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Air Transport Deregulation and Airport Congestion: The Search for Efficient Solutions

J. R. G. BRANDER AND B. A. COOK

Two broad approaches to the congestion problem exist. It is possible to expand slot availability. This analysis suggests the futility of such action. The other solution is to use price to ration capacity. Peak load pricing reduces social cost, shifts traffic to less congested periods, and improves the overall utilization of the airports. An auction mechanism would be the most efficient alternative. Under this approach, each slot would be awarded to the highest bidder. In addition to controlling congestion, the approach maximizes the return that could be generated by each slot and, hence, airport revenues.

A deregulated air transportation system is an open access commons. This is a system characterized by unrestricted (or open) access to everyone. This results in some form of adverse interaction among system users, which generates external costs such as congestion or, in the case of natural resource systems, depletion. The common property nature of the air passengers, the absence of entry barriers, and the ease with which productive capacity can be reallocated among the various air travel markets all establish the parallel. Economic rents will be totally exhausted if there are no constraints on landing slots. The available passenger stock will be over exploited and excess capacity will emerge. Congestion will develop exacerbated by the inherent tendency toward service scheduling. The congestion generates social costs due to overcrowding. Note that, strictly speaking, economic rent is the return to a resource with a supply that is absolutely fixed and nonaugmentable. However, when some inputs are fixed only in a short-run sense, this return may be called a quasi-rent.

A brief review of the applicability of the common property framework to the industry is given at the beginning of the paper. Industry equilibrium is then discussed. Next, the tendency toward service scheduling and the resultant traffic peaks are reviewed. A variety of proposed solutions, both supply side and demand side, are reviewed in light of the analysis. In conclusion, demand management policies are required to increase the social surplus and control congestion.

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THE AIRLINES AND COMMON PROPERTY EQUILIBRIUM

The theoretical structure, which was developed in the original paper *(1)* and on which this policy analysis is based, utilized a framework developed by Copes *(2)*. Copes followed Carroll, Ciscil, and Chisholm *(3)* by focusing on the imperfect specification of property rights and the negative externalities that this creates for existing firms. Copes used that framework to demonstrate the common property outcome. Such an outcome aptly describes a deregulated airline industry. For a particular passenger volume, increases in the number of flights on a particular link will occur, constrained only by the number of landing slots available. Economic rents will be dissipated as the industry expands capacity above socially desirable levels. Restricting entry will increase the social surplus, but may have adverse effects on the consumer.

In an existing market, the industry will establish a level of output that equates price and average costs. Should output be below this level, economic rents will exist. This results in the entry of new firms, the expansion of existing carriers, or both. The process continues until all rents are dissipated. This situation is shown in Figure 1, which shows the marginal social cost (MSC) curve, as well as the marginal private cost (MPC) curve that, according to Walters *(4)*, is also the average social cost (ASC) curve. MPC is the cost incurred by an additional unit of output from producers. MSC consists of the MPC of the private sector producer plus the external cost incurred in producing an additional unit of output.

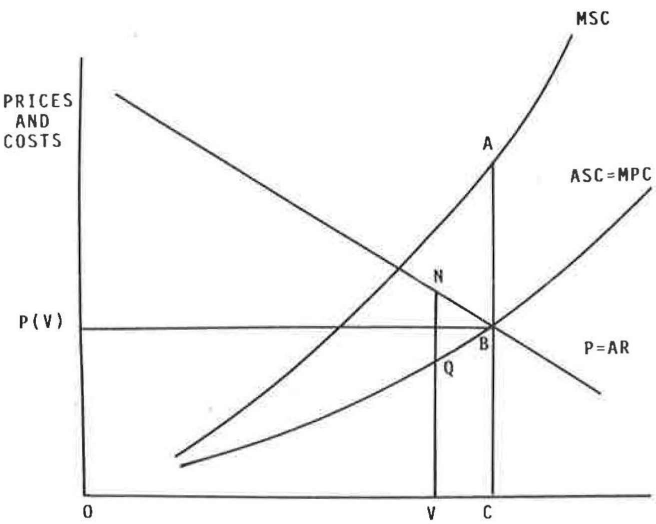

FIGURE 1 The dissipation of economic rents.

