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An Economic Policy Analysis

by

Donald Koran and Jonathan D. Ogur

Bureau of Economics Staff Report
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ACKNOWLEDGMENTS

The authors wish to recognize the contributions to this report of numerous Federal Trade Commission staff members. Helpful comments on several drafts were provided by Keith Anderson, Neil Averitt, Ronald Bond, Art Cornell, Richard Higgins, Andrew Strenio, and Bruce Yandle. Steven Wanser provided invaluable computer programming services. Delores Munson and Carolyn Samuels gave able statistical assistance. Word Processing was efficiently performed by Betsy Zichterman, Dianne Jones, and Angela Newsome. Finally, the report was carefully proofed by Deborah Ruggles and Annette Shanklin.

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# Introduction

## Overview of the Problems

In the United States, government has the primary responsibility for building airports and the air traffic control system and for operating them to provide services to airlines and travelers. For the most part, these services are provided at zero or nominal prices, with costs paid out of tax revenues. Government supply of these services contrasts sharply with the provision of goods and services by competitive private sellers who charge prices equal to costs.

Government provision of airport and air traffic control services at minimal prices can lead to airport access problems that would not exist if these services were supplied at cost-based prices. First, absent a meaningful price or regulatory restrictions to limit the quantity demanded, congestion occurs at certain times of the day and is especially severe at particular times of the year. Users during these periods incur added costs in the form of lost time and extra fuel burned. Overuse may also raise government's cost of providing service; for example, the Federal Aviation Administration (FAA) has cited peak-hour staffing as "a main cause of air traffic controller burnout" (Aviation Week & Space Technology, 7/26/82, p. 42). In addition to this peaking problem, actual use at all periods (peak and off-peak) is likely to differ from planned levels. In other words, some facilities may remain largely idle while, nearby, others are congested; for example, Dulles Airport appears to be underutilized because airlines prefer National Airport at existing nominal prices for airport and air traffic control services. In addition, use of airports at certain times of the day creates noise that imposes costs on people living nearby. These costs are reflected in reduced property values in the vicinity of certain airports, (Airport Access Task Force, 1983, p. 44).

Thus far, government has generally taken a non-market approach to these problems of airport access. This approach attempts to control use by goverment regulation, which in some cases may operate in conjunction with agreements among private users. For example, since the late 1960's, the FAA has used regulation to limit the number of landings per hour at certain airports. For much of that time, the FAA delegated to a committee composed of the airlines permitted to serve each controlled airport the task of allocating the limited number of landing rights (slots)[1] available at that airport. Thus, all the certificated carriers allowed to provide service to Washington National Airport decided in committee the portion of the limited number of slots that each could use during each hour of the day to which a limit applied. Since the Professional Air Traffic Controllers Organization's 1981 strike, the FAA has allocated slots directly by detailed regulation.[2] In other words, the agency itself has decided the number of slots each carrier may use during each limited hour at the restricted airports.

While the non-market approach to the problem of airport access achieves the benefit of controlling the use of airport and air traffic control services, this approach imposes losses on airlines and travelers. Regulations often cannot distinguish between high-valued and low-valued flights. As a result, some low valued flights are permitted, while other high valued flights are denied access. For example, the FAA probably permits too many landings by small aircraft during peak periods at restricted airports. During those same periods, some large aircraft are denied landing rights, although these flights are probably more-highly valued than flights using smaller aircraft because of the greater number of passengers carried in the large planes. The non-market approach can also create monopoly power, either by regulatory

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1 Except where otherwise indicated, a slot is a right to use the limited navigable airspace, during a specified hour at a specified airport, for the purpose of landing an aircraft. Under present policy, the FAA grants these rights to airlines for the duration of the emergency conditions caused by the air traffic controllers' 1981 strike, subject to certain restrictions which are discussed in Appendix II.

2 When we refer below to the air traffic controllers' strike, we mean the strike by the Professional Air Traffic Controllers Organization (PATCO).

restrictions which limit potential entrants' ability to become actual competitors, or by encouraging anticompetitive agreements among existing providers to exclude potential rivals. For example, airlines find it more costly to enter particular air transportation markets, because current FAA regulations permit trades, but not sales, of landing rights, and (in some cases) because airlines already serving those markets agree in committee to limit the number of rights available to these potential entrants.

Finally, the regulatory approach has great difficulty obtaining the information needed to make decisions about expanding existing facilities. Without meaningful prices, it is hard to estimate the benefits of expanding airports or the air traffic control system and to compare these benefits to the cost of new facilities. Moreover, without meaningful prices to discourage peak period use, expensive new facilities may be required prematurely.

As this study will attempt to demonstrate, substitution of a market approach for the current non-market methods would solve these airport access problems.[1]

Summary of the Study

This study will present an economic policy analysis of the provision of services by airports and by the air traffic control system. Its specific purpose is to compare market and non-market approaches to the allocation of landing rights (slots). The study is divided into four sections.[2] In the next section, we identify and estimate the gains that would accrue to consumers if a slot market were created. These gains would come from elimination of the losses attributable to current FAA regulatory policies. Three types of losses can be identified: the loss that results from

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1 A market approach attempts to simulate the operation of a largely unregulated market, by utilizing the price mechanism to control quantity demanded. This approach is used by government in a number of areas; for example, the federal government auctions rights to cut timber and to drill for off-shore oil.

2 Two appendices contain, respectively, the methodology used to derive our results and a history of the development of the FAA's non-market slot-allocation policy.

giving slots to low-valued flights, the loss resulting from a reduction in competition because potential competitors cannot obtain slots and enter new markets, and the long run loss caused by an incorrect level of investment in airport and air traffic control capacity. We estimate that these losses are in the tens of millions of dollars each year. The third section answers some objections raised about the operation of a slot market: that large airlines and dense markets will buy up slots and that fares will rise. We find these objections unconvincing and present evidence to support our position. The final section contains our conclusions and recommendations. There we urge that, to eliminate the substantial losses caused by present policies, decision makers should consider substituting market methods for existing non-market methods in the allocation of airport access rights.

## The Continuing Problems of Airport Access

At present, the most obvious reason for slot limits is the still incomplete recovery of the air traffic control system from the effects of the 1981 controllers' strike. As that recovery is completed, this reason will disappear. However, the problem of allocating a limited number of slots will remain at many airports. FAA slot limits preceded the controllers' strike at National and three other airports, and limited air traffic control capacity will continue at National and at other airports after the strike's effects have ended.[1] In addition, several airports currently impose limits to access because of noise or because of ground facility congestion (e.g., of baggage handling facilities or ground transportation).[2] For example, some airports in the Los Angeles area have adopted a cumulative noise ceiling (Bailey and

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1 In its recent report to Congress, the Airport Access Task Force concludes that limitations on the number of flights will continue only at National and John Wayne Airports (1983, p. 27). However, minority comments suggest that airport access constraints will be more widespread (p. 40).

2 Congestion and noise are examples of external costs, which are borne by a party who is not compensated for them. The economic literature on airport noise and congestion includes: Levine (1969), Carlin and Park (1970), Graham, Kaplan and Sharp (1981), Walters (1975), Walters (1978), Borins (1978), and Fitzgerald and Aneuryn-Evans (1973).

Panzar, 1981), and National has a 1000 mile limit to the stage length of flights (Airport Access Task Force, 1983, p. 21). Our analysis generalizes to these continuing problems of airport access; however, to apply it to these problems, one should focus on the level of noise, or the number of passengers, rather than the number of landings. In other words, the conclusions we reach about the relative merits of non-market and market approaches to slot allocation will also be applicable to the allocation of the rights to make noise or to board passengers.[1]

Operation of a Slot Market

Before proceeding further we note that there is no apparent reason why a market in landing rights would not work. The simplest way to create such a market would be to remove the current prohibition on cash sales and permit airlines currently holding slots to sell them. Events during the six-week period when the FAA permitted slot sales suggest that a resale market would evolve on its own in such circumstances. During that six-week period, airlines sold over 190 slots, despite uncertainty about how long the purchased landing rights would be valid,[2] and despite the existence of slot barter programs. In addition, at least one firm, National Transportation Research Corporation, initiated a slot brokerage operation. In sum, the FAA's slot sale

1 However, our concern in this study is not to evaluate the number of slots consistent with the present or future air traffic control system or to determine the optimal level of congestion and noise.

2 Although it has not officially done so, the FAA may have the authority to grant property rights in slots as part of its authority to promulgate rules to insure "the efficient utilization of the navigable airspace" (Federal Aviation Act 49 U.S.C. sections 307 (a) and (c).

experiment appears to have generated the beginnings of a successful aftermarket in slots, which was then nipped in the bud by reregulation.[2]

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2 For suggestions on how the FAA might initially allocate slots through an auction, see Grether, Isaac and Plot (1979); Balinski and Sand (1980); and Rassenti, Smith, and Bulfin (1982).

Bidding in a slot auction would be more complex than bidding in most other auctions because the value of a slot is dependent on whether or not complementary slots can be obtained. For example, if an airline would find it most profitable to fly from A to B to C, then the value of a slot at B depends on whether the airline can obtain a slot at C. Moreover the slots at B and C should be separated by sufficient time to permit needed ground activities at B and the flight from B to C, but not by so much time as to force an excessive layover at B.

In another form of initial sales the FAA would set the prices of slots for each restricted time period at each controlled airport and allow the market to determine quantities. This approach is explored by Graham, Kaplan, and Sharp (1981) with respect to National Airport.

## CHAPTER II

### The Benefits of a Slot Market

As suggested above, a slot market could eliminate the losses induced by non-market methods of allocating slots. These losses result from persisting low-valued uses, reduced competition and an incorrect amount of investment in air transportation facilities. In this section, we will present evidence that regulations do not necessarily give slots to the highest valued flights. We will examine the reduction in competition that results because the absence of a market in slots creates a barrier to entry into airline markets. We will also estimate the losses that result from low-valued flights and barriers to entry. Finally, we will describe the way in which an incorrect level of investment results because airports, the FAA, and Congress lack the information needed to estimate the value of use for existing facilities and hence have difficulty judging when to expand capacity in response to excess demand. In each case we will argue that these losses could be eliminated if a market for slots were substituted for the existing FAA regulations.

#### The Loss Due to Low-Valued Uses of Slots

In a market for slots, price would be determined by supply and demand. Assume that the supply of slots continues to be set administratively by the FAA. Demand would be determined by airlines' willingness to pay for slots. The maximum price an airline would pay for a slot is the amount that, when added to the other costs of the flight that will use the slot, equals the flight's expected revenues. This amount is directly related to the value that passengers place on the flight which, in turn, is a function of such variables as passengers' income, purpose of the trip (e.g., business vs. pleasure), and the availability of alternative flights and ground transportation. If passengers value a flight highly, then (other things equal) the airline providing that flight will be willing to pay a relatively high price to obtain the needed slot.[1]

Whether or not slot transactions are permitted, each airline will use its initial allocation of slots in the most efficient manner possible. Through internal adjustments, it will substitute high valued flights for low-valued ones, to the extent possible.[2] Large carriers may have an advantage in this substitution, because their more complex networks may provide added opportunities for these adjustments and may permit them to be made at lower cost. For example, such carriers may already have ground facilities in place to handle the added high valued flight. Even the large airlines' ability to make these internal transactions is limited, however, by the need to coordinate slots geographically and chronologically. Hence, in the absence of slot trading and slot sales, some low-valued flights will continue, while higher valued flights are prevented. In other words, not all of the loss caused by the initial allocation of slots to low-valued flights will be eliminated.

