Airport Congestion and Airport-Airline Interaction

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Some academic issues on airport congestion

- Objectives of airport management
- Airport-airline-passenger interaction
- Aeronautical activities vs. commercial activities at airport

Objectives of airport management

- Ideally to maximize social welfare
  - SW = Pax S + Airline S + Airport S
- Problem: max SW may lead to fiscal deficit
- Alternatives
  - Max SW | s.t. fiscal breakeven
  - Privatized airport: max profit
  - Regulated airport: max profit | s.t. pricing regulation

Aeronautical and commercial operations

- Economies of density in aeronautical operations leads to fiscal deficit, commercial operations provide subsidy
- Commercial operations become major source of revenues
- Regulations
  - Single-till: total revenues subject to regulation
  - Duel-till: only aeronautical revenues subject to regulation

Airport-airline-passenger interaction

- Traditional approach (Basso and Zhang, 2007)
  - Assume airline market is competitive
- Passengers
  - Travel costs depend on ticket price and congestion delay cost

$$\rho = P + D$$

- Passenger demand only responds to airport charge and airport capacity
- Airport may levy congestion charges to curtail demand and finance capacity

New approach to airport-airline interaction

- Brueckner (2002)
  - Considers airline market as monopoly or oligopoly
  - Congestion affects passenger travel costs which in turn affect airline profits
- Implications
  - Airline will internalize (partially) congestion cost
  - No place (or only partial) for congestion charge to be levied by airport

Congestion and capacity

- Internalization of congestion cost by airlines deprives the airport a source of funds for capacity financing

- Zhang and Zhang (2006)
  - Assumes no commercial revenues
  - No impact on public airport receiving subsidy
  - Distorts the capacity investment decision for private airport (over investment)

Current work: Zhang and Zhang

- Consider both aeronautical and commercial operations
- Model the airport-airline in a two stage game
- Stage 1
  - Airport set airport charge μ and capacity K
- Stage 2
  - Airlines set output to max profits
  - Aggregate demand $Q = \Sigma q = Nq$
  - Ticket price P set by aggregate demand

Airline decision

- Airline profit

$$\pi = qP - cq - \mu q$$

- Max airline's profits leads to

$$P = \mu + c + s(Q\frac{\partial D}{\partial Q} + \frac{\rho}{\varepsilon})$$

- Aggregate demand depends on full price
  - Q = Q(P + D)

Airport-airline interaction

- When airlines make output decision in stage 2, they take airport charge μ and capacity K as given

- Airport can use μ and K to affect subsequent decisions by the airlines and so to affect aggregate demand

$$\frac{\partial Q}{\partial \mu} = N/[(N+1)(\rho' - \frac{\partial D}{\partial Q}) + Q(\rho'' - \frac{\partial^2 D}{\partial Q^2})]$$

$$\frac{\partial Q}{\partial K} = (N\frac{\partial D}{\partial K} + Q\frac{\partial^2 D}{\partial Q \partial K})/[(N+1)(\rho' - \frac{\partial D}{\partial Q}) + Q(\rho'' - \frac{\partial^2 D}{\partial Q^2})]$$

Welfare-maximizing airport

Decisions for the airport:

μ: aeronautical charge

K: capacity

u: price for commercial goods/services

$$SW = \text{Pax surplus} + \text{Airlines Profits} + \text{Airport Profits}$$

$$= [\int_0^Q \rho(\xi)d\xi - \rho Q] + [N(Pq - cq - \mu q)] + [\mu Q - c_0 Q - rK] + QV$$

$V = \text{Consumer surplus in concessions}$

Airport decisions

- Pricing

$$\frac{\partial SW}{\partial \mu} = 0 \quad \Rightarrow \quad P = c_0 + c + Q\frac{\partial D}{\partial Q} - V$$

- Airport charge is such that to induce optimal ticket price

$$P = SMC - V$$

- When there is commercial operations, ticket price is lowered by the amount of passenger surplus in concession consumption

Airport decisions

- Capacity

$$\frac{\partial SW}{\partial K} = 0 \quad \Rightarrow \quad -Q\frac{\partial D}{\partial K} = r$$

- Optimal capacity is such that marginal reduction in congestion cost equal to marginal cost of capacity

Induce optimal ticket price

- Given airlines' response in stage 2

$$P = \mu + c + s(Q\frac{\partial D}{\partial Q} + \frac{\rho}{\varepsilon})$$

- Optimal airport charge in stage 1 should be

$$\mu = c_0 + (1 - s)Q\frac{\partial D}{\partial Q} - s\frac{\rho}{\varepsilon} - V$$

- For monopoly airline

$$\mu = c_0 - \frac{\rho}{\varepsilon} - V$$

  - Public airport to give subsidy to monopoly airline?

Profit-maximizing airport

- Objective

$$\pi_0 = \text{Airport profit} = \mu Q - c_0 Q - rK + QR$$

  - R = concession profits

- Pricing

$$\frac{\partial \pi_0}{\partial \mu} = 0 \quad \Rightarrow \quad \mu = c_0 + \frac{\mu}{\varepsilon_0} - \frac{R}{\varepsilon_1}$$

- Airport charge reflects marginal cost, airport market power and cross-subsidy from concession to aeronautical operation

Profit-maximizing airport

- Capacity

$$\frac{\partial \pi_0}{\partial K} = 0 \quad \Rightarrow \quad -Q\frac{\partial D}{\partial K} - \frac{Q^2}{N}\frac{\partial^2 D}{\partial Q \partial K} = r$$

  - So

$$-Q\frac{\partial D}{\partial K} < r$$

- Airport capacity is socially inefficient in the sense that the marginal benefit is smaller than marginal cost of capacity

Budget-constrained airport

- Single-till regulation
  - No incentive to improve efficiency for airport
- Duel-till regulation
  - Only aeronautical operations are subject to cost recovery
  - Objective

$$\max \ \mu Q - c_0 Q - rK + QR$$
$$s.t. \ \mu Q - c_0 Q - rK = 0$$

Budget-constrained airport

- Pricing

$$\mu = c_0 + \frac{rK}{Q}$$

- Capacity

$$-Q\frac{\partial D}{\partial K} - \frac{Q^2}{N}\frac{\partial^2 D}{\partial Q \partial K} = r$$

- As

$$-Q\frac{\partial D}{\partial K} < r$$

- Airport capacity is inefficient unless $N \to \infty$

Conclusion

- We consider both aeronautical and commercial operations
- Air carriers who have market power will internalize congestion delay cost
  - Serve well for demand management
  - Leave less resource for airport investment
- Airport may use commercial operation for cross subsidy

Conclusion: Welfare-maximizing airport

- Cost recovery on commercial operation
- Aeronautical charge is even lower than without commercial operation
- Investment in capacity is socially efficient but airport has financial deficit. With commercial operations, deficit is even bigger

Conclusion: Profit-maximizing airport

- Pricing of both aeronautical and commercial operations involve monopolistic mark-up
- Cross-subsidy exists between commercial and aeronautical operations
- Over investment in capacity

Conclusion: Budget-constrained airport

- Cost recovery on aeronautical operation
- Overinvestment in capacity similar to profit-maximizing airport
- As the carrier market moves towards monopoly, over investment become more severe

Thank You!