h=1,2} Q_i D(Q, K_h)$$

- There exists a unique and symmetric Cournot-Nash equilibrium
- Stable?
- Using the FOC, imposing symmetry we get….

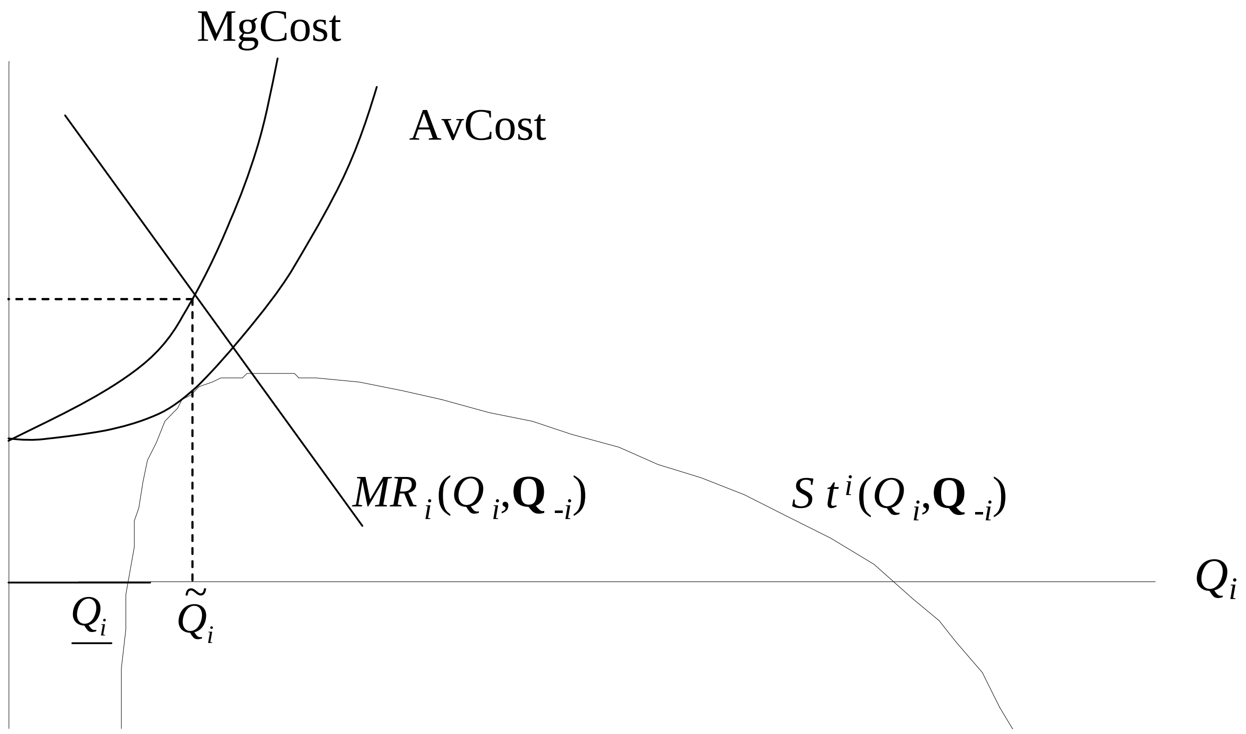
$$\Omega(Q, P_h, K_h, N) = (\alpha S + \beta)\sum_{h=1,2}\left(D^h(Q, K_h) + \frac{Q}{N} D_Q^h(Q, K_h) \right) + S\left(g(\frac{Q}{N}) + \frac{Q}{N} g'(\frac{Q}{N}) \right)$$
$$+ S^2\left(2B + (N-1)E\right)\frac{Q}{N} + c + \sum_{h=1,2} P_h - AS = 0$$

➔ Implicitly gives airports' demand: $Q\ (P_h, K_h, N)$

and airports' inverse demand $P\ (Q, K_h, N)$ (with $P=P_1+P_2$)

The Airline Market

- Free entry long-run equilibrium:



- Schedule delay cost puts, by itself, a limit to the number of firms that can be active in the industry.