The magnitude of the loss that remains depends on the existence of an aftermarket. If slots could be freely bought and sold among airlines, carriers with high-valued flights would bid slots away from those with low-valued flights. These transactions would continue until the value that passengers place on each flight that obtains a slot is at least as great as the value of each flight that does not obtain a slot. In other words, the loss due to an initial allocation of slots to low-valued flights, or due to declines in the values of flights after they receive slots, would be eliminated. From the airlines' point of view, voluntary transactions would take place in a slot market only if both buyer and seller are made no worse off and at least one (and often both) parties are made better off. The buyer increases his revenues by

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1 Other flight costs are among the other things held equal. For a more rigorous treatment of airline willingness to pay for slots, see Appendix I.

2 If each slot were assigned to a specific city-pair market, such internal transactions could not take place.

using the slot, while the seller receives more money for the slot than he could earn through its use. By forbidding slot sales, the FAA prevents these mutually advantageous transactions and therefore harms both airlines and consumers.

Because the FAA currently permits slot trading (but not slot selling), more low-valued flights are replaced by high-valued flights than if no trades were permitted. However, trading does not allow all possible replacements. For example, small airlines that lack slots to trade may be unable to obtain additional slots, even if there are high-valued flights that they could provide. Also, small airlines that wish to reduce their service in a city-pair market are denied this source of capital to finance their potential entry into another market where they might provide a higher valued service. Opportunities for such small airlines to grow may have to be neglected. In addition, an airline with a slot at A that desires a slot at B may find that no B slot holders want a slot at A. Even if the B slot holder wants a slot at A, he may value his B slot more than the A slot offered to him. While the possiblity of trading slots in other than a 1:1 ratio may permit an exchange in some situations where two air lines place different values on slots, it does not permit an exchange in all such cases. Thus, because the FAA does not allow a resale market, some beneficial transactions are not made.[1]

Evidence that a slot market would permit additional substitution of high valued for low valued flights is provided by the operation of such a market for a six-week period during 1982. Reports filed with the FAA by carriers indicate that over 190 slots were sold, during this brief experiment, despite the simultaneous existence of slot trading programs. Most of the participants in the slot market were small airlines (e.g., new certificated carriers and commuter carriers), which may indicate that the market tended to offset the disadvantage of these

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[1] If trades with cash side payments were permitted, then more exchanges would be possible than without such payments. However, small airlines that lack slots would still be unable to make desirable exchanges.

carriers in slot trading.[1] In most transactions, a commuter carrier sold slots to a larger, certificated carrier.[2] This suggests that the commuter was providing a lower-valued service, which would not have been replaced by the certificated carrier's higher-valued service, in the absence of a slot market.[3]

The six-week slot sale experiment provided only a limited amount of information on the workings of an aftermarket. For one thing, the period of time allowed for this experiment was hardly long enough to allow the entry of service firms that promote efficient transactions, such as sellers of market information, brokers, and providers of credit. Partly as a result, slot price information is not readily available. Second, the useful life of a purchased slot was uncertain, because airlines did not know how quickly the FAA would restore the air traffic control system to its pre-strike capacity. Third, purchases were limited to operating airlines. This eliminated a group that would obtain special benefit from an aftermarket: newly formed airlines that were not yet in operation and that had no slots to trade. It also eliminated banks who might have extended credit for slot purchases and accepted the slots as collateral.

To supplement the information available from the slot sale experiment, we have predicted the outcomes of transactions in a simulated aftermarket for slots at St. Louis.[4] The supply of slots in this market is given by the restricted number of St. Louis slots that the FAA set after the air traffic controllers'

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1 For example, People Express (a new, small, low-fare certificated carrier) almost failed because it lost slots at Newark (its hub), after the air traffic controllers' strike. However, People was able to begin to reestablish its hub-and-spoke system by purchasing slots from other airlines (New York Times, 11/2/82, p. D2).

2 People bought 12 slots at Newark from Princeton Airways, a commuter carrier that subsequently halted its service (New York Times, 7/10/82).

3 As we will argue in section IV., this does not imply that the markets served by commuters would lose all service if a slot market continued. In fact, some commuter airlines bought slots during the sale.

4 For a brief discussion of our selection of St. Louis and a detailed description of the methods used to make these predictions, see Appendix I.

strike. We estimated market demand by estimating airlines' willingness to pay for St. Louis slots and arraying these estimates in descending order. To construct airline willingness to pay, we estimated a cost function for the flight that would use the slot and employed Ippolito's (1981) estimated market demand function for air transportation. Some interesting results obtained from this procedure are presented in Table 1.[1]

The estimated price presented for each hour at St. Louis indicates airlines' willingness to pay for the marginal (i.e., lowest-valued) slot made available by the FAA at that hour. For unrestricted hours, airlines are willing to pay nothing for that marginal slot. In other words, there are enough slots available to permit all flights that wish to land even at a zero price to do so during those hours. For restricted hours, we estimated that slot prices would have ranged from about $100,000 per year between noon and 1 in the afternoon to just over $420,000 per year between 5 and 6 in the evening. These slot price estimates were made using several simplifying assumptions (see the Appendix), some of which introduce bias.[2] Nevertheless, they are in the ballpark of prices reported for actual transactions during the FAA's slot sale experiment. Those reported prices range from about $12,000 per slot,[3] to over $500,000 per slot.[4] Thus, our estimating procedure

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1 Additional results are presented in Appendix I.

2 For several reasons, our estimates are large in relation to the prices that an actual slot market would generate. First our estimates embody the assumption that airlines can charge higher fares for flights during restricted hours without inducing passengers to shift to flights offered during unrestricted hours. Second, the annual estimates were calculated from daily price estimates that reflect the period immediately following the air traffic controllers' strike, when slot scarcity was at its maximum. As a result, the annual estimates are based on the assumption that airlines believed scarcity would remain at that level, rather than declining as the FAA expanded the number of slots. Third, our estimates are based on the assumption that airlines do not engage in slot bartering, which (as suggested above) would eliminate some low-valued flights.

3 People Express bought 16 Newark slots from Princeton Airways for a reported total outlay of $200,000 (New York Times, 7/10/82).

4 American purchased three O'Hare slots from Empire, reportedly in exchange for $1.5 million worth of computerized reservation services and a slot at Kennedy (Washington Post, 6/25/82, p. D1).

TABLE 1

Number of Flights Permitted, Estimated Flight Value Lost, and Estimated Slot Prices by Hour for Certificated Carriers at St. Louis--Non-Market vs. Market Allocation.

| Time of Day | Number of Flights Before Cutback | After Cutback | Value Lost FAA | Market | Difference | Slot Price |
|---|---|---|---|---|---|---|
| | | | (thousands of dollars per year) | | | |
| am | | | | | | |
| 12:00-12:59 | 2 | 2 | 0 | 0 | 0 | 0 |
| 1:00- 1:59 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2:00- 2:59 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3:00- 3:59 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4:00- 4:59 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5:00- 5:59 | 5 | 5 | 0 | 0 | 0 | 0 |
| 6:00- 6:59 | 3 | 3 | 0 | 0 | 0 | 0 |
| 7:00- 7:59 | 6 | 6 | 0 | 0 | 0 | 0 |
| 8:00- 8:59 | 40 | 23 | 1,017 | 913 | 104 | 107 |
| 9:00- 9:59 | 21 | 21 | 0 | 0 | 0 | 0 |
| 10:00-10:59 | 6 | 6 | 0 | 0 | 0 | 0 |
| 11:00-11:59 | 19 | 14 | 1,095 | 708 | 388 | 239 |
| pm | | | | | | |
| 12:00-12:59 | 14 | 12 | 334 | 183 | 152 | 101 |
| 1:00- 1:59 | 33 | 19 | 2,644 | 1,861 | 783 | 189 |
| 2:00- 2:59 | 9 | 9 | 0 | 0 | 0 | 0 |
| 3:00- 3:59 | 28 | 12 | 2,719 | 2,329 | 390 | 259 |
| 4:00- 4:59 | 15 | 15 | 0 | 0 | 0 | 0 |
| 5:00- 5:59 | 34 | 14 | 6,519 | 5,231 | 1,279 | 421 |
| 6:00- 6:59 | 23 | 14 | 1,589 | 971 | 618 | 212 |
| 7:00- 7:59 | 19 | 19 | 0 | 0 | 0 | 0 |
| 8:00- 8:59 | 8 | 8 | 0 | 0 | 0 | 0 |
| 9:00- 9:59 | 9 | 9 | 0 | 0 | 0 | 0 |
| 10:00-10:59 | 12 | 12 | 0 | 0 | 0 | 0 |
| 11:00-11:59 | 3 | 3 | 0 | 0 | 0 | 0 |
| Total | 309 | 224 | 15,909 | 12,196 | 3,713 | -- |

Source: See Appendix I.

* Totals may differ from sums of hourly figures due to rounding.

appears to have produced lost-value estimates of the correct order of magnitude.[1]

As suggested above, airlines' willingness to pay for slots is directly related to the value passengers place on the flights that would use those slots. When the number of slots is restricted, passengers initially lose an amount equal to the value they placed on the cancelled flights. In the long run, passenger losses depend on whether market or non-market slot methods are used to allocate the reduced number of slots.

Table 1 presents estimates of the value lost (in the long run) because of non-market allocation of slots to certificated carriers at St. Louis. After the air traffic controllers' strike, the FAA reduced the total number of flights by certificated carriers to St. Louis from 309 to 226 per day, a 27 percent decrease. Non-market allocation of the reduced number of slots led to a loss of flights which passengers valued at approximately $15.9 million per year.[2] If a slot market had been used to allocate these slots, we estimate that buying and selling would have reduced the value of the lost flights to about $12.2 million per year. The difference, approximately $3.7 million per year, represents the extra loss at St. Louis because non-market allocation gave slots to relatively low-valued flights, and certificated carriers were unable (through internal adjustments or barter) to switch these slots to more highly valued flights.[3]

St. Louis is one of 22 airports whose slots were restricted by the FAA after the air traffic controllers' strike. Thus, the loss due to the persistence of low-valued flights is some multiple

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1 Our estimates are high relative to these reported prices for an additional reason. The reported prices pertain to a period about six months later than that of our estimates. Actual slot scarcity was lower in that later period because the FAA had, in fact, increased the number of slots.

