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A Note on Pricing of Hub-and-Spoke Networks

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WORKING PAPER SERIES ON THE POLITICAL ECONOMY OF INSTITUTIONS
NO. 17

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October 1988

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A Note on Pricing of Hub-and-Spoke Networks

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A NOTE ON PRICING OF HUB-AND-SPOKE NETWORKS

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September 1988

Abstract: The difference between competitive and monopolistic pricing of airlines' hub-and-spoke networks is examined. It is found that under reasonable cost conditions pass-through passengers pay lower prices per mile than those originating or ending at the hub. Thus, higher per/mile prices in large hubs do not necessarily signal market power.

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1. Introduction.

Airline deregulation has had a profound effect on the way airlines handle their business. Not only airline pricing has become substantially more sophisticated, but the role of airline networks has become crucial in the overall strategy of the industry. Recently, however, there has been some concern about the pricing in airports that are dominated by one or two airlines. In particular, it seems that in those airports, airlines charge relatively higher prices to passengers originating or whose end point is the hub-airport, than to those passengers that use the airport exclusively as a hub (see Bailey and Williams (1988)).

In this note I show that efficient prices in the presence of capacity constraints would have exactly that characteristic. Market power or market failure inferences cannot be derived from such observation.

2. Hub-and-spoke Networks.

Airlines' modern networks are almost all of the hub-and-spoke type. A hub-and-spoke network consists of two dimensions: physical and temporal. On the physical dimension, airlines route most of their flights through the hub-airport. On the temporal dimension, the airline coordinates its landing and departing times so that passengers can connect through the hub with a minimum of layover time.

The advantage of a hub-and-spoke network is that it allows an airline to serve small markets that otherwise would be unprofitable because of minimum airplane sizes. For example, in the first quarter of 1982 American Airlines carried between Albany, NY, and Minneapolis-

St Paul, MN, on average 1 passenger a day in direct service and 6 passengers in connecting service.¹ If American Airlines would have to serve a non-stop flight between those two cities, it would have preferred not to do so. Having a hub in Chicago allowed American to carry those passenger, and many others like them.

The hub-and-spoke network, then, is a way to save on fixed costs. Going through a hub, however, involves longer total travel time. Not only because of the potential increase in distance, but also because of the layover time. Thus, for a given fare, the full price of a flight through a hub is higher than that of a non-stop flight. Passengers will then require a discount to fly through a hub. On the other hand airlines will achieve, because of the lumpiness of aircraft, better load factors in flights going through their hubs than on non-stop flights. As a consequence, the equilibrium price differential that will develop between non-stop and connecting flights will just compensate airlines for the higher costs of the non-stop flight.

To make a hub-and-spoke network competitive, then, airlines have to find airports that allow them to minimize total flying time for their passengers. In particular, an already congested airport is not a good candidate for a hub. Even if enough gate space were available, the probability of delays would diminish the competitiveness of the hub, implying that even lower prices would have to be offered to attract passengers. Similarly, airports located in the middle of the

¹ Direct service is defined as a single plane, no connections, flight. This information is taken from the Origin and Destination Survey, Reconstructed Data Bank 1A, supplied by the Boeing Computer Services Inc. Seattle, WA.

country have an advantage as hubs over those in either coast.

3. Price Differences between Pass-through and Local Passengers.

Consider an airline, as in figure 1, that serves 3 cities, A, B and C, using A as its hub. Because of travelers' preference of direct over connecting service,² it is efficient to route flights in the form B-A-C rather than having each airplane return to its origin city (i.e. a B-A-B, C-A-C or A-B-A, A-C-A network).

Assume that each airplane has exactly the same number of exogenously given seats, K . Furthermore, let the airline be the sole supplier of flights to A. Hub competition, however, makes parametric the price for a trip B-C. Call that price P_0 .³ The demand for each individual segment is given by the inverse demand functions

$$P_j = P_j(Q_j)$$

with $j=AB, AC, BC$.

Assume costs are given by a constant marginal cost c (independent of distance), and by a fixed cost, F , per round trip BC.⁴ The problem for the airline is given by (AP)

$$\begin{aligned} & \text{Max } \{(P_{AB}-c)Q_{AB} + (P_{AC}-c)Q_{AC} + (P_0-c)Q_{BC} - F\} \\ & \quad (Q_{BC}, Q_{AB}, Q_{AC}) \\ \text{s.t.} & \\ & \quad Q_{AB} + Q_{BC} \leq K \\ & \quad Q_{AC} + Q_{BC} \leq K \end{aligned} \tag{AP}$$

² See Carlton, Landes and Posner (1980), and Reiss and Spiller (1988).

³ Congestion at the hub will make P_0 an endogenous variable.