The Airline Market

- Comparative Statics (in the sub-game only…)

$$\frac{dQ}{dN} = -\frac{\Omega_N}{\Omega_Q} = \frac{Q}{N}\left(\frac{(\alpha S+\beta)\sum D_Q^h + S^2(2B-E)}{(\alpha S+\beta)\sum D_Q^h + S^2(2B-E) + (\alpha S+\beta)\sum (ND_Q^h + QD_{QQ}^h) + S^2 EN}\right) > 0$$

…but Q_i decreases with N. Others?

$$\frac{\partial P}{\partial Q} < 0, \quad \frac{\partial P}{\partial N} > 0, \quad \frac{\partial^2 P}{\partial Q \partial N} > 0, \quad \frac{\partial^2 P}{\partial Q^2} < 0, \quad \frac{\partial Q}{\partial N} > 0,$$

$$\frac{\partial Q}{\partial P_h} < 0, \quad \frac{\partial Q}{\partial K_h} > 0, \quad \frac{\partial^2 Q}{\partial P_h^2} < 0, \quad \frac{\partial^2 Q}{\partial P_h \partial K_h} > 0$$

$$\frac{\partial P}{\partial K_h} > 0, \quad \boxed{\frac{\partial^2 P}{\partial Q \partial K_h} > 0,} \quad \frac{\partial^2 P}{\partial K_h^2} < 0, \quad \frac{\partial^2 P}{\partial K_1 \partial K_2} = 0, \quad \frac{\partial^2 P}{\partial K_h \partial N} < 0$$

- $dt^i / dN < 0$? ... not always…

Outline

1. Introduction: two approaches to the economic analysis of airports
2. The *One Market Approach:* details
3. An oligopoly model for the airline market
4. Relation between the two approaches
5. Analysis of airports markets
6. Numerical results
7. Final comments

Relation between approaches

- In the one-market approach, *consumer surplus* was:

$$\int_{\rho}^{\infty} Q(\rho)\, d\rho \qquad \text{or} \qquad \int_{0}^{Q} \rho\, dQ - \rho Q$$

- The full price idea was useful but now we are interested in…

$$\int_{P}^{\infty} Q(P, K_h, N)\, dP \qquad \text{or} \qquad \int_{0}^{Q} P(Q, K_h, N)\, dQ - P(Q, K_h, N)Q$$

- First, calculation of consumer (passenger) surplus:

$$CS = \int_{\boldsymbol{\theta}(P,K,N)}^{\mathbf{A}} \sum_{i}^{N} q_i(\boldsymbol{\theta}) d\theta_i$$

Taking a linear integration path:

$$CS(P_h, K_h, N) = \frac{\big(B + (N-1)E\big) S^2 Q(P_h, K_h, N)^2}{2N}$$

Relation between approaches

- For CS in the homogenous case, just B=E (calculation is different!)
- $dCS / dN > 0$? …not necessarily….
- Consider airlines' profits in equilibrium…

$$\Phi(P,K_h,N) = QS\left[A - \frac{QS}{N}(B+(N-1)E) - g\left(\frac{Q}{N}\right) - \alpha\sum D(Q,K_h)\right] - Q\left[c + P + \beta\sum D(Q,K_h)\right]$$

…and calculate total derivative of Φ with respect to P. Using Shepard's lemma, the envelope theorem and Ω=0 we get:

$$\frac{d\Phi}{dP} = -Q(P,K_h,N) - \frac{(N-1)ES^2Q}{N}\frac{\partial Q}{\partial P} - \frac{(N-1)}{N}(\alpha S + \beta)Q\sum_h D_Q^h \frac{\partial Q}{\partial P}$$

⬇

$$\int_P^{\infty} Q(P,K_h,N)\,dP = \Phi + \frac{(N-1)ES^2Q^2}{2N} - \frac{(N-1)}{N}(\alpha S + \beta)\int_P^{\infty} Q\frac{\partial Q}{\partial P}\left(\sum_h D_Q^h\right)dP$$

Got Intuition?