2 Annual totals were obtained assuming 5 flights per week, 52 weeks per year. See Appendix I for a definition of value lost.

3 As suggested by the evidence generated during the six-week slot sale experiment, a greater loss probably results from the use of air traffic control capacity during restricted hours by commuter flights. An even bigger loss may result from general aviation flights during these hours.

of the $3.7 million estimated for St. Louis. Without redoing the same estimation procedure for every restricted airport (a laborious task), we cannot provide a precise estimate of system-wide losses of this type. However, the total loss to passengers, due to airlines' inability to eliminate low-valued flights in the absence of a slot market, is probably in the tens of millions of dollars per year.[1]

FAA slot allocation rules produce another loss associated with flights that become low valued relative to their costs because of a temporary decline in demand. Air transportation markets are highly cyclical, with passenger demand falling during recessionary periods. When the demand for a flight declines to the point where its revenues no longer cover its variable costs (e.g., fuel, flight crew salaries, meals and entertainment), the airline providing the flight will drop it until demand recovers. Moreover, from society's point of view, such flights should be dropped, because the value travelers place on them has become less than the cost, and it is now more efficient to ground the equipment.[2]

FAA slot regulation tends to keep such low-valued flights going during recessions, because slots are allocated to carriers on a use-or-lose basis. In other words, slots revert to the FAA and can be reallocated if not used a specified number of days per week.[3] Airline executives have argued that the use-or-lose provision induces inefficient aircraft utilization and causes carrier

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1 To the extent that passengers are willing to switch from cancelled peak-period flights to flights shifted to off-peak periods, all the loss estimates must be reduced. We do not know the extent of such shifting. Table 1 presents data on the number of flights permitted by the FAA, not on the actual number of flights made.

2 Because the fixed costs of the equipment (e.g. interest) are incurred whether or not the flight is made, they do not enter into the decision to drop the flight.

3 In general, the FAA requires that slots be used four days per week (47 FR 35156, 8/12/82), although it permits seasonal use of some slots (47 FR 43278, 9/30/82).

losses.[1] Instead of dropping flights that no longer cover their variable costs, airlines are induced to continue them (despite the losses incurred), to avoid losing the slot.

The Loss Due to a Reduction in Competition

An interesting feature of the debate surrounding slot allocation is the opposition of most of the major airlines to the idea of buying and selling slots. One possible explanation for this stance is that these airlines fear that the FAA may hold auctions to decide the initial allocation of slots, rather than using the current distribution as the starting point. If this occurred, incumbent airlines would be forced to pay for their current landing rights, which, absent such an auction, they obtain for nothing.

However, even if they were guaranteed their present slot allocation, it might be in the interest of large incumbent airlines to oppose an aftermarket. At first glance this appears illogical since, as suggested above, a carrier would buy or sell slots in the aftermarket only if it were made better off by doing so. The paradox is removed by recalling that large incumbent airlines may have advantages in the absence of a slot market and by recognizing that slot sales may reduce or eliminate the monopoly profits that these carriers might otherwise earn. As described in the previous section, slot sales would permit airlines to substitute high-valued flights for lower valued flights. However, in the absence of a market, some of these substitutions can still be made by internal adjustments and slot trading--in which large airlines may have advantages. More importantly, a large incumbent airline's profits might be reduced by a slot market if, because of a potential rival's slot purchase (or merely the threat of one) the incumbent airline could not raise price as

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1 The Economist, 2/27/82, p. 60 and Travel Weekly, 3/1/82, p. 101, cited in Comments of Muse Air Corporation before the CAB, Docket No. 40545, 4/9/82, pp. 5-6 and New York Times, 11/23/82, p. D2.

much above costs as when that purchase was prevented by regulation. In other words, the absence of a slot market tends to weaken potential competition.

A weakening of competition can occur whether slot reallocation is controlled by detailed regulation, or by agreement among incumbent carriers. Evidence that competition can be inhibited when incumbent carriers control slot allocation is provided by the actions of the carrier committee at Washington National:

> "At the last meeting the dispute was so intense that nine airlines voted against a proposal that would have given each of them exactly the number of flights they wanted. They did so, they said, to keep New York Air and USAir from increasing the number of their flights." (Washington Post, November 8, 1982).

Potential competition can be especially important in air line city-pair markets because there are relatively few actual competitors in most of them. Even in dense markets, estimated average seller concentration is extremely high.[1] Despite this highly concentrated market structure, low barriers to entry discourage incumbents from pricing above costs, since doing so would stimulate entry.

It is evident that the non-market approach to slot allocation can reduce competition in airline markets. If, alternatively, a market approach were taken, it might appear an airline could monopolize an air transportation market through purchases in a resale slot market. The likelihood of successful monopolization by buying slots, however, appears to be very small. While a slot market would facilitate the obtaining of slots by the airline attempting to monopolize, it would be necessary for the airline to obtain most of the slots available at an airport to monopolize any route into that airport. And, the existence of the slot market would also facilitate entry by rivals, if the would-be monopolizer attempted to raise his price.

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[1] In a sample of 5,503 relatively dense city-pair markets representing 92 percent of the passenger trips for the second quarter of 1981, Graham and Kaplan(1982) found a mean Herfindahl Index of 0.77, which is equivalent to 1.3 equal sized airlines. Moreover, the lowest Herfindahl index observed was 0.17, well above the 0.10 competitive ceiling contained in the Justice Department's merger guidelines.

Non-Market Slot Allocation as an Entry Barrier

Absent government imposed restrictions, entry into airline city-pair markets is easy relative to entry into many other industries. Because there are no significant economies of scale in airline operations,[1] carriers can enter a city-pair market at a very small size without incurring higher costs than larger incumbents.[2] In addition, airline costs are not "sunk" in the sense that, on withdrawing from a city-pair market, an airline no longer incurs any costs associated with that market.[3] Because sunk costs are absent, economists describe entry into airline markets as free and exit as costless;[4] markets with these characteristics are called contestable.[5] Such markets exhibit most of the desirable performance characteristics of competitive markets, regardless of market concentration: e.g., price is equal to the cost of providing each service.

Although unregulated airline markets would probably be reasonably contestable, FAA slot regulation has imposed entry barriers.[6] Consider the city-pair market between A and B and assume that the number of slots is restricted at B. If slots could be bought and sold in an aftermarket, a potential entrant into the A to B market could purchase the marginal slot at B and shift its use to the A to B market. In other words, the potential entrant could purchase the slot that was being used by the

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1 The absence of economies of scale with respect to airline size was found by Douglas and Miller (1974), Eads, Nerlove and Raduchel (1969), Pulsifer, Keyes, Eldridge, McMahon and Demory (1975) and White (1978).

2 For a discussion of the effect of economies of scale on entry, see Scherer 1980, pp. 274-75.

3 For a rigorous definition of sunk costs see Baumol, Panzar and Willig (1982, p. 280). Although some airlines enter into long-term leases for airport facilities, subleasing is common.

4 For a discussion of sunk costs as an entry barrier see Baumol, Panzar and Willig (1982, p. 282).

5 For a detailed explanation of the theory of contestable markets, see Baumol (1982), Baumol, Panzar and Willig (1982), Bailey (1981), Bailey and Panzar (1981) and Wentz (1982).

6 Bailey (1981, p. 181) and Bailey and Panzar (1981, p. 134) specifically cite the committee process that was used to allocate slots at National, LaGuardia, Kennedy and O'Hare as a factor that inhibits contestability.

lowest valued flight to B from any point of origin. The slot's price would be its value in its current use. This shifting of the marginal slot would occur whenever an incumbent airline serving the A to B market raised its fare above the level needed to cover the operating costs of an A to B flight, including the price of a slot. A fare above this level would make the marginal slot more valuable for an A to B flight than in its current use.

Because the FAA does not permit slot sales, the potential entrant cannot currently use the marginal slot to enter the A to B market unless he already owns the marginal slot (i.e., he operates the lowest valued flight into B), or he succeeds in trading a slot he holds (say, at C) for the marginal slot at B. Failing to obtain the marginal slot, the potential entrant would have to own or trade for a slot at B that is more valuable in its current use than is the marginal slot. As before, entry into the A to B market will only occur if the value of the needed slot is greater on that route than in its current use. Now however, because the potential entrant would have to enter using a slot that is more valuable than the marginal slot, incumbent airlines can raise the A to B fare above the level that would cover the price of the marginal slot, without inducing entry.[1]

Even if the potential entrant could trade for the marginal slot at B, entry into the A to B market would be more costly than if he could purchase that slot for cash. Transaction costs would be incurred to arrange the trade or trades needed to obtain the marginal slot. Especially if several trades are needed, these transaction costs will exceed the minimal cost of arranging a single cash deal. Without slot sales, entry into the A to B market will not occur unless the fare is high enough to cover the higher transaction costs of slot trades. As a result, incumbents

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1 Entry would occur when the A to B fare covered operating costs plus the value of the needed slot. The difference between the value of that slot and the value of the marginal slot is a measure of the height of the entry barrier created by FAA regulation.

can raise the A to B fare above the level that would cover the cost of buying the marginal slot, without inducing entry.[1]

To see how non-market allocation of slots can create entry barriers in an actual city-pair market, consider its likely impact on potential entrants in the Houston-New Orleans market. Our analysis will be carried out using the relatively restrictive definition of potential entrant that is implied in CAB member Elizabeth Bailey's opinion on Texas International Airlines' bid to acquire National Airlines (Bailey 1981). This definition limits potential entrants to a group of carriers that could most easily enter into the Houston-New Orleans market: those with ground facilities in both cities.

Bailey wrote her opinion prior to FAA extension of slot regulation to the market in question. In it she notes that, even though the merger would have increased the two firm market share in the Houston-New Orleans market from 51 percent to almost 75 percent, the merger would not have had an anticompetitive effect because entry was easy.[2] As evidence, she observes that there were eleven carriers with ground facilities at both ends of the market: five actual competitors and six not yet in the market. Because these potential competitors already had ground facilities, it would have cost relatively little for any of them to enter the market should prices be elevated as a result of the merger. Hence, the amount of price elevation that would be possible would be minimal.

If slots had been restricted at Houston (as they are now), potential entrants lacking slots at Houston would have had to obtain them through trade, or through purchase, if permitted. As suggested above, the absence of a slot market would have increased

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1 In this case the fare can be raised above operating costs by an amount equal to the transaction costs of trading, which would also equal the height of the entry barrier.

2 The Herfindahl Index would have risen from .217 to .347, putting it well within the range that the Justice Department considers potentially anticompetitive.

the fare necessary to induce these airlines to enter the Houston-New Orleans market. Potential entrants that already held Houston slots could have entered by shifting those slots from another city-pair market to the Houston-New Orleans market. However, unless those slots were being used for flights with value equal to that of the lowest flight from any origin to Houston, the fare necessary to induce entry would be higher than if slots were sold in a market. If the flights had a higher value, then a higher New Orleans-to-Houston fare could have been charged by incumbents without inducing entry. If slots had been restricted in both cities the entry barriers would have been even greater, because potential entrants would have needed slots at each city that were reasonably synchronized. In sum, when slots are restricted and cannot be sold in an aftermarket, entry barriers are created and monopoly profits can be earned in otherwise contestable markets.