⁴ The marginal cost per passenger c represents for example the cost of selling and issuing a ticket, airport and baggage handling. These costs are assumed to be independent of distance. The results in this paper will carry through even if c is weakly dependent on distance. For simplicity, c is assumed to be unaffected by distance.

Letting δ_j , $j = AB, AC$ represent the lagrange multipliers associated with the respective constraints of (AP), the first order conditions are given by

$$\begin{aligned} P_j(1+1/\epsilon_j) - c &= \delta_j, & j &= AB, AC \\ P_0 - c &= \delta_{AB} + \delta_{AC} \end{aligned} \tag{1}$$

The first order conditions imply that as long as the capacity constraints are binding (i.e. $\delta_j > 0$), the sum of the marginal revenues has to equal the competitive price P_0 plus c . The solution to (1) is represented in Figure 2. Observe that if the demand functions were identical, then, from the constraints to (AP) it follows that $Q_{AB}=Q_{AC}=K-Q_{BC}$. Consequently, prices of both segments AB and AC are the same. Let those prices and quantities be given by P^* and Q^* respectively. Substituting P^* and Q^* into the first order conditions we obtain

$$P^* = \frac{P_0+c}{2(1+1/\epsilon^*)} \geq \frac{P_0+c}{2} \tag{1a}$$

If, however, segment demands are not identical, then the segment with the larger demand will be quoted a higher price. As long as both constraints are binding, however, both quantities will be the same. It is also feasible that the price for the large demand segment will exceed P_0 . For this to be an equilibrium outcome, however, the two segments have to have largely different demands.⁵

This result provides the economic rationale for the current

⁵ This will be the case, for example, if the capacity constraint is not binding in one segment. In that case, the marginal revenue for that segment equals the marginal cost c , while for the segment with the large demand its marginal revenue equals P_0 . Thus, price will exceed, in this case, the competitive price.

concern about the pricing in "captured" airports. It may be useful to illustrate this result with an example. An airport that has been said to be "captured" is St.Louis, where TWA holds a large share of total departures and landings in that airport. A one way ticket from Champaign, IL (CMI), to Los Angeles (what I called the route BC) is currently (as of July 1988) being quoted at \$405 (the price being the same whether through St.Louis with TWA or through Dayton with Piedmont). A similar one way ticket from CMI to St.Louis (the segment BA) currently costs (with TWA) \$170, while one from St. Louis to Los Angeles (the segment AC) is \$298. Thus, those passengers using St.Louis as a hub, going from CMI to LA, pay less than the sum of the individual segments' fares. The difference in this case is of \$63.

It is now worth investigating the structure of optimal prices for the individual segments. The optimal prices can be derived from (1), by assuming that the airline behaves as a perfect competitive firm. That is, it faces perfectly elastic demands for both segments. In this case, equation (1) implies that the sum of both segment prices has to equal the competitive price P_0 plus the marginal cost of a passenger c . This is represented in Figure 3. Again, we find that the sum of the individual segment prices exceed the price for the whole circuit. If marginal passengers' cost was zero, then the sum of both prices should equal the competitive price P_0 .

It is feasible that the optimal price for a single segment be exactly P_0 , as in Figure 4. This is the case when the capacity constraint in one segment is not binding. Thus, the price for that segment is just the marginal cost c , while the price for the other

segment is P_0 .

In either case, the sum of both segment prices exceeds the whole circuit price by the marginal cost of a passenger. Thus, both, monopoly and efficient competitive pricing imply a similar price structure. The observation that passengers originating or ending in a hub pay relatively higher prices than those using the airport as a hub is not enough to distinguish competitive from monopoly pricing. In the St. Louis example, without knowledge of actual marginal passenger costs, we cannot ascertain whether the \$63 difference is the result of monopoly pricing, or whether it just represents a passenger's marginal cost. Thus, to infer market inefficiencies from pricing, a more structural analysis is needed.

Finally, there are several airports where multiple carriers have located their hubs (e.g. Chicago). In those instances, each airline could bring passengers into the airport and switch them to another airline so as to accommodate an outbound (or inbound) local passenger. If passengers are willing to pay a premium for single airline connections, then the airline that is not able to accommodate the pass-through passenger will face a loss in revenue. Such revenue loss will also be charged to the local passenger. It may be that the larger the number of airlines using the airport as their hub the easier the connection for the diverted pass-through passenger. In that case, the discount offered to diverted pass-through passengers may be smaller. Hence, average prices at hub-airports may fall with the number of airlines that use the airport as their hub.

Network efficiencies, then, suggest that hub-and-spoke pricing

should tax local passengers. Whether current fare levels at major hubs are inefficient, remains to be empirically ascertained.