The demand curve is P = AR. Suppose initially the traffic volume is OV. Price is VN and exceeds MPC by NQ, generating a rent per unit of that amount. The existence of this economic rent will lead to capacity expansion, and output will expand to OC. At that output level, P = AR = MPC. All economic rents have been dissipated. This result follows from the open access common property nature of the deregulated airline industry. Firms make their decisions on what they perceive to be their marginal private cost curve (that is, on the average social cost curve). It is to be noted that at that level of traffic, there are social costs, represented in the diagram as AB, that the firms are able to externalize.

Across markets, the process will continue until profit ratios are equalized, which is the same result as before. Average revenue and average cost are equal for the typical firm; therefore, economic profits (or rents) are zero. Specific firms may be more or less efficient than the average. Therefore, some firms will earn a positive intramarginal rent, or suffer an economic loss. All markets will move toward the rent-exhausting level of output, a level that will be reached in the absence of constraints on the availability of airport capacity. This is the same outcome that occurs any time a commons is involved.

The supply of runway landing slots is finite, and may limit the number of flights (that is, the amount of effort) that is possible (Figure 2). A constraint is imposed on the number of

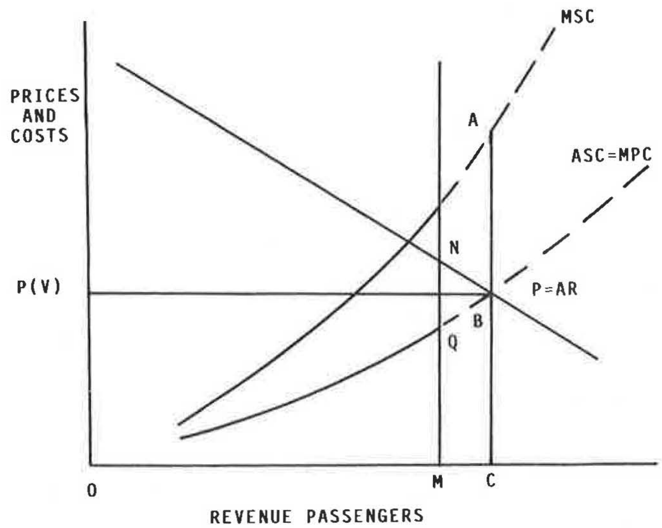

FIGURE 2 Slot constrained congestion externality.

landing slots, and hence, on the potential passenger volume. Given the constraint, passenger volume is limited to OM. Where the constraint is at an output level below the common property outcome (here, OM), all economic rents are not dissipated. Excess demand for slots exists because the airlines want to exploit the unexhausted profit opportunities, and establish a passenger volume of OC as in Figure 1. Conflict over slot availability and allocation between the airlines and the airport operators is inevitable in this situation. This excess demand for slots is exacerbated by the clustering of flights, especially at the hub airports. As shown later in this paper, such clustering is an inherent characteristic of the industry.

Two observations must be made about this constrained equilibrium. First, it does not generate maximum rents for the industry as a whole. Closely related is the fact that the social surplus is not maximized in terms of output due to excess capacity. The social surplus includes both rent and consumer surplus, and is defined as the difference between total costs of output and total utility derived from the consumption of this output. Maximizing the social surplus is equivalent to the marginal-cost pricing decision. Second, from the perspective of the individual airlines, the existence of unexploited rents will lead to demands for capacity expansion. Should this occur, total exhaustion of the rents will follow. This outcome emerges because individuals make their decisions based on the average social cost and benefit curves that they perceive to be their marginal private cost and marginal private benefit curves.

Social costs are not included in the decision-making process. Individuals operating in isolation can make myopic decisions without recognizing the full societal impacts.