If FAA slot regulation raises an entry barrier to carriers that already have ground facilities in place, then it is evident that such regulation will also deter entry by less favorably situated carriers. The broadest definition of potential entrant would include anyone with the resources to start an airline. A somewhat less broad definition would include all existing airlines. These two relatively broad definitions are useful ones for purposes of promoting competition in airline markets, because they include among potential entrants some low-fare airlines seeking to expand to new city-pair markets.[1] Evidence that newly certificated carriers play an important role in restraining fares is presented in the next section.

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[1] For example, PSA has been prevented from competing in new markets, in part because of its inability to obtain the needed slots from the bankrupt carrier, Braniff (New York Times, 3/22/83, p. D1).

The Effect of Entry Barriers on Fares

The threat of entry tends to restrain incumbent sellers' pricing behavior in concentrated markets.[1] This has two implications: markets where entry barriers are high should 1) tend to have higher fares and 2) exhibit a stronger relationship between concentration and fares than markets with little or no entry barriers. The higher prices result because entry barriers reduce the likelihood that entry will occur in response to those higher prices. The stronger relationship between concentration and fares arises from the fact that, absent potential competition, the ability to raise fares is more dependent on actual competition. A recent study provides evidence that is consistent with these two implications and with the notion that the non-market allocation of slots is an entry barrier.

Graham and Kaplan (1982) examined the relationship between airline fares and market structure.[2] Included in their model are measures of the following structural variables: distance; the volume of passenger traffic;[3] the Herfindahl Index--a measure of the concentration of actual competitors in the market; the product of the per capita incomes in the city-pair; and dummy variables for tourist markets (defined as those involving Florida, Hawaii, Las Vegas and Reno), markets with newly certificated airlines, and the three cities that had slot constrained airports before the

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[1] F. M. Scherer (1980, p. 266) argues in his classic Industrial Organization textbook that "Long-run substitution and the threat or actuality of entry by new competitors place a ceiling--and sometimes a low one--on producers' pricing discretion." Recent work by Baumol, Panzar and Willig (1982, p. 222) leads them to conclude "Our analysis, if anything, should lend itself to interpretation as a powerful argument for freedom of entry, indeed the mere threat of incursions by entrants into the market, may effectively discipline the monopolist, even if entry is never successful."

[2] Fares are measured by the logarithm of operating revenue per passenger mile.

[3] Since traffic is endogenous they used a two-stage-least-squares technique of regressing traffic against the exogenous variables in the model and then using the fitted value of traffic in the yield equation.

PATCO strike--New York, Washington and Chicago. Their results are presented in Table 2.[1]

The coefficients of the Herfindahl Index are of particular interest; they are positive and significant at the 95 percent level for all five quarters. Of additional interest is the small magnitude of these coefficients for the samples covering the third quarter of 1980 through the second quarter of 1981. If the air transportation markets in the samples were perfectly contestable, concentration would have no effect on fares, because the threat of potential competition would always keep them at the level of costs.[2] The small magnitudes of the coefficient during the pre-strike period indicate that, while the markets are not perfectly contestable, an increase in concentration leads to only a small increase in fare. By contrast, the results for the second quarter of 1982, after the PATCO strike, show a coefficient for the Herfindahl Index that is 1.8 to 2.5 times higher than for the pre-PATCO samples.

From the post-strike increase in the strength of the concentration-price relationship, we can draw inferences about non-market slot allocation as a barrier to entry. The second quarter 1981 (pre-strike) Herfindahl coefficient implies that a city-pair market with a single airline would have fares 8.6 percent higher than a market with four equal-sized carriers. By contrast in the same quarter in 1982 (after the strike), the single airline market would have fares 19.8 percent higher than the market with four carriers. This increase is consistent with the hypothesis that the FAA's post-strike non-market slot allocation created an entry barrier which reduced the contestibility of

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[1] The results for the third quarter of 1980 through the second quarter of 1981 are from Appendix L of Graham and Kaplan (1982). The results for the second quarter of 1982 were provided by Dan Kaplan and Tadas Osmolskis, at our request.

[2] One explanation why some airline markets are not perfectly contestable, absent slot restrictions, is that until recently the different treatment of local service carriers and trunks prevented the trunks from competing with the locals in short-distance markets. See Bailey and Panzar (1981).

TABLE 2

Estimated Relationships Between Market Structure Characteristics and Fares

| Independent Variable | 3rd quarter 1980 | 4th quarter 1980 | 1st quarter 1981 | 2nd quarter 1981 | 2nd quarter 1982 |
|---|---|---|---|---|---|
| intercept | 8.189 | 8.050 | 7.407 | 8.041 | 8.733 |
| ln distance | -.481 | -.463 | -.436 | -.483 | -.498 |
| | (.003) | (.003) | (.003) | (.003) | (.004) |
| ln passengers (fitted) | -.017 | -.012 | -.003 | -.021 | .011 |
| | (.003) | (.003) | (.004) | (.003) | (.005) |
| ln Herfindahl Index | .080 | .078 | .109 | .086 | .198 |
| | (.010) | (.009) | (.010) | (.008) | (.012) |
| newly certificated | -.251 | -.212 | -.205 | -.212 | -.276 |
| | (.010) | (.010) | (.010) | (.010) | (.012) |
| tourist | -.095 | -.073 | -.112 | -.096 | -.060 |
| | (.006) | (.005) | (.005) | (.005) | (.007) |
| ln per capita income | .021 | .012 | .060 | .053 | -.024 |
| | (.009) | (.009) | (.009) | (.008) | (.011) |
| New York | .055 | .046 | .046 | .062 | .020 |
| | (.013) | (.014) | (.014) | (.013) | (.018) |
| Chicago | .008 | .021 | .021 | .040 | .038 |
| | (.011) | (.011) | (.011) | (.020) | (.015) |
| Washington | .063 | .030 | .030 | .041 | .042 |
| | (.014) | (.013) | (.013) | (.018) | (.017) |
| R2 | .889 | .870 | .842 | .868 | .897 |

(Standard errors are in parentheses. The standard errors for the second quarter 1982 results are biased upwards very slightly due to the use of two-stage-least-squares.)

(ln=logarithm)

Sources: Graham and Kaplan (1982) and special model run for 2nd quarter 1982 by Kaplan and Osmolskis.

airline markets and increased the incumbent airlines' ability to exert monopoly power over fares.

Some additional information on the effects of entry barriers which may be created by non-market slot allocation was obtained from the sample of flights that terminate at St. Louis during the seven slot restricted hours. Using Ippolito's (1981) market demand function for air transportation, we derived a demand function for an individual flight.[1] With that function, we obtained estimates of the average fare and passenger volume for flights terminating at St. Louis, during restricted periods under three assumptions about the average height of the barriers to entry: (1) There are no barriers to entry and therefore airline fares are just equal to the cost of providing the service. (This is what would be expected if the sale of slots was permitted); (2) Barriers to entry are moderate and a carrier can increase fares by 10 percent over cost without new entry occurring, and (3) Entry barriers are insurmountable, so that the carriers currently serving a market can charge the monopoly price.

Using these estimated fares and passenger volumes, we developed estimates of the loss to consumers due to barriers to entry created by non-market slot allocation at St. Louis.[2] These estimates are presented in Table 3. If non-market allocation completely blocked entry--permitting incumbent carriers to raise fares to monopoly levels, 48 percent above cost--then the loss to consumers would be about $22 million per year. This estimate is an upper bound of the loss due to barriers to entry into the city-pair markets terminating at St. Louis that are included in our sample. If non-market slot allocation only partially blocked entry, permitting a 10 percent elevation of fares over costs, then the loss would be about $3 million per year. Extrapolating from these results for St. Louis to the effects of barriers to entry

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1 For a detailed description of this procedure, see Appendix I.

2 For the derivation of these consumer-surplus loss estimates, see Appendix I.

into all restricted markets, it appears that non-market slot allocation is costing consumers tens of millions of dollars per year.

TABLE 3

Estimated Loss by Hours Due to Barriers to Entry Created by Non-Market Slot Allocation at St. Louis

| Time of Day | Entry Barrier Moderate | Entry Barrier Insurmountable |
|---|---|---|
| | (thousands of dollars per year) | |
| am | | |
| 8:00 - 8:59 | 195 | 1,682 |
| 11:00 - 11:59 | 378 | 2,808 |
| pm | | |
| 12:00 - 12:59 | 106 | 916 |
| 1:00 - 1:59 | 682 | 4,631 |
| 3:00 - 3:59 | 567 | 4,259 |
| 5:00 - 5:59 | 538 | 2,688 |
| 6:00 - 6:59 | 614 | 4,977 |
| Total* | 3,079 | 21,962 |

Source: See appendix.

* Totals may differ from sums of hourly figures due to rounding.

The Long-Run Loss Due to Investment Errors

The discussion has so far been based on the assumption of a fixed number of slots available at each airport. In the long run, air traffic control capacity can be expanded.[1] As suggested above, the non-market regulatory approach to allocating the services of this capacity does not provide a good measure of the value of these services. Without such a measure it is extremely difficult for decision makers to determine whether the costs of added capacity are justified. The prices generated by a slot market would provide such a measure and would signal when more capacity was needed. If, in addition, the ownership of any newly created slots were given to the FAA, or to the local airport authority if they undertook the investment that allowed the creation of the additional slots, the revenue earned from selling

[1] With minor modifications, this discussion can be applied to airport services (e.g. of runways and terminal facilities). In that case ownership rights to those services should be held by the airport authority.

the slots would provide investment funds to build added air traffic control capacity.

In a competitive market for slots,[1] the price would equal the cost of air traffic control services for an additional landing. If air traffic control capacity were fully utilized during peak periods, then the price would be higher during those periods than during off-peak hours.[2] By encouraging the shifting of low-valued flights to off-peak times, this price difference would delay the need to make expensive additions to capacity as the number of flights increases in response to the growth of traveler demand.

To attain the correct level of air traffic control capacity, the FAA should adopt the rule of expanding capacity at any airport where profits are being earned on slots (i.e., the revenue from the slots exceeds the cost of providing service). In the absence of increasing returns to scale, this would allow the air traffic control system to be self financing in the long run, while eliminating losses due to low-valued flights and barriers to entry and providing for the correct long run level of capacity.[3, 4]

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1 The economic literature on airports deals primarily with the question of runway capacity. For a general analysis of the pricing and capacity decisions in that context see Levine (1969), Carlin and Park (1970), Fitzgerald and Aneuryn-Evans (1973), Borins (1978), Borins (1979) and Walters (1978). For the problem of pricing uncongested airports (i.e. in the face of economies of scale) see Morrison (1982) who examines Ramsey pricing possibilities when a break-even constraint is added.