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FIGURE 1

Simplest hub-and-spoke network

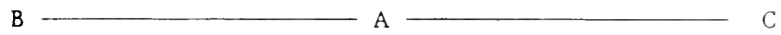


FIGURE 2

Monopoly Pricing of Two Segments Feeding into the Hub

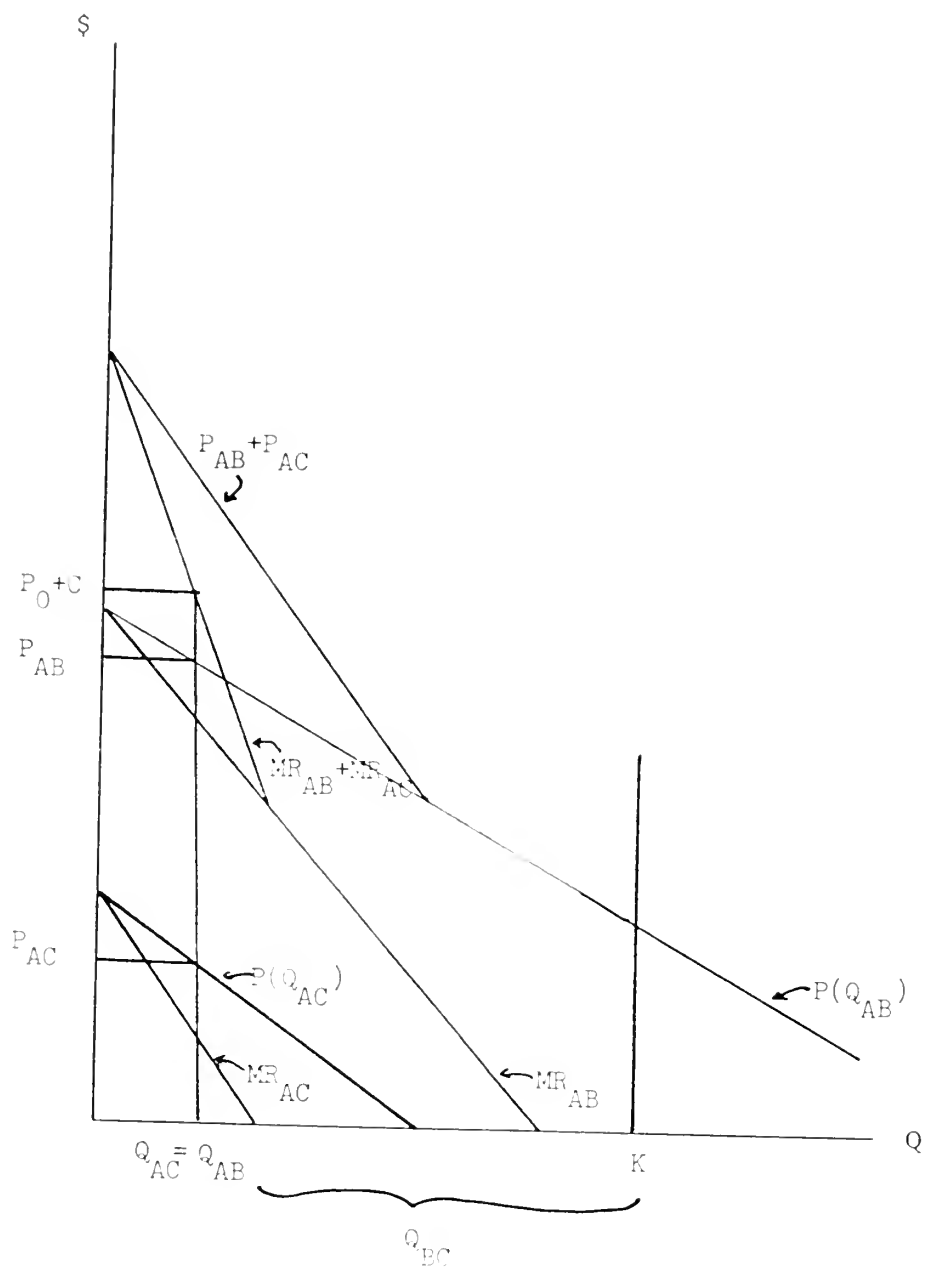


FIGURE 3