Relation between approaches

- Assume first $g = D = 0$, and N very large first and then small….

$$\int_P^\infty Q(P, K_h, N=\infty)\, dP \equiv \Phi_{N=\infty} + CS_{N=\infty}$$

$$\int_P^\infty Q(P, K_h, N=1)\, dP = \Phi_{N=1}$$

(Jacobsen, 1979)

- When $1 < N < \infty$ …

$$\int_P^\infty Q(P, K_h, N)\, dP = \Phi + CS - \frac{BS^2 Q^2}{2N}$$

- If we assume homogeneity (B=E)….

Quimbarch (1984)

$$\int_P^\infty Q(P, K_h, N)\, dP = \Phi + \frac{N-1}{N} CS = PSW$$

Bergstrom and Varian (1985)

The strong relation is between Input Market Surplus

and *what is maximized downstream*

Relation between approaches

- Here we have….

$$\int_P^{\infty} Q(P, K_h, N)\, dP = \Phi + CS - \frac{BS^2Q^2}{2N} - \frac{(N-1)}{N}(\alpha S + \beta)\int_P^{\infty} Q \frac{\partial Q}{\partial P}\left(\sum_h D_Q^h\right) dP$$

- Consumers of airports are airlines and passengers
- Integration of Q is not *consumer surplus.* Not even when N $\rightarrow \infty$
- Need to use an *airline-market approach* to reassess things that were analyzed with the other approach. Will insights persist?
- Bad news: even under perfect info, optimal pricing and capacity of public airports or regulation of private airports are tough
- The same goes for other input market cases!

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Analysis of Airports Markets

- Four cases are analyzed
  - System of Private Airports (SPA)
  - System of Public Airports (W)
  - Max Joint Profits, Airports and Airlines (TPT)
  - Independent Private Airports (IPA, ITPT)
- …then we do comparisons between them, both analytically and numerically

Analysis of Airports Markets

- System of Private Airports (SPA)

$$\max_{Q,K_1,K_2} \pi(Q,K_h;N) = P(Q,K_h;N)Q - 2C(Q) - (K_1 + K_2)r$$

$$\Rightarrow \quad P = 2C' + \frac{P}{\varepsilon_P} \quad \text{and} \quad Q\frac{\partial P}{\partial K_h} = r$$

- SOC? At the optimum $K_1 = K_2 = K$.
- dQ^{SPA}/dN ? dK^{SPA}/dN ? We can't say much but numerically both are positive
- What we can say is:

$$\frac{d\pi}{dN} = \pi_Q Q_N^{SPA} + \sum \pi_{K_h} K_N^{SPA} + \pi_N = \pi_N = Q^{SPA} P_N > 0$$

➔ The SPA prefer a large N

Analysis of Airports Markets

- System of Public Airports (W)

$$\max_{Q,K_1,K_2} SW(Q,K_h;N) = \pi + \Phi + CS$$

or

$$\max_{Q,K_1,K_2} SW(Q,K_h;N) = \int_0^Q P(Q,K_h,N)\,dQ - 2C(Q) - (K_1+K_2)r + \frac{BS^2Q^2}{2N}$$

$$+\frac{(N-1)}{N}(\alpha S+\beta)\int_P^\infty Q\frac{\partial Q}{\partial P}\left(\sum_h D_Q^h\right)dP$$

$$\Rightarrow \quad P = 2C' + \frac{(N-1)}{N}(\alpha S+\beta)Q\sum_h D_Q^h - \frac{BS^2Q}{N}$$

$$-Q(\alpha S+\beta)\frac{\partial D(Q,K_h)}{\partial K_h} = r$$

- Preferred N?

$$\frac{dSW}{dN} = \frac{(B-E)S^2Q^2}{2N^2} + Sg'\left(\frac{Q}{N}\right)\frac{Q^2}{N^2}$$

Analysis of Airports Markets

Comparison between SPA and W airports

- How do we compare?....difficult because simultaneous equations.
- Let us fix *K* first…

Proposition 1: For a given *K*, the system of private airports will induce fewer flights than the public ones or, equivalently, it will charge a higher price.