2 Ignoring non-capacity costs, the price of a landing right during an off-peak period would be zero. Current landing fees probably do not accurately reflect air-traffic-control costs. Nevertheless, these fees are likely to indicate the correct order of magnitude. For this purpose, we have calculated the landing fee for a 727-200 at St. Louis to be approximately $128.

3 If, however, the provision of air traffic control services is a natural monopoly (i.e., economies of scale continue no matter how large the system is expanded), a competitive slot market would lead to long run losses for the FAA. This would necessitate a subsidy of the agency's air traffic control operations. However, the subsidy would be smaller than the total level of expenditure for the air traffic control system by the amount of revenue obtained from selling slots.

4 The results presented in Table 1 provide some information on the revenues obtainable from the sale of slots at St. Louis. For the post-cutback number of flights and the estimated slot price at each restricted hour, the air traffic control system could earn over $23 million per year for St. Louis slots.

## CHAPTER III

### Some Arguments Against A Slot Market

In the preceding sections, we have presented evidence on the gains that could be obtained through a market approach to slot allocation. However, as suggested above, this approach has also generated controversy, focusing on the questions of which airlines and which city-pairs would be most likely to obtain slots in a market and on the extent to which slot prices would be passed on to consumers. For example, former Secretary of Transportation Drew Lewis has argued that:

> "With regard to the auctioning of landing rights (at National Airport), we believe this would not be in the best interests of the industry or the public. ...
>
> The auction process could...work to the detriment of the consumer. Our experience with slot allocations in the aftermath of the air traffic controller strike suggests that, while some means had to be devised to assure equitable distribution of slots among competing carriers, the buying and selling of those slots tended to benefit the high bidders, not necessarily the traveling public. The largest carriers, serving the high density markets, have the cash resources to outbid the smaller carriers serving the lesser markets. The travel options available to the public would therefore be limited, if not curtailed, and almost certainly the airlines would pass the higher costs along to the public." (Letter to David Stockman, December 17, 1982.)

These concerns are addressed in this section. Specifically, we examine the following questions about the operation of a market for slots:

- Would large carriers tend to bid slots away from small ones?
- Would high density markets tend to bid slots away from low density markets?
- To what extent would the buying and selling of slots at market prices cause higher costs to be passed on to the public?

<u>Would Large Airlines Dominate Slot Buying?</u>

In a slot market, airlines with a high willingness to pay for slots would be net buyers. Other things equal, an airline will be willing to pay a high price for a slot if it expects to use that slot for a relatively high-valued flight. Despite former

Secretary Lewis' suggestion of the importance of cash resources, an airline would not buy a slot in order to operate a flight that is expected to have a relatively low value, simply because it has the cash to do so. Moreover, a carrier that expects to use a slot for a high-valued flight, but does not have sufficient cash resources to pay for that slot, should in most instances be able to raise the needed capital by selling stock, or by borrowing. In principle, a slot purchase is like any other investment, and would sometimes be made in conjunction with complementary investments in equipment and ground facilities to initiate a planned new service. Capital markets exist precisely to evaluate such investments and to provide funds for those that appear sufficiently attractive.[1] If small carriers are able to finance equipment purchases, then they should also be able to finance the complementary slot purchases.[2]

The ability of a carrier to finance slot and equipment purchases depends in part on the carrier's past performance. One frequently used indicator of performance is the rate of return on equity. The data in Table 4 show that there is little or no relationship between size and this measure of airline profitability. In fact, the twelve largest carriers had a combined loss for 1982. Moreover, their rates of return were worse than those of the next largest group in both 1981 and 1982 and were the worst of any size group in 1982. To the extent that slot purchases can be financed like other investment outlays, the empirical evidence suggests that the more profitable smaller carriers would be no

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[1] An airline that is already heavily in debt because it has financed previous risky investments may find it harder to borrow the additional funds than another airline that is more conservatively financed. This suggests that debt/equity ratios may have more influence on slot purchases than the level of current assets. However, if banks were permitted to own slots, then they would probably accept them as collateral, and the problems of such airlines would be lessened.

[2] An example of a small airline's ability to borrow large sums is provided by People Express' $22.5 million credit agreement with Bank of America and four other banks, to finance the purchase of used aircraft from Canadian Pacific Airlines (Wall Street Journal, 3/22/83, p. 8).

less likely to obtain slots in a market than the largest carriers.[1]

TABLE 4

Operating revenues and operating Profit/Equity by Carrier Group

| Carrier Group | Operating Revenues (millions of dollars per year) | Operating Profit/Equity 1981 | Operating Profit/Equity 1982 |
|---|---|---|---|
| | | (percent) | |
| Majors | over 1,000 | 0.3 | -16.5 |
| Nationals | 75-1,000 | 15.8 | 2.4 |
| Large Regionals | 10-75 | -3.7 | -1.6 |
| Medium Regionals | under 10 | * | 8.1 |

Source: CAB, Air Carrier Financial Statistics; June, 1982.

* In 1981, medium regionals had a loss of $5.8 million on net equity of minus $9 million.

Some added evidence on the probable effects of a slot market on large and small carriers is found in Table 1. After the air traffic controllers' strike, the FAA restricted the number of slots at St. Louis during only seven hours of the day. In other words, it appears that additional flights could have been handled by the restricted air traffic control system during a majority of the hours. Such excess capacity would have important implications for the operation of a slot market. For example, slots would be free at St. Louis for 17 of the 24 hours each day. Thus, even assuming that a carrier were unable to purchase a slot, it could continue to provide service by switching the time of its arrival to an unrestricted hour. In addition, even during the restricted hours, we estimate that the price of a slot at St. Louis would

[1] The extent of slot buying and selling during the six-week experiment provides evidence that, despite their recent difficulties, airlines are in a financial position to buy slots. Nevertheless, any remaining concerns could be addressed by giving airlines free use of slots, with that use being marketable, for some fixed period of time. At the end of that time, if the financial health of the airlines has improved sufficiently, the slots would revert to the FAA for sale.

range from $100,000 per year to $420,000 per year.[1] It is hard to imagine that many certificated carriers would have trouble paying such a price. In fact, these prices are small in relation to the outlays that even small airlines currently make with borrowed funds for equipment expansion.[2] Nevertheless, any airline that was unwilling to pay one of these prices would have the option of shifting its arrivals to an unrestricted hour.[3]

Would Airlines Serving Dense Markets Dominate Slot Buying?

The assertion that carriers serving dense city-pair markets would dominate slot buying is misleading. Although (almost by definition) dense markets are those with a large demand for air transportation, they also tend to be served by more flights.[4] Other things equal, the large demand increases the willingness of airlines that serve these markets to pay for slots. However, the existence of many flights tends to decrease these carriers' willingness to pay for slots to provide additional flights. The net impact of these opposing influences on the willingness to pay of carriers serving dense markets is unclear.

If slots were sold in an aftermarket, dense city-pair markets would almost certainly obtain more slots than thin city-pair markets--a result that also occurs under non-market slot allocation. However, it is not obvious that a slot market would transfer additional slots from thin to dense city-pair markets. If such a transfer occurred, it would indicate that non-market slot allocation had given excessive (and therefore relatively low-valued) slots to thin markets. Moreover, even if a slot market

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1 For purposes of this calculation, we assume 260 flights per year. On a per-flight basis, estimated slot prices range from $389 to $1,621.

2 For example, People Express has agreed in principle to buy approximately $80 million worth of aircraft from the bankrupt carrier, Braniff, and to finance the purchase through its "normal bank group" (Wall Street Journal, 3/22/83, p. 8). Also, Pacific Southwest Airlines has agreed to purchase four aircraft from Air Canada for $24 million (Wall Street Journal, 4/20/83, p. 33).

3 It seems likely that some general aviation and some commuter flights would shift to off peak hours.

4 For a rigorous analysis of the effects of density and number of flights on airlines' willingness to pay for slots, see Appendix I.

caused a transfer of slots from thin to dense markets, it does not follow that thin markets would have fewer flights. As indicated in Table 1, slots at many hours of the day are likely to remain free, even with a slot market. As a result, low-valued flights serving thin markets could continue by shifting to the unrestricted hours of the day.

Air Service to Small Communities

Air transportation markets tend to be dense to the extent that they serve large, high income, or widely separated cities.[1] Conversely, markets serving small, low income, or closely located cities tend to be thin. As a result, our conclusions about the relationship between density and airlines' willingness to pay for slots have important implications for any efforts to maintain air service to small communities.[2] Because of the small size of these cities and to the extent that the flights serving them are short distance, the willingness of airlines serving them to pay for slots will be relatively low. As a result, these airlines might be outbid for some slots by airlines serving denser city-pair markets. However, to the extent that the air service currently available in the small communities consists of infrequent flights, then the airlines serving these cities might bid some slots away from airlines serving larger cities. Moreover, as suggested above, airlines serving small communities could maintain the same number of flights by shifting some of them to off-peak hours.[3]

A plan to preserve the level of air service desired by small communities was suggested by Robert Frank (1980). Under this plan, slots at constrained airports would be vested in the origin city and a market for slots would be allowed. The communities

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1 For a derivation of the relationships between these variables and market density, see Appendix I.

2 The Sec. 419 subsidy program is designed to provide small communities with air service deemed by policy makers to be essential.

3 Nevertheless, if policy makers decide to increase the level of peak-hour air service to small communities above the level that would arise out of a slot market, the existing Sec. 419 program could be used to subsidize slot purchases.

receiving initial endowments of slots would then be allowed to sell the slots if they so desired. If small communities really do place a high value on air service they could keep the slots. By contrast, if the value were not as great as the benefits that they would derive from more revenues, they could sell or lease the slots. In sum, the choice would be in the hands of the small communities and could be delegated to their elected representatives, or to local airport authorities.[1]

When considering the effect of a slot market on service to small communities, it is important also to consider the impact on those cities of non-market methods of allocating slots. The FAA and carrier committees allocate slots to airlines, not to the communities served. The airlines receiving the slots may use them to serve any market that they choose. If it is more profitable to serve large cities, the current system will not guarantee service to small cities. In other words, the present non-market approach to allocating slots does not preserve the level of air service to small communities that Congress desires; hence, the current subsidy program.

Would A Slot Market Result in Higher Fares?

Contrary to the assertion of Secretary Lewis, creation of a slot market would not result in a general increase in the level of airline fares. While fares might rise on some routes, they would fall on others. What Secretary Lewis failed to recognize is that the prices which would be paid for slots if a market existed would only be a reflection of the value of the existing scarcity of slots. That scarcity is not created by the slot market, it is created by the FAA's restriction on the number of landings permitted at an airport, at least during some parts of the day. That scarcity will cause airline fares to be higher than otherwise whether or not there is a slot market. The higher level of fares occurs because not all persons wishing to take flights that terminate at a slot-restricted airport can be accommodated at the

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[1] One danger in giving slots to a local authority is that the uses of those slots might be determined by a politically powerful minority in the community.

time they wish to fly. As a result, airlines will be able to raise the fares they charge on flights into a restricted airport.[1]

Evidence that fares are higher on routes involving a slot-constrained airport, is found in the Graham and Kaplan study discussed above (Graham and Kaplan, 1982). As presented in Table 2, the 15 coefficients of the constrained airport dummies are positive, and 14 of them are significantly different from zero at the 95 percent level. Thus, although the airlines using the scarce slots did not pay for them, fares are higher in city-pair markets where one or both ends are slot-constrained cities than in other city-pair markets, all else equal.