Optimal Pricing of Two Segments Feeding into the Hub

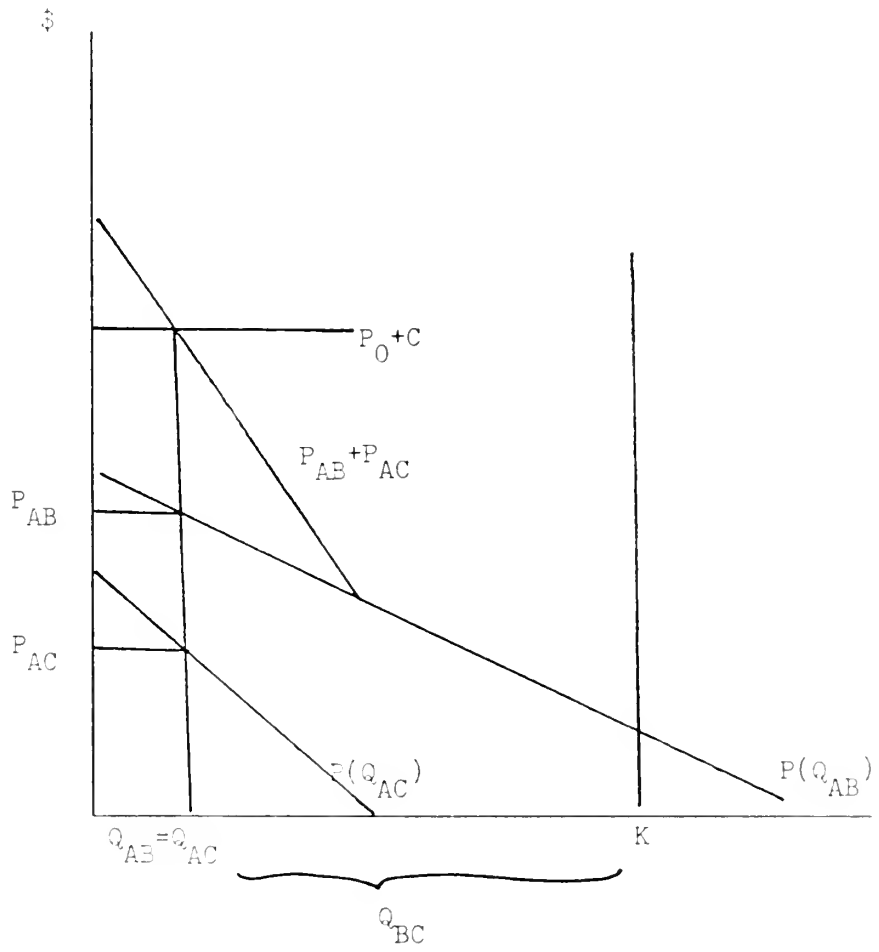
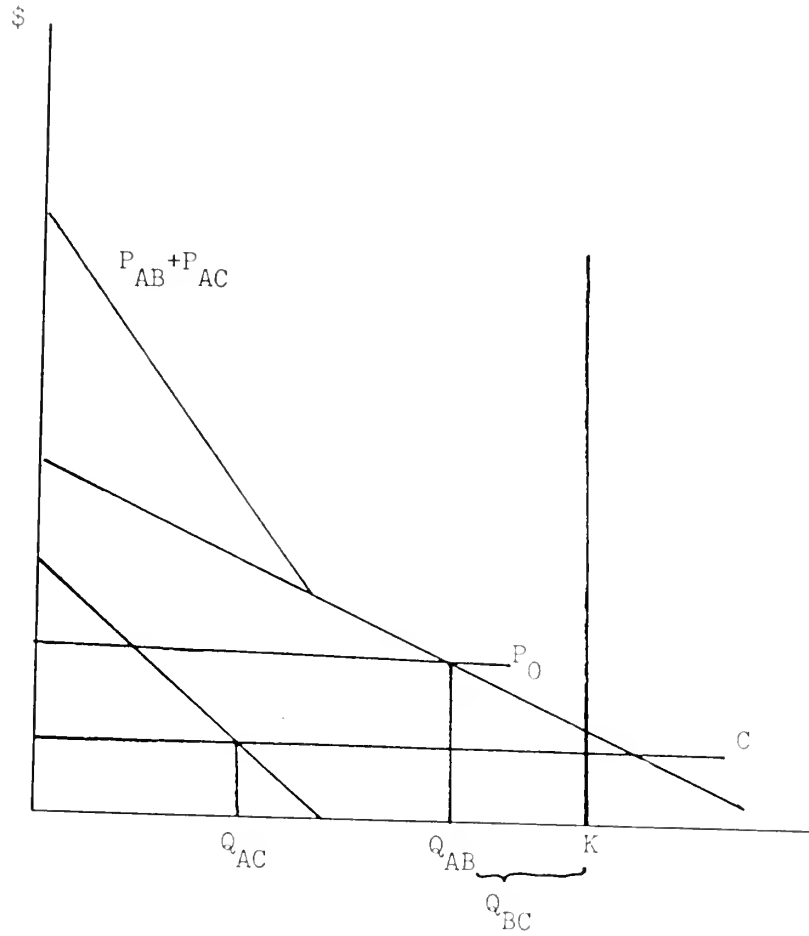


FIGURE 4

Optimal Pricing of Two Segments Feeding into the Hub
where the price for a segment equals P_0 .



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