- How do we compare capacities?....related to Spence (1975).
- …we'll do it in three ways: for given Q, actual K and second best K

Proposition 2: For a given *Q*, the system of private (SPA) airports will oversupply capacity with respect to public ones (W).

Analysis of Airports Markets

Comparison between SPA and W airports (cont.)

- Actual capacities:

$$Q^{SPA}(K) << Q^{W}(K) \Rightarrow K_i^{SPA} < K_i^{W}$$

$$Q^{SPA}(K) \approx Q^{W}(K) \Rightarrow K_i^{SPA} > K_i^{W}$$

$Q^{SPA} = 36$	$K^{SPA} = 45$
$Q^{W} = 101$	$K^{W} = 110$

- Second Best Capacity. Consider

$$\max_K \widetilde{SW}(K) = \max_K SW(Q^{SPA}(K))$$

- How does $\tilde{K}^{W}$ compare to K^{SPA}? We cannot say a priori….

$$K^{SPA} = 45 \rightarrow \tilde{K}^{W} = 59$$

$$Q^{SPA} = 36 \rightarrow \tilde{Q}^{W} = 41$$

Analysis of Airports Markets

- Maximization of Joint Profits: airlines and airports (TPT)
  - Why? Formal coalitions, Two-Part Tariff
- Two ways to write the objective function

$$\max_{Q,K_1,K_2} \pi + \Phi = \int_0^Q P(Q,K_h,N)\,dQ - 2C(Q) - (K_1+K_2)r - \frac{(N-1)ES^2Q^2}{2N}$$

$$+\frac{(N-1)}{N}(\alpha S+\beta)\int_P^\infty Q\frac{\partial Q}{\partial P}\left(\sum_h D_Q^h\right)dP$$

- When N=1: third reason to examine this case

$$\Rightarrow \qquad P = 2C' + \frac{(N-1)}{N}(\alpha S+\beta)Q\sum_h D_Q^h + \frac{(N-1)ES^2Q}{N}$$

$$-Q(\alpha S+\beta)(\partial D/\partial K_h) = r$$

- Preferred N? $\quad \dfrac{d(\pi+\Phi)}{dN} = \dfrac{(B-E)S^2Q^2}{N^2} + Sg'\left(\dfrac{Q}{N}\right)\dfrac{Q^2}{N^2}$

Analysis of Airports Markets

- *Maximization of Joint Profits: airlines and airports (cont)*

Borenstein criticism about privatization (1992, p.68):

“without competition from other airports, an operator’s profits would probably be maximized by permitting dominance of the airport by a single carrier and then extracting the carrier’s rents with high facility fees”.

– Is this harmful for social welfare?
– Two more reasons for TPT airports to prefer N=1

Comparisons of prices and capacities

Proposition 3: For a given *K*, the TPT airports will: (i) induce fewer flights than W airports (ii) induce more flights than SPA airports.

Proposition 4: For a given Q, the TPT airports will: (i) have the same capacity as W airports (ii) have less capacity than SPA airports.

Analysis of Airports Markets

Comparisons of prices and capacities (cont.)

Proposition 5: As for actual capacities and quantities, TPT airports will induce fewer flights and will have smaller capacities than W airports.

- This would be the case for *public airports* maximizing the wrong social welfare function (from the *one-market approach*)
- What about 2nd best capacity? TPT and W rules are the same

Proposition 6: TPT airports undersupply capacity with respect to the 2nd best social welfare capacities (in spite of having the same rule).