A similar study was conducted by Diana Strassmann (1982). She used first quarter 1981 data to test for the relationship between the markup of both coach and average fares over the Standard Industry Fare Level (SIFL) and: the volume of passenger traffic; a dummy variable indicating whether the market is primarily a connecting market, as opposed to a turn-around market; a dummy variable indicating whether one or both cities has a slot constrained airport (i.e., New York, Chicago and Washington); and a dummy variable for markets of over 1000 miles. She found that slot constrained markets had coach fares that were 30 percent higher than other markets and average fares that were 20 percent higher. These results corroborate those of Graham and Kaplan.

In sum, the empirical evidence is inconsistent with the notion that the scarcity of slots is reflected in fares only when airlines must pay for scarce resources. Fares were higher in restricted markets even though slots were allocated by regulation and carrier committees.

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1 That slots are more highly valued during some parts of the day than at others might or might not mean that fares differ by time of day. Some airlines have begun to charge higher fares on flights during the business day than they charge for evening and weekend flights. That fares are not more finely tuned to the scarcity of slots is more likely due to the transaction costs involved in an airline having many different fares on flights between the same cities, than because airlines do not pay for the slots they use. Since these transaction costs would not be decreased by the creation of a slot market, we would not expect more variation in fares if a slot market was created.

What then would happen to fares if the sale of slots were permitted? The answer to this question depends on whether the number of slots used for flights serving a city-pair market changes when a slot market is created. If the number of flights serving a market were unchanged after slot sales were permitted, then fares on that route would not increase; they would either fall or remain constant. Because actual competition tends to be weak in air transportation markets, it is probable that fares on such routes would fall as the creation of a slot market increased potential competition and eliminated entry barriers.

On routes which gained flights when the sale of landing rights was permitted, the likelihood that fares would fall is even greater. In addition to the elimination of entry barriers, increasing the number of flights serving the market would increase the number of passengers who could be served and lower fares.[1]

Only on routes which lost flights after the slot market was created would there be a significant likelihood of fares increasing. It is not, however, certain that fares would rise even on these routes. The elimination of entry barriers would create pressure to lower fares even in these markets. On the other hand, the reduction in the number of flights serving the market would tend to move fares in an upward direction. If fares did rise, however, it would be because non-market slot allocation had provided excessive slots to low valued flights in these city-pair markets, while denying slots to more valuable flights in other markets.

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[1] In unusual instances, fares might rise in city-pair markets that obtained added slots. See Appendix I for a detailed discussion of this result. In brief, this could occur if economies of scale with respect to aircraft size were very important. No conclusive evidence exists on the effect of aircraft size on long-run average cost. Further, in any instance when fares did rise after the addition of more flights, we could conclude that the greater convenience created by the additional flights was worth more than the increase in fares.

## CHAPTER IV

### Summary and Conclusions

In this study we have presented estimates of the losses induced by non-market allocation of airport landing rights that are in the tens of millions of dollars per year. We have argued that losses arise because similar allocation methods are applied to the problems of noisy aircraft and of congested ground facilities. We have also argued that the use of a market to allocate slots would eliminate the losses caused by non-market slot allocation. As a result, we strongly recommend that decision makers give serious consideration to the substitution of market for non-market approaches to the problems of noise, ground congestion, and air traffic control limits.[1]

The current non-market slot allocation system results in three kinds of losses. First, slots are allocated to low-valued flights. Trades can substitute high-valued flights for them only by imposing relatively high transactions costs on airlines. By contrast, a slot market would insure that slots go to the highest valued uses, at relatively low transactions costs. The second, and potentially much more important, problem with the non-market system is that it reduces competition in the airline industry, by creating a barrier to entry into city-pair markets. A slot market would eliminate these barriers to entry. Third, non-market slot allocation denies needed information to decision makers when they are considering air traffic control system expansions. Moreover, because non-market allocation provides inadequate incentives to shift flights to off-peak periods, expensive additions to air traffic control capacity are required prematurely. By providing a measure of the value of air traffic control services and by encouraging shifting of low-valued flights to off peak periods, a

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1 In minority comments on the report of the Airport Access Task Force, the Departments of Justice and Transportation have proposed a market approach to these problems (1983, pp. 37, 43-47, 106, and 120). By contrast, the majority of the Task Force gave short shrift to that approach (see, for example, pp. 25-26).

slot market would permit better-informed and better-timed expansion decisions.

In this study we have also responded to three objections raised to the creation of a market for slots. First, we have argued that large airlines would not dominate slot buying; small, profitable airlines would compete effectively for slots. Second, we have argued that all slots would not be used to serve dense markets. Rather, some slots would be devoted to serving thin markets, as would flights shifted to off-peak periods. Finally, a slot market would not cause most fares to rise. To the contrary, the elimination of barriers to entry would cause most fares to fall. Fares might rise in markets to which the FAA had allocated extra slots that were being used for low-valued flights, if economies of scale in city-pair markets are unimportant.

In addition, we have argued that present non-market methods of allocating slots do not assure the preservation of a minimum level of air service to small communities: hence the existing subsidy system. This system would mesh well with the operation of a slot market, because the amount of subsidy would be viewed by the airline receiving it as profit. Hence, the subsidized airline's willingness to pay for slots would increase by the amount of the subsidy.

The use of a non-market approach to slot allocation represents the reregulation of an industry about which Congress expressed its clear intent to pursue a deregulatory policy in the Airline Deregulation Act of 1978 (Public Law 95-504, 92 Stat. 1705). Moreover, the barriers to entry that non-market allocation creates are in direct opposition to the Congressional decision to "...[place] maximum reliance on competitive market forces and on actual and potential competition" to organize economic activity in the airline industry (92 Stat. 1706). Because non-market slot allocation weakens competition and imposes losses on society, consideration should be given to adopting market allocation of slots, which would promote competition and eliminate these losses. Because the non-market approach to slot allocation has these drawbacks, we also consider its use ill-advised for other airport access problems, such as noise and ground facility congestion. Instead, we urge that a market approach to these problems also be given serious consideration.

## APPENDIX I

### An Evaluation of a Slot Market

A-1: Introduction

The restrictions on aircraft landings that resulted from the Professional Air Traffic Controllers' Organization (PATCO) strike in early August, 1981 had a severe impact on the nation's air transport system. In reducing the number of landings during peak hours at 22 major airports the Federal Aviation Administration (FAA) was faced with the problem of allocating the limited landing rights (slots) to the airlines. In this appendix, we attempt to evaluate empirically the effect of the FAA's policies. Specifically, we examine the FAA's prohibition of slot sales.

Since we are unable to observe how a market for slots would operate,[1] we cannot compare the actual outcome of a market allocation to the FAA's administrative allocation. However, we can make some inferences about how a market would operate which allow us to evaluate the effects of the FAA's prohibition of a slot market.

In order to examine a market for slots we must examine both the supply and demand for slots. The supply of slots is determined administratively by the FAA which is charged with insuring the safe and efficient operation of the Air Traffic Control system. In the short run, the supply is fixed, regardless of the slot price.

The demand for slots is more difficult since we cannot observe it directly. However, we do know that the demand for slots, like the demand for all other factors of production, is a derived demand.[2] In other words, the demand for slots depends on the market for air transportation. Since the market for air

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[1] A market for slots was allowed on an experimental basis for six weeks. Unfortunately, the market was hampered by uncertainty as to the future of slot allocation and the need for FAA approval of all sales. In addition, no data on the price of slots that were sold on the market are available. Thus little information as to how a freely functioning slot market would behave is provided by the experiment.

[2] For a general discussion of input demand functions, see Henderson and Quandt (1971, ch. 3) and Varian (1978, ch. 1).

travel is observable, we can use information based on the market for air travel to evaluate the demand for slots.

Ideally, we would like to examine the market for slots at all 22 airports that were restricted as a result of the PATCO strike. Time and resource limitations make that impossible. Instead, we have chosen one airport, St. Louis (Lambert International), to study. We make no claim that St. Louis is typical or representative of the 22 airports although we know of no reasons to believe that it is not.[1]

In this appendix, we estimate the demand for landing slots at St. Louis based on what we know about the demand and supply (i.e., cost) of air travel to St. Louis.[2] Having estimated the demand for slots, we can make inferences about how a slot market would perform. Specifically, we can evaluate two potential welfare losses that may arise from prohibiting a slot market. The first welfare loss results from the administrative allocation itself. If the FAA does not give slots to the airlines that are in the best position to use them, a slot market would allow airlines that have slots but are unable to use them in an efficient manner to sell the slots to airlines that can best use them. By not allowing such transactions, any initial misallocation of slots

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1 For the purposes of our study, St. Louis had two important characteristics. First, it had not been restricted before the PATCO strike. Thus, unlike New York, Washington and Chicago, pre-strike air travel to St. Louis was not affected by the FAA's High Density Airport Rule. Second, St. Louis has relatively little international travel. Since data on international travel are not as complete as those available for domestic travel, we felt it best to minimize the effect of international travel on slot demand.

2 Since the starting point of our analysis is the economic literature on air travel, it is incumbent on us to mention two of the most important weaknesses of that literature. First, the airline literature uses city-pairs as the relevant market. To the extent that passengers connect from one market to another and the availability of aircraft for use in a city-pair depends on its use in another, this market definition is flawed. The second major problem in dealing with airlines is defining the price. On most flights there is a plethora of fares. The choice of which fare to use in empirical studies is therefore fraught with problems. In order to make analysis of slot demand tractable, we follow the literature on airlines in assuming that each city-pair market is independent of all other city-pairs and that one fare prevails for each flight.

is maintained. The other welfare loss arises if the prohibition of a slot market introduces a barrier to entry into airline markets. Barriers to entry prevent the competitive workings of airline markets and may result in higher air fares than would otherwise exist. In addition to examining these potential welfare losses, our analysis sheds light on an important distributional question, namely: what type of flights would be least likely to continue if a slot market were allowed?

In the next section, we derive the demand for landing slots from the demand and cost functions for air travel. We find that an airline's demand for slots is independent of its ability to set fares above costs. Our derivation of the demand for slots allows us to estimate the demand for slots from estimates of airline demand and cost functions. We estimate the demand for slots by flights into St. Louis in July, 1981 (i.e., before the PATCO strike).[1]

In the third section, we examine how market characteristics such as population, flight frequency and distance affect the demand for slots. Using our sample of St. Louis flights we are able to address the often expressed contention that flights in dense markets would be able to outbid flights in thin markets if slot sales were allowed.