SERVICE SCHEDULING

The low profit ratios of the airline industry have been observed for many years. Economists frequently commented that the industry had a tendency to compete away almost all of the potential economic rents. Such erosion was seen as the result of head-to-head scheduling that, in turn, was seen as the outcome of a regulatory regime in which price competition was precluded. Industry consensus was that the best way to increase the passenger-load factor was to schedule departures to meet those of competitors. Such a practice is not related to a particular regulatory system. It is a natural outcome of the desire to maximize profits.

Decades ago, Hotelling sought to determine the best location for a new entrant to a market *(5)*. His example involved a ribbon community currently served by one general store located exactly at the midpoint. Hotelling concluded that the optimal strategy for the new entrant was to locate next door to the existing firm. Doing so maximizes the number of customers, and, given the assumed constancy of costs, also its profits. This is the clustering phenomenon, and is readily observable in a variety of economic activities.

From the perspective of the airlines, the argument can be either temporal (a schedule change) or spatial (an attempt to enter a new market); however, the concept remains the same. In the case of the former, relocation can only occur at the time of a schedule change. It then involves a minimum of transactions costs. If start-up costs are ignored, this also applies to an airline's relocation in space. If start-up costs are incorporated into the analysis, relocation costs arise but will affect only the timing of relocation and not the decision to relocate.

The airline market can be divided into two more or less equal parts. First, the business market has a travel demand pattern with a bimodal distribution involving early morning and late afternoon flights. This component is highly sensitive to time of departure. The other, termed the recreational market, is much more sensitive to price and much more evenly spread over the day.

A hypothetical demand pattern for the New York to Los Angeles link is given in the first column of Table 1. It is based on the notion that one-half of the business market (that is, 25 percent of the total traffic) desires early morning departures; however, the balance of that market desires late afternoon and early evening departures. On the other hand, the recreational market is assumed to be evenly spread throughout the day. When the two are combined, the travel demand pattern of the first column in Table 1 emerges. This pattern can be compared with actual available seats on the link for four different time frames. The pattern of seat departures may be expected to mirror the demand pattern, but this is not the case. Instead, the clustering of flights is observed, with the tendency apparently becoming stronger as a consequence of deregulation and the increase of competition it has engendered. During April 1985, for example, 47 percent of the seat departures occurred between 5 p.m. and 11 p.m. The two peak periods combined accounted for 82.6 percent of the seat departures, but for only 74.9 percent of the hypothetical demand for seats. Clustering of flights is therefore observed in the market and provides prima facie evidence that the Hotelling clustering theory applies in the airline case.

Therefore it can be concluded that head-to-head scheduling is an inherent characteristic of the industry. It contributes to excess capacity and to the dissipation of the economic rents that could otherwise be earned. More important, from the perspective of the present discussion, head-to-head scheduling exacerbates the congestion problem.

Hartwick *(6)* suggests, in a common property model, that firms make their decisions exclusively on the basis of the present. They have no concern for the future because any gains realized from present abstinence will have to be shared with their competitors later on. In the current context, this point can be considered from the perspective of scheduled departure time. Any action by a carrier to voluntarily reduce peak flights in favor of off-peak departures would result in a loss of traffic and, hence, lower profits. Rival firms, of course, gain.

Congestion arises because of the confluence of airport capacity that is fixed in the short run, and a traffic volume that varies intertemporally. At the limit, congestion occurs whenever two or more carriers simultaneously need to use the landing slot. Congestion problems are both time related and specific. Their effect increases both the operating costs of the carriers and the

TABLE 1 PERCENTAGE TIME DISTRIBUTION OF HYPOTHETICAL DEMAND AND ACTUAL SEAT DEPARTURES FOR NEW YORK TO LOS ANGELES DAILY NONSTOP FLIGHTS

Time of Day	Hypothetical Demand	Actual Seat Departures			
		Nov. 1977	Nov. 1980	Dec. 1984	April 1985
8 a.m.–10:59 a.m.	33.3	18.1	23.2	27.0	36.5
11 a.m.–12:59 p.m.	8.3	22.1	15.0	7.3	7.4
1 p.m.–2:59 p.m.	8.3	0.0	0.0	0.0	0.0
3 p.m.–4:59 p.m.	8.3	10.1	6.4	20.9	9.9
5 p.m.–6:59 p.m.	20.8	26.2	34.1	21.2	31.9
7 p.m.–10 p.m.	20.8	23.5	23.2	23.6	15.1