- There is a capacity distortion in addition to the one induced by pricing

- Comment on W budget adequacy: can charge optimal price and cover costs with fixed fee (sort of Loeb-Magat mechanism)
- Less efficient alternative: Ramsey-Boiteaux prices

Analysis of Airports Markets

Why two airports?

- Independent Private Airports
  - Tactical choice: Prices or quantities?
  - K and P: simultaneous or sequential? (open- or closed-loop?)

- Look first at linear prices, open-loop (IPA)

➔ $$P = 2C' + 2\frac{P}{\varepsilon_P} \quad \text{and} \quad Q\frac{\partial P}{\partial K_h} = r$$

$$Q^{SPA} = 36 \qquad K^{SPA} = 45 \quad \text{and} \quad Q^{IPA} = 20 \qquad K^{IPA} = 26$$

- Closed-loop: Capacities will be higher. Airports follow *top-dog* strategies
  - Why? Investment in capacity makes an airport tough: it leads to an increase in own price, which hurts the other airport
  - Additionally, prices are strategic substitutes (demands are complement)

Analysis of Airports Markets

- *Independent Private Airports (cont.)*

- Now, two-part tariffs each (ITPT)

$$\Rightarrow \quad P = 2C' + 2\frac{(N-1)}{N}(\alpha S+\beta)Q\sum_h D_Q^h + 2\frac{(N-1)ES^2Q}{N}$$

$$-Q(\alpha S+\beta)(\partial D/\partial K_h) = r$$

$Q^{TPT} = 50$	$K^{TPT} = 56$	and	$Q^{ITPT} = 34$	$K^{ITPT} = 39$

- The horizontal double marginalization also arises here, but its effect is strong:

  In the TPT case Q and K increases with N but here they *decrease*

Outline

1. Introduction: two approaches to the economic analysis of airports
2. The *One Market Approach:* details
3. An oligopoly model for the airline market
4. Relation between the two approaches
5. Analysis of airports markets
6. Numerical results
7. Final comments

Numerical Simulation

Parameter values of the numerical simulation

Demand				***Airlines***		***Airports***	
α	40	A	2000	S	100	r	10000
β	3000	B	0.15	N	varies	C'	2000
γ	4	E	0.13	c	36000		

- α, γ : Morrison and Winston (1989)
- β : Morrison (1987)
- S : Swan (2002, aircraft size), Oum and Yu (1997, load factor)
- c : Brander and Zhang (1990) and Oum et al. (1993)