In the fourth section we examine the welfare loss associated with a misallocation of slots. Our estimates of the demand for slots at St. Louis allow us to compare the estimated welfare loss resulting from a reduction in available slots under the FAA's allocation of slots to the welfare loss that we predict would have resulted if a slot market had been permitted.

If the prohibition of a slot market reduces potential competition in airline markets, airlines would be better able to exert monopoly power. This would result in higher fares and restricted

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[1] The sample used throughout this appendix consists only of domestic, non-stop, passenger flights by certificated carriers. International flights, commuter flights, and cargo flights are excluded due to data limitations. These other types of flights represent less than 18 percent of flights into St. Louis for the six months prior to the PATCO strike.

output and hence a welfare loss. In the final section we attempt to quantify the welfare loss that would result from such an increase in fares for flights into St. Louis.

A-2: The Derivation of the Demand for Slots

An airline's willingness to pay for a slot for a particular flight depends on the revenues that would be realized from the flight and the other costs of operating the flight. Thus, anything that affects a flight's demand and costs, and hence its profits and fares, would also affect its demand for a slot.[1] We can therefore derive the slot demand from the underlying airline demand and cost functions.

The rest of this section is devoted to estimating the willingness to pay for slots for flights into St. Louis. We first specify demand and cost functions. Then, using those functions, we derive the willingness to pay for slots by a flight that is free from the threat of entry. This willingness to pay is expressed as a function of exogenous variables. We then show that this maximum willingness to pay is the same as that obtained under the assumption that the flight faces the threat of instantaneous entry.(i.e the market is contestable).

Airline Demand

The first step in estimating a flight's willingness to pay for a slot is specifying the flight's demand and cost functions. Unfortunately, the lack of adequate flight specific data prevents

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[1] A flight's willingness to pay for a slot is the maximum amount that an airline would pay for a slot required by that flight. The flight's demand for the slot is the number of slots that the airline would purchase for the flight at each price. Since the flight would purchase either one or zero slots, we can think of the willingness to pay for slots as the inverse of the demand for slots. In other words, at a price equal to the flight's willingness to pay, the flight demands one slot and its maximum willingness to pay for one slot is that price. Since the terms willingness to pay and demand convey the same information, we can use them interchangeably.

the estimation of flight demand functions.[1] There is, however, an extensive literature on city-pair demand functions (e.g., Abrahams (1981), DeVaney (1974), Ippolito (1981), Olson and Trapani (1981 and 1982), and Verleger (1972)). For our purposes, Ippolito's demand function is most suitable.[2] It is:

(1) $Q = A \exp(bP2)\, N^{\beta}\, L^{\gamma}$

where: $A = \exp(\lambda_0)\, D^{\lambda_1}\, X^{\lambda_2}\, Y^{\lambda_3} \exp(\lambda Z)$
P = price
N = the number of flights in the market
L = the market load factor
D = the market distance
X = the product of the populations of the two cities
Y = the simple average of the per capita populations of the two cities
Z = a vector of dummy variables (see Table A-1)
$\beta$, $\gamma$, $\lambda_0$, $\lambda_1$, $\lambda_2$, $\lambda_3$ and $\lambda$ are constants.

In order to convert the demand for air travel for a city-pair market into the demand for air travel on a particular flight, we assume that passengers are highly sensitive to arrival time. Specifically, we assume that passengers fly on the most convenient flight available, regardless of fare differences between flights.[3] This assumption implies that each flight has a monopoly over some

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1 Ideally, we would estimate the flight demand function (or at least the city-pair demand function) for our sample of flights into St. Louis in July, 1981. Unfortunately, we are unable to do so because, since airline deregulation, we are unable to observe the fares that passengers actually pay. The use of the coach fare or some measure of average fares is appropriate when passengers on each flight pay the same fare or when the fraction of each type of fare is the same on each flight. Since this is no longer the case, we are unable to estimate the demand due to inadequate fare data. We know of no estimates of demand functions using data for the post-deregulation period.

2 Among the features that we believe are important for obtaining good estimates of a demand function that are inherent in Ippolito's study are: (1) the possibility for fare elasticity to vary with distance (the relationship between fare elasticity and distance is discussed in Section A-3); (2) the inclusion of load factor and flight frequency as a quality of service variable; and, (3) the use of two-stage-least-squares to account for the endogeneity of load factor and flight frequency.

3 While this assumption is obviously not realistic, the empirical results in section A-3 do not depend on it. In fact, we obtain identical results under the assumption that passengers are completely indifferent to arrival time. The empirical results in sections A-4 and A-5 do depend on this assumption. We therefore discuss the effects of relaxing the assumption in those sections.

fraction, $\delta$, of the potential passengers in the market.[1] We can express the demand curve of a flight as

(2) $q = \delta Q = a \exp(bP^2) N^{\beta} L^{\gamma}$

where $\delta$ = the flight's share of city-pair demand[2]
$a = \delta A$.

Ippolito's estimates of the coefficients of the market demand function, equation (1), are presented in Table A-1.

Airline Costs

Prior studies of airline costs (e.g., Douglas and Miller (1974), Eads, Nerlove and Raduchel (1969), Pulsifer et al. (1975), and White (1979)) found no economies of scale with respect to airline size. In other words, large airlines, on average, do not appear to be any more or less efficient than small airlines. However, we know of no studies of economies of scale at the city-pair market level.[3] Thus we do not know to what extent dense markets are served at a lower average cost than thin markets.

Bailey and Panzar (1981) offer the presence of economies of scale in aircraft size as an argument in favor of the existence of

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1 Our analysis could be made without assuming highly time sensitive passengers. Under the Loschian model of spatial competion, firms assume that their market shares are fixed. This assumption implies that firms match other firms price changes (i.e., the conjectural variation is one). Thus, instead of assuming time sensitivity in order to hold market shares constant, we could assume constant market shares and explain the assumption based on Loschian price behavior. For a comparison of various assumptions concerning market shares in spatial models, see Capozza and Van Order (1978).

2 Since the diurnal distribution of passenger demand is not necessarily equal to the distribution of flights, the market shares of flights in a city-pair are not necessarily equal. One possibility for obtaining the flight demand function from the city-pair demand function is to let $\delta$ equal each flight's share of passengers in the market. However, we observe that some of the peak in demand is reflected in the form of higher fares for peak period flights. Thus, demand for peak period flights is higher than would be indicated by passenger shares. Since the higher demand would affect the flight's willingness to pay for slots, we take account of it for empirical purposes by letting $\delta$ equal each flight's share of market revenues--as opposed to market passengers. Revenue shares are based on each flight's total passengers and the coach fare (or night coach fare when appropriate).

3 The major problems inherent in estimating city-pair economies of scale are the lack of city-pair specific cost data and the endogeneity of density and service quality.

TABLE A-1

Ippolito's Estimates of The Determinants of the Demand for Air Travel#

| Variable | Coefficient | t-value |
|---|---|---|
| constant ($\lambda_0$) | -26.04 | 3.14 |
| N ($\beta$) * | .755 | 3.03 |
| L ($\gamma$) * | -.854 | 1.68 |
| P2(b) | -.000105 | 2.56 |
| D ($\lambda_1$) | .733 | 2.35 |
| X ($\lambda_2$) | .336 | 2.71 |
| Y ($\lambda_3$) | 2.35 | 5.05 |
| dummy variables: | | |
| 0-100 miles | -2.09 | 4.17 |
| 100-200 miles | -.258 | .99 |
| Las Vegas | 1.94 | 6.22 |
| Florida | .258 | .80 |
| California | .334 | 1.36 |

# Two modification are made before these estimates are used with the values of the exogenous variables in order to estimate 1981 daily flight demand. First, a is multiplied by 10 and divided by 365 to reflect Ippolito's use of a ten percent sample of annual passenger traffic; next, b is deflated by $(1.62)^2$ and Y is deflated b 1.62 in order to account for the 62 percent increase in prices from 1976 (the period on which the estimates were based and 1981 (the period for which the slot demand is estimated.

* Since Ippolito assumed that frequency, N, and load factor, L, were endogenous, he used two stage least squares to estimate the demand function. Thus, load factor and frequency were regressed against the exogenous variables in the model. Using these the results of this first stage regression, fitted values of flight frequency and load factor were used in estimating the demand equation.

Source: Ippolito (1981, p. 13)

economies of scale at the city-pair level.[1] Thus, if larger aircraft are used in dense markets and costs per passenger are lower for larger aircraft, dense markets may have lower costs. Comparisons of costs per seat-mile of different sizes of aircraft exhibit lower costs for larger planes (e.g., Douglas and Miller (1974, p. 11)). While these cost comparisons exaggerate the the cost advantage of larger aircraft by ignoring other factors that affect costs,[2] the advantage clearly exists.[3] The relevant issue, however, is not whether economies of scale with respect to aircraft size (and hence city-pair market size) exist but whether they are important for the size of city-pair markets in our sample and for the types of aircraft used to serve them. All of the aircraft used in our sample are relatively large (more than 76 seats), and most are similar in size.[4] Therefore, for purposes of estimating

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1 They note, however, that passenger preference for frequent service is a countervailing force that mitigates the relationship between economies of scale with respect to aircraft size and economies of scale with respect to city-pair market size.

2 The most important reason why seat mile cost comparisons overstate economies of scale is that larger aircraft are generally used on longer routes. Since costs per mile decline with distance (see below), part of the apparent economies of scale is due to the longer average stage length of larger aircraft. In addition, CAB regulations resulted in the use of jet aircraft in markets for which they were not really suited. Deregulation and rising fuel prices (which increases the relative efficiency of turboprop aircraft for short markets) have resulted in the replacement of jet aircraft with more appropriate turboprop aircraft in many markets. For a thorough discussion of this shift see Meyer et al. (1982).

3 If there were no advantage to larger aircraft, airline passengers could be served individually with frequent, convenient service and airlines markets could be, absent barriers to entry, competitive and not merely contestable.

4 Aircraft in our sample range from the 76 seat BAC-1-11-200 to the 272 seat Lockheed L-1011 with 268 of the 309 planes in the sample being either B-727s, B-737s or DC-9s. Interestingly, the two flights by a certificated carrier in the thinnest market in our sample (Cape Girardeau, Mo.) used DC-9s as did 16 of the 21 flights in the densest market (Chicago). Of course, the smaller aircraft operated by commuter airlines may suffer a cost disadvantage although this disadvantage is presumably small since the commuters appear to be able to compete with the larger aircraft used by certificated carrers.

flight costs, we follow the airline literature[1] and assume that long run costs[2] are independent of density in the relevant range.[3] This simplifies our analysis by allowing us to treat average costs as exogenous. We note the effect of this assumption when our results are sensitive to it.