Sources: M. Brennan and Associates, November 1977 and November 1980. Official Airline Guide, December 1984 and April 1985.

time delay costs experienced by the industry and its passengers. Congestion stems from the common property nature of the deregulated industry, and is complicated by the inherent tendency on the part of the carriers toward head-to-head scheduling which creates traffic peaks.

TOWARD AN EFFICIENT SOLUTION FOR AIRPORT CONGESTION

The foregoing analysis has profound policy implications. It has been shown that service scheduling is an inherent characteristics of the industry. With open access there will be overexpansion of capacity, and rent dissipation at the industry level. Potential solutions to the slot shortage problem need to be assessed in light of the model. Solutions exist on both the supply side and the demand side of the market. Several of these, together with their probable impacts, are given in Table 2. In each case, the policy and its impact on congestion, the social surplus, and industry rents are shown. The "do nothing" option is shown only for the purpose of baseline comparisons.

One possibility is to pursue demand management. It has been applied rarely, though has been widely discussed in the literature. It is to this side of the market that attention is first to be turned. The U.S. Department of Transportation has reviewed the slot shortage problem by focusing on three alternatives to alleviate the difficulties. As reported by Ott *(7)*, these were (*a*) allowing airlines to buy and sell slots, (*b*) refusing new entry at airports that are overly congested, and (*c*) an administrative allocation of the available capacity. Each of these, together with the semiannual slot auction proposed by the Port Authority of New York and New Jersey, must be assessed against the aforementioned theoretical background.

The policy option first discussed by Ott and given in Table 2 is the slot aftermarket. It neither deals with the congestion problem, nor does it presume to do so. The policy option simply allows the private sector to reallocate slots after some other mechanism has been used to make the initial allocation. It provides the individual airline with the choice of utilizing the slot or of selling to a competitor. The profit-maximizing airline would choose the alternative that provides the greatest return. The existence of such markets strongly suggests that the initial allocation, however made, was suboptimal. Unless the buying airline could make more profitable use of the slot than could the selling airline, the sale would not occur. On that basis, it might be concluded that allowing the sale of slots increases the social surplus even though the number of flights is not reduced. However, because the slot resale market does not address the question of the number of flights and passengers, it will not maximize the social surplus. In spite of this, the slot resale market is a useful correcting mechanism, and should be retained in the airport's system.

One potential negative side effect of the purchase and sale of landing slots should be noted. There is considerable danger that by allowing such transactions the runway slot will be converted into a new property right, if only in the short run. From this perspective, the landing slot, being transferable, would replace the operating authority that existed during the days of regulation. Therefore, each time slots were somehow allocated, there would be potential transitional gains for those obtaining the initial allocation. Furthermore, because potential gains would exist, individual airlines would have a vested interest in requesting more slots than are actually required. The potential for increasing the excess demand for landing slots must be recognized, as well as the related pressures on the selected allocative mechanism caused by allowing the resale market to function.

The second policy option discussed by Ott and the second option given in Table 2 is the refusal of a new entry policy. It gives the illusion of freezing the excess demands for runway slots at their existing levels by refusing new entry at congested airports. However, it is not clear whether carriers already holding at least one landing slot at such a facility could increase the number of slots requested. If so, the new entry policy simply reintroduces entry control, albeit in a new form, and reestablishes protection of the existing firms in a market. In effect, carriers currently using a congested airport are given grandfather rights to their landing slots just as existing carriers were granted grandfather rights when economic regulation was first initiated. The parallel is too striking to ignore. Even if this is not the case, the policy gives quasi-permanent property rights to slots to carriers currently using a highly congested airport and provides them with potential transitional gains when this option is combined with the slot market. As Tullock *(8)* observed, there is a trap in providing transitional gains. In his view, actions resulting in such gains are largely irreversible. In effect, the system would have come full cycle, except for the hidden nature of the reregulation of air transport. Such action is to be avoided, for all of the old problems would recur, albeit in different forms.