Numerical Simulation

N	Type	Q	K	P	D	t	CS	Φ	π	π + Φ	SW
	SPA	21.92	31.21	93,629	0.076	1,665	360,368	798,224	1,424,078	2,222,301	2,582,670
	W	92.18	100.18	-134,263	0.115	608	6,372,189	14,599,332	-14,383,318	216,014	6,588,203
1	TPT	45.85	51.48	4,000	0.158	1,300	1,576,519	4,080,700	-850,188	3,230,512	4,807,032
	IPA	11.62	17.78	123,352	0.106	1,817	101,304	252,124	864,509	1,326,184	1,427,487
	ITPT	45.85	51.48	4,000	0.158	1,300	1,576,519	4,080,700	-850,188	3,230,512	4,807,032
	SPA	36.10	45.52	93,533	0.084	1,500	890,628	719,011	2,462,264	3,181,276	4,071,904
	W	101.23	109.62	-33,201	0.110	608	7,001,866	5,800,933	-5,557,153	243,781	7,245,646
3	TPT	50.36	56.27	61,129	0.152	1,299	1,733,133	1,606,429	1,949,207	3,555,636	5,288,770
	IPA	19.80	26.23	123,174	0.117	1,719	267,820	238,905	1,593,238	2,148,730	2,416,550
	ITPT	34.34	39.21	90,607	0.180	1,516	805,821	820,940	2,323,350	3,144,290	3,950,111
	SPA	41.35	50.36	93,476	0.091	1,438	1,145,831	570,051	2,854,380	3,424,431	4,570,262
	W	103.25	111.73	-10,883	0.109	608	7,142,886	3,611,707	-3,362,283	249,424	7,392,310
5	TPT	51.37	57.34	73,602	0.150	1,299	1,768,213	997,475	2,630,397	3,627,871	5,396,085
	IPA	22.87	29.10	123,074	0.126	1,683	350,461	192,678	1,870,000	2,420,000	2,770,000
	ITPT	32.48	37.21	104,084	0.185	1,549	706,809	446,535	2,630,000	3,080,000	3,790,000
	SPA	46.41	54.67	93,389	0.103	1,378	1,421,451	363,240	3,236,644	3,599,884	5,021,335
	W	104.83	113.37	6,379	0.108	607	7,252,401	1,855,122	-1,602,683	252,439	7,504,840
10	TPT	52.16	58.17	83,218	0.149	1,299	1,795,457	509,499	3,173,101	3,682,600	5,478,058
	IPA	25.87	31.67	122,926	0.141	1,646	441,640	124,213	2,154,232	2,666,694	3,108,334
	ITPT	31.16	35.79	113,528	0.188	1,572	640,840	205,027	2,817,756	3,022,783	3,663,623
Homogenous case (B=E=0.15)											
	SPA	33.66	42.67	93,517	0.088	1,488	849,825	630,475	2,290,466	2,920,941	3,770,766
	W	92.18	100.18	-28,669	0.115	608	6,372,189	4,865,377	-4,650,163	215,214	6,587,403
3	TPT	45.85	51.48	63,343	0.158	1,299	1,576,519	1,359,167	1,870,546	3,229,712	4,806,232
	IPA	18.44	24.59	123,148	0.122	1,713	254,959	210,658	1,479,126	1,985,366	2,240,325
	ITPT	30.86	35.47	92,850	0.189	1,522	714,385	684,341	2,152,188	2,836,529	3,550,913
	SPA	41.29	48.99	93,354	0.110	1,371	1,278,949	292,105	2,871,224	3,163,329	4,442,278
	W	92.18	100.18	8,289	0.115	608	6,372,189	1,455,973	-1,243,559	212,414	6,584,603
10	TPT	45.85	51.48	84,113	0.158	1,299	1,576,519	404,110	2,822,802	3,226,912	4,803,432
	IPA	22.99	28.39	122,868	0.150	1,641	396,384	100,615	1,907,508	2,353,402	2,749,785
	ITPT	27.24	31.56	114,228	0.200	1,574	556,377	162,791	2,475,951	2,638,742	3,195,119

Numerical Simulation: main results

- Theoretical results: OK (…which is a good thing!)
- SPA: airport charges are fairly high (~$40,000) but OK with literature (Morrison and Winston, 1989, indirectly calculated)
- W: airport charges increase with N; congestion effect dominates market power effect as N increases.
- W: subsidies may be very high when N small (~$130,000) but smaller than in the literature (Pels and Verhoef, 2004).
- **Delays (SPA) < Delays (W) < Delays (TPT) !** at least up to N=10
- TPT is less harmful for society than SPA.
- Budget adequacy of W airports may be possible.

Final Comments

- There have been two approaches in the literature
- Here, we used an *airline-market approach* and showed that the *one-market approach*'s abstractions are not good approximations
- The *Airline-market approach* should be used and in fact, it is useful to explore the questions that both approaches looked at, **particularly privatization**
- Other aspects should be re-examined as well
  - Effect of concession revenues, lumpy capacity
- Our results are bad news for both publicly owned and private-but-regulated airports
- Furthermore, the insights of this paper apply to many other cases as well
- Main results of the airport market:
  - schedule delay cost and potential differentiation of airlines are important.
  - The scope for vertical control is important
  - Privatization is quite unattractive here (but…)

Final Comments

- The airline oligopoly model was an improvement: schedule delay cost and differentiation…What about the assumptions we made?
  - Timing of the game
  - Are the linear demands too stringent?
  - Variable proportions
  - Round trips ➔ airports face no competition! Worst case scenario for privatization

- Competition between airports: in two ways
  - Geographic competition: address models
  - Network competition: Route structure choice models

- More future research
  - Peak-load pricing, in addition to congestion pricing
  - Actual policies: information **is** incomplete, X-inefficiency…
  - Is privatization a good idea in more real cases? How de we **actually** regulate?