Furthermore, the approach makes the implicit assumption that the slots are better used by existing carriers than by new

TABLE 2 IMPACTS OF VARIOUS POLICY ALTERNATIVES

Policy Option	Impacts		
	Congestion	Social Surplus	Economic Rents
Slot aftermarket	None	Increases	Increases
Refusing new entry	None	Reduces	Reduces
Administrative allocation	None	Reduces	Reduces
Increase slots	Reduces	Reduces	Reduces
Congestion pricing	Reduces	Increases	Increases
Do nothing	Worsens	Reduces	Reduces

entrants.This suggests that the current allocation of slots is optimal from the societal viewpoint, and that the slots are currently being used this way by the incumbents. No documentation has been found regarding this. From the perspective of the social surplus, the exclusion of new carriers is a solution that is inferior to the administrative allocation of slots. As Koran and Ogur *(9)* observed, administrative allocation is inferior, in turn, to some kind of market allocation.

The third policy option discussed by Ott is the administrative allocation policy given in Table 2. It simply involves an administrative allocation of the available capacity. Comment on this option is difficult because all such mechanisms tend to be highly specific, and because the large number of alternative approaches differ primarily in the parameters incorporated into their formulas and in the weights given to each factor. What can be said is that, with current practices, any such allocative mechanism would be administered by the FAA, and that the solution amounts to the reregulation of air transportation in the United States.

One possible approach to the administrative allocation of airport runway landing slots has been suggested by Geisinger *(10)*. It is profitable to review his methodology, for it is illustrative of the difficulties encountered in dealing with scarcity through any mechanism involving administrative fiat.

Geisinger's proposal involves a two-stage allocative procedure. First, slots are allocated among airlines on the basis of enplanements and deplanements per operation and an undefined "re-allocation factor." This factor determines the fraction of current slots that an airline may keep. A number of slots is set aside for new entrants to the market, although the mechanics of determining the number is not explained. Responding to a critic of his paper, Geisinger suggests that "the current thinking is that four slots would be a reasonable number" *(10*, p.7). From the total slots available, those reserved for new entrants and the base allocations of existing carriers are subtracted. The raw allocation is achieved by taking the remainder and dividing it among existing carriers on the basis of their relative shares of enplanements and deplanements per day and their base allocations.

As Brander *(10)* suggested, this approach to the allocation of scarce runway slots is overly protective of the existing carriers. In defence of that criticism, Geisinger argues that "turbulence caused by sudden and drastic changes in allocations would be harmful to everyone" *(10)*. He also notes the investment made by the existing carriers in developing their markets and suggests that gross changes would be bad. The nature of these defences suggests that the protection of incumbents against the inroads of new competition is likely to be a factor of some importance in any administrative allocation mechanism. However, this is equivalent to substituting one form of regulation for another.

The new regulatory system would differ from the old in being hidden rather than open. There would also be less concern with economic factors in making decisions and concomitantly more concern with political ones. If the desire is to maximize the social surplus, any arbitrary approach to the allocation of runway slots is to be avoided.

The fourth option given in Table 2 involves supply side adjustments. On the supply side, for example, it is possible to expand a given airport, or to increase its capacity by changing the rules regarding landing separations and, hence, runway acceptance rates. This expands the volume of flights and, hence, revenue passengers. The option has had an unknown impact on congestion in the absence of information regarding the level of excess demand for existing landing slots. However, supply side adjustments are likely to reduce rather than increase the social surplus in terms of output because the slot constraint shifts to the right. With this supply side adjustment, either the conflict between the airlines and the airport authorities will continue or all economic rents will be dissipated. However, the approach is politically attractive, because of the potential to match the desired number of flights at a hub with its capacity to handle those flights. Conflict between the airlines and airports would disappear, if only in the short run. Supply side adjustments must therefore be rejected because they deal with the consequences of the problem rather than its causes.