Economic Analysis of Airport Pricing and Privatization

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On schedule delay Cost

$$g(Q_i) \equiv G(\tau_i(Q_i))$$

τ_i: expected gap between passengers' actual and desired departure time.

We assume:

- Monetary cost of the gap is proportional to its length
- τ is inversely proportional to the frequency of flights

➔ $$g(Q_i) = G(\tau_i(Q_i)) = \gamma \cdot \tau_i(Q_i) = \gamma \cdot \eta \cdot Q_i^{-1}$$

➔ $$g(x) + xg'(x) = 0$$

➔ $$2g'(x) + xg''(x) = 0$$

Existence, Unicity and Stability in the Airlines' game

$$\phi_i^i = \left(AS - 2BS^2 Q_i - ES^2 \sum_{j \neq i} Q_j - c - \sum_{h=1,2} P_h \right) - S\left(g(Q_i) + Q_i g'(Q_i)\right)$$
$$- (\alpha S + \beta) \sum_{h=1,2} \left(D^h + Q_i D_Q^h\right) = 0$$

$$\phi_{ij}^i = -ES^2 - (\alpha S + \beta) \sum_{h=1,2} \left(D_Q^h + Q_i D_{QQ}^h\right) < 0$$

$$\phi_{ii}^i = -2BS^2 - S\left(2g'(Q_i) + Q_i g''(Q_i)\right) - (\alpha S + \beta) \sum_{h=1,2} \left(2D_Q^h + Q_i D_{QQ}^h\right) < 0$$

- So we have existence….Unicity? Look at best reply function

$\phi_i^i\left(\Psi_i(\mathbf{Q}_{-i}), \mathbf{Q}_{-i}\right) = 0$ But… $\Psi_i(\mathbf{Q}_{-i}) = \Psi_i\left(\sum_{j \neq i} Q_j\right)$

.

Best reply functions have slope greater than -1.

- Cournot Stability? Is the BR mapping a contraction?: $\phi_{ii}^i + \sum_{j \neq i} \left|\phi_{ij}^i\right| < 0$

$$-\left(2B - (N-1)E\right)S^2 + (\alpha S + \beta) \sum_{h=1,2} \left((N-3) D_Q^h + \frac{(N-2)}{N} Q D_{QQ}^h \right) < 0$$

Calculation of consumer surplus

- We have path independence. We take a linear path:

$$\Theta_i(\sigma) = \theta_i(P_h, K_h, N) + \sigma(A - \theta_i(P_h, K_h, N)) \quad , \quad \sigma \in [0,1] \quad , \quad \forall i \in [1..N]$$

- Changing variables…

$$CS(P_h, K_h, N) = \int_{\boldsymbol{\theta}(P,K,N)}^{\mathbf{A}} \sum_i^N q_i(\boldsymbol{\theta}) d\theta_i = \sum_i^N \underbrace{\left(A - \theta_i(P_h, K_h, N)\right)}_{I} \underbrace{\int_0^1 q_i\left(\boldsymbol{\Theta}(\sigma)\right) d\sigma}_{II}$$

- But we know θ_i. We get: $I = \dfrac{SQ(P_h, K_h, N)}{N}\left(B + (N-1)E\right)$

- We also know q_i so: $II = \displaystyle\int_0^1 \left(a - b\Theta_i(\sigma) + \sum_{j \neq i} e\Theta_j(\sigma) \right)$

- Replacing Θ_i and Θ_j and solving the integral: $II = \dfrac{SQ(P_h, K_h, N)}{2N} + \underbrace{\dfrac{a - A(b - (N-1)e)}{2}}_{0}$

$$\Rightarrow \quad CS(P_h, K_h, N) = \frac{\left(B + (N-1)E\right) S^2 Q(P_h, K_h, N)^2}{2N}$$

Comparative Statics in the airport market

- Differentiating SPA first-order conditions with respect to N and solving

$$\frac{dQ^{SPA}}{dN} = \frac{\pi_{QN}\pi_{KK} - \pi_{QK}\pi_{KN}}{\pi_{QQ}\pi_{KK} - \pi_{QK}} \qquad \frac{dK^{SPA}}{dN} = \frac{\pi_{KN}\pi_{QQ} - \pi_{QK}\pi_{QN}}{\pi_{QQ}\pi_{KK} - \pi_{QK}}$$

But:

$$\pi_{QK} = P_{QK}Q + P_K > 0$$

$$\pi_{QN} = P_{QN}Q + P_N > 0$$

$$\pi_{KN} = P_{KN}Q < 0$$

So the signs are not determined. In fact, if the three cross derivatives were positive, then profit would be supermodular and $dQ^{SPA}/dN>0$, $dK^{SPA}/dN>0$ would follow directly from results in Lattice programming

Proof of proposition 2

- SW function can be written as:

$$SW = \int_0^Q P\,dQ - P\,Q + \pi + \frac{BS^2Q^2}{2N} + \frac{(N-1)}{N}(\alpha S + \beta)\int_P^\infty Q\frac{\partial Q}{\partial P}\left(\sum_h D_Q^h\right)dP$$

$$\Rightarrow \quad \left.\frac{\partial SW}{\partial K_1}\right|_{K^{SPA}(Q)} = \underbrace{\int_0^Q P_{K_1}\,dQ - P_{K_1}\,Q}_{\Gamma<0} - \frac{(N-1)}{N}(\alpha S + \beta)Q\left(\sum_h D_Q^h\right)\frac{P_{K_1}}{P_Q}$$

So the sign is not determined. Spence's proposition 1 is not enough.

If we use the other expression for SW, though:

$$\left.\frac{\partial SW}{\partial K_1}\right|_{K^{SPA}(Q)} = -Q(\alpha S + \beta)D_{K_1}^h - QP_{K_1} = \frac{Q^2}{N}(\alpha S + \beta)D_{QK_1} < 0$$

Second best capacity when pricing is SPA

$$\max_K \widetilde{SW}(K) = \max_K SW(Q^{SPA}(K))$$

$$\Rightarrow \left.\frac{d\widetilde{SW}}{dK}\right|_{K^{SPA}} = \underbrace{\left.\frac{\partial SW}{\partial Q}\right|_{Q^{SPA}(K^{SPA}),K^{SPA}}}_{+\text{ by Prop. 1}} \cdot \underbrace{\left.\frac{\partial Q^{SPA}(K)}{\partial K}\right|_{K^{SPA}}}_{+} + \underbrace{\left.\frac{\partial SW}{\partial K}\right|_{Q^{SPA}(K^{SPA}),K^{SPA}}}_{-\text{ by Prop. 2}}$$

So the sign is not determined.

Closed loop for independent private airports (linear prices)

$$\left.\frac{d\pi^h}{dK_h}\right|_{K_h^{O-L}} = \frac{\partial \pi^h}{\partial P_k}\frac{\partial \hat{P}_k}{\partial K_h} = \frac{\partial \pi^k}{\partial P_h}\frac{\partial \hat{P}_h}{\partial K_h}\frac{\partial \hat{P}_k}{\partial \hat{P}_h} < 0$$

Because:

$$\underbrace{\underbrace{\frac{\partial \pi^k}{\partial P_h}}_{-} \cdot \underbrace{\frac{\partial \hat{P}_h}{\partial K_h}}_{+}}_{-} \quad \cdot \quad \underbrace{\frac{\partial \hat{P}_k}{\partial \hat{P}_h}}_{-}$$

Investment makes you tough

Strategic substitutes