TOWARD A PREFERRED ALTERNATIVE

The fifth policy option given in Table 2 allows some agency to estimate the marginal social costs of congestion and to use these estimates as the basis for a set of congestion tolls. Price would thus be used to restrict the demand for landing slots, reducing congestion and increasing both the social surplus and economic rents. However, the number of slots for which such estimates would have to be made is large, being the cross product of the number of airports and the number of slots at each. It is possible to estimate the optimal price for each slot and to perform the necessary reestimations as often as required. Although feasible, this exercise is both time consuming and costly. The auction approach does provide one mechanism by which this can be done: sealed tender bids for each slot being awarded to the highest bidder. Although not all carriers would be completely satisfied with the outcome, and although excess demand for slots might well remain, the approach does provide an efficient solution for the present difficulties. As Koran and Ogur *(9)* have stated with reference to the slot aftermarket, the larger carriers need not dominate such an auction. The ability to pay for a slot reflects the profitability of particular flights rather than carrier size.

In addition to shifting the cost calculations to the airlines, the approach has a second major advantage. It would move the system to the optimal price more quickly than would any successive approximation approach that would have to be employed by government. There is, of course, one risk to be noted that involves the potential for collusion among the carriers in making bids for the slots. However, with open access the market is contestable, as termed by Baumol *(11)*, and this seems to preclude significant amounts of collusion.

At least one auction approach has been proposed. This proposal comes from the Port Authority of New York and New Jersey *(12)*. Under this scheme, slots would be auctioned to the highest bidder. So far there is no problem. The difficulty arises with the notion of refunding the proceeds of the auction at the end of the relevant period on the basis of some performance indicator or other. The rationale for the approach is not entirely clear, but relates to some extent to the desire to re-allocate airline scheduling voluntarily to less congested periods of the day. Because a slot auction process would have this effect by itself, it is uncertain as to why the refundability concept was added.

A final point must be made. Available literature suggests that one problem with congestion pricing is that there is a low cross elasticity of demand between peak and off-peak periods. This is seen as reducing the effectiveness of congestion pricing. To the extent that this is true, it may be necessary to supplement the peak period toll with an off-peak subsidy in order to encourage the necessary traffic diversion. Then, peak period congestion tolls could be used to subsidize the users of the airports at off-peak periods. This would provide additional incentive to move to off-peak periods. The balance of the congestion toll revenue could be used to finance necessary airport improvements.

CONCLUSIONS

Two broad approaches to the congestion problems exist. On the one hand, it is possible to expand capacity and increase slot availability. The foregoing analysis suggests the futility of such an approach. The pressures of excess demand would continue as long as profit opportunities exist. The other solution uses price to ration capacity, and to divert traffic to off-peak periods. Would the airport system be more optimally used with congestion demand management techniques in place? From the foregoing analysis, the answer is clearly yes. Peak load pricing would reduce social cost during peak loading periods, shifting traffic to less congested time slots and, on average, result in improved utilization of the infrastructure. In addition, it would maximize the social surplus in terms of output though some consumer surplus would be transferred to the airlines.

The adoption of the auction approach to the allocation of runway slots would easily deal with the runway slot shortage problem. It would do so in the same fashion as the price mechanism always operates: shortages lead to increases in price and this increase in price decreases the volume demand. The alternatives appear to be a government attempt to establish a market clearing price through some kind of trial and error process, or to take refuge in the arbitrary formula-type allocation process. The former has the potential to work, provided the agency is prepared to hold firm for long enough. The auction approach would get the system to that point much faster. The most significant danger here is the potential for political interference that leads to a reduction in the price in response to the demands of the airline operators. However, the auction scheme is still preferable if it is recalled that another objective is to have the airport operators maximize their revenues. Under the auction approach, each slot would go to the highest bidder. This would maximize the return that could be generated by a given slot. Given the small number of firms involved, collusion is possible. However, it appears that open access would preclude long-run collusion.

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