While we assume that long run average costs are independent of traffic for the size of aircraft in our sample, we allow the costs to vary with distance. We estimate the relationship between cost and distance by regressing average costs, c, against the natural logarithm of distance, lnD, for our sample of the 59 city-pair markets involving St. Louis.[4]

Average costs are computed for each city-pair market as follows. The average seat-mile cost for each flight in the sample is multiplied by the distance of the market to give the average

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1 Olson and Trapani (1981 and 1982), Douglas and Miller (1974), Schmalensee (1977), and Ippolito (1981) express an airline's costs in a city-pair market as a linear function of passengers and either seats or flights with the function passing through the origin. Such a cost function implies that per passenger and per seat costs are constant and hence there are no economies of scale. This specification follows from either the assumption of no economies of scale with respect to aircraft size or the assumption that aircraft size is given exogenously for a particular market, or some combination of the two (i.e., there may be some variation in aircraft size and some economies of scale but within the range of aircraft size the economies of scale are nugatory).

2 By long run we mean the period in which airlines can both alter their schedules and aircraft fleets in response to changes in market conditions.

3 The assumption that long-run average costs are independent of density is made in order to make the estimation of flight costs tractable and because we have no information with which to quantify a relationship between density and costs. The assumption can be made here as it does not affect the basic conclusions of this study--though some of the estimates provided here may be affected by it. In other policy areas, such an assumption would be much more important and would have to be examined much more critically.

4 The specification of costs as a function of the logarithm of distance is used to allow costs per mile to decline with distance. Such a concave cost function with respect to distance was implicit in the regulated fares that had fare per mile declining with distance. The economic evidence (e.g., Douglas and Miller (1974), Bailey and Panzar (1981), and Meyer, et al. (1982)) indicates that costs actually declined at an even faster rate than the regulated fares.

seat costs for the flight.[1] The seat-mile costs are airline and aircraft specific as given in Aircraft Operating Cost and Performance Report (1982). The average seat costs for each city-pair are then computed as the weighted average of average seat costs for the flights in the city-pair. (Each flight's share of seats in the city-pair is used as the weight.)[2] Average seat costs are translated into average passenger costs by assuming a load factor of 60. These average passenger costs were then doubled to reflect the assumption that flight costs are one half of total costs.[3]

The estimated cost function is

$$(3)\quad c = 22.633(\ln D)$$

standard error of estimate = 2.2885
$R^2 = .87$

We now demonstrate how the willingness to pay for slots is derived from the demand and cost functions for air travel. We first do so under the assumption that there is no threat of entry and then under the assumption that entry is instantaneous. We see that the willingness to pay for slots is the same under both of these extreme assumptions.

Willingness to Pay Absent the Threat of Entry

Our assumption that passengers are highly sensitive to arrival time implies that each flight is a monopoly over its

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[1] Of course the cost per mile of operating each aircraft is not constant with distance so that the marginal cost per mile is not everywhere equal to the average cost per mile. However, we are assuming that each airline operates its various types of aircraft at roughly the distance where costs per mile are at a minimum for each type of aircraft. In this range, average costs per mile approximate marginal costs per mile.

[2] Olson and Trapani (1981 and 1982) calculate seat-mile costs for city-pair markets in a similar manner.

[3] The assumption that flight costs are one-half of total costs is arbitrary but not unreasonable. Graham and Kaplan (1982) estimated that, for the year ending in June, 1981, flight specific costs were slightly less than 60 percent of total costs for trunk carriers and about 55 percent for three former intra-state carriers. However, they included all cabin crew costs as flight specific while we believe that there is a variable component to such costs.

share, $\delta$, of the city-pair demand. The profit that the flight earns would therefore be

(4) $\pi = (P - c)\ q.$

Absent the threat of entry,[1] an airline with monopoly power over some fraction of the market would set the fare at the level that maximizes profits. This fare is found by differentiating the profit function with respect to the decision variable of each flight, price, which gives the first order condition of profit maximization as

(5) $P\ (P - c) = - \frac{1}{2b}.$

This quadratic equation is solved for its positive root, the profit maximizing price,

(6) $P' = \frac{c + (c^2 - 2/b)^{1/2}}{2}.$

Equation (6) is substituted into equation (2) in order to find the profit maximizing quantity, q', for each flight. The profit maximizing price and quantity are substituted into equation (4) to find the profit that each flight would earn, absent the threat of entry, $\pi'$. Since the right to land is essential to conducting the flight, each flight would be willing to pay up to its profits for a slot. Thus, the profit function gives the willingness to pay for each flight as a function of the exogenous variables that determine its actual profit,[2]

(7) $\pi' = (P' - c)\ q'.$

Willingness to Pay with the Threat of Instantaneous Entry

The assumption that airlines can charge monopoly prices is often unrealistic. In many instances, barriers to entry will not be insurmountable and airlines will have to price below the

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1 It is actually sufficient to assume that the airline operating the flight acts as if it were free from the threat of entry.

2 The number of flights in the city-pair is endogenous to the market. However, we assume that airlines making pricing decisions for each flight act as if the number of other flights is fixed. In other words, we view the number of flights as being endogenously determined in the market but exogenous to the pricing decision of each flight.

monopoly level or encounter competitive entry which will erode the profits they can earn. The lower are entry barriers, the lower will be the price that can be charged without inducing new entry--the limit price.[1] Insurmountable entry barriers and monopoly pricing represent one end of the pricing spectrum. The opposite end of the spectrum is represented by a perfectly contestable market in which entry is free and exist is costless.[2] In this section, we demonstrate that the maximum price a flight would be willing to pay for a slot is the same in a perfectly contestable market as it is in a market where entry barriers are insurmountable and monopoly prices are charged.

In a perfectly contestable airline market with a market in which scarce slots are sold, an airline cannot raise the price of airline tickets above the average cost of providing the air service, including the price of the slot used by the flight, even though there is only one flight in a city-pair in any time period.[3] If a price higher than average cost were charged, another airline would offer a flight in the same market at the same time and charge a lower price. Because of the lower fare, passengers would begin flying on the new entrant rather than the incumbent carrier. Because such entry would occur instantaneously, the mere threat of entry limits each flight's fare level to that which just covers costs.[4]

While each flight would earn zero profits when there is a slot market under our entry assumption, it may still be willing to pay for a slot. The amount that it would be willing to pay for the slot is determined by its passengers' willingness to pay for

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1 For a discussion of limit pricing see Scherer (1980, ch. 8).

2 For a detailed examination of contestable markets, see Baumol, Panzar and Willig (1982).

3 This conclusion has to be modified slightly if there is no slot market. In that case, fares on a flight in a perfectly contestable market could exceed costs by the scarcity value of a slot--that is by the scarcity rents being earned in its current use by the slot which would be used to establish additional service on the route in question--without attracting new entry.

4 It is sufficient to assume that the airline operating the flight acts as if entry were instantaneous.

the slot in the form of higher fares. Thus, while the flight could not raise fares above average costs, it can pass on the increase in average costs attributable to a slot fee as long as its passengers are willing to pay the higher fares. The willingness to pay for each flight would be the difference between revenues and the costs of operating the flight excluding the cost of the slot, when fares are set so as to maximize this difference. This fare level is given by the tangency of the average cost function (including the slot fee, F) and the demand function.[1] This condition obtains when price equals average cost,

$$(8)\quad P = \frac{F}{q} + c = AC,$$

and the partial derivative of the inverse demand function with respect to quantity equals the partial derivative of average costs with respect to quantity

$$(9)\quad \frac{\partial P}{\partial q} = \frac{1}{2bPq} = -\frac{F}{q^2} = \frac{\partial AC}{\partial q}.$$

Equation (8) is solved for q. Substituting the result into equation (9) yields equation (5). Hence, the profit maximizing price is also the price that an airline in a contestable market would charge, if the flight paid the maximum slot fee that is consistent with zero profits. At that price, the flight would have the same number of passengers as it would if it were a profit maximizing monopolist. Since, at the tangency, the flight in a contestable market has the same price, P', and the same quantity, q', as the monopolist, equation (8) can be solved for

$$(10)\quad F = (P' - c)\, q',$$

which is identical to the monopolist's willingness to pay as shown

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1 Note that in the Chamberlinian model of monopolistic competition, this tangency is the long run equilibrium. In that case, airlines would be unable to pay any more than the equilibrium scarcity value of the slot. However, Baumol, Panzar and Willig (1982, pp. 329-332) demonstrate that the tangency is not necessarily the equilibrium in a contestable market. The equilibrium may be an intersection of the demand and average cost curves to the right of the tangency. Thus, airlines may be willing to pay more than the equilibrium scarcity value of the slot.

by its profits, equation (7).[1] Thus, regardless of which of the two extreme assumptions are used--absolute barriers to entry or no barriers to entry--the maximum willingness to pay for slots can be expressed as the same function of variables and coefficients of the demand and cost functions as shown in equation (7).

Results

With Ippolito's estimates of the demand function (see equation (1) and TABLE A-1), our estimates of the cost function (see equation (3)), and our derived demand for willingness to pay (see either equation (7) or equation (10)), we are able to estimate a flight's willingness to pay for a slot as a function of city-pair characteristics. We estimate the willingness to pay for our sample of flights to St. Louis. The mean values of the sample variables are presented in Table A-2.[2]

We find that the average profit maximizing (absent the threat of entry) fare, P', in the sample is 202 dollars and that the average flight would have 22 passengers at the profit maximizing monopoly fare. We estimate that the average flight would be willing to pay 1,275 dollars per day for a slot. Of course these are not necessarily the equilibrium values of price and quantity. If there is any threat of entry (which there surely is for airline markets), fares would be much closer to costs (including both operating costs, c, and the per passenger scarcity value of slots, F/q) and consequently flights would have more passengers and lower profits. In a contestable market, fares would equal average costs, including the scarcity value of slots, although the willingness to pay would be the same in either case. We would also like to emphasize that the equilibrium slot fee would not be 1,275

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1 The result that the willingness to pay is independent of whether entry barriers are insurmountable or zero does not depend on the demand and cost functions assumed here. General specifications of demand and cost functions yield the same result although the willingness to pay for slots cannot be derived as an explicit function of exogenous variables for all demand and cost functions.

2 Instead of using the actual load factor, we use a load factor of 60 to be consistent with our cost function estimates.

TABLE A-2

Sample Means

| Variable | Mean Value |
| --- | --- |
| Flight Frequency (N) | 8 |
| Load Factor (L) | 54 |
| Distance (D) | 561 |
| Population (X)* | 2,318,886 |
| Per Capita Income (Y)# | 7,847 |
| Dummy Variables: | |
| 0-100 miles | .107 |
| 100-200 miles | .053 |
| Las Vegas | .014 |
| Florida | .047 |
| California | .047 |

* This figure is the population of the origin city. For Standard Metropolitan Statistical Areas (SMSAs) we use the population of the SMSA. For cities that are not part of an SMSA we use county population data. The figure used in the estimation is the product of the origin city population and the population of St. Louis, which is 2,356,460.

# This figure is the per capita income of the origin city. For SMSAs we use the per capita income of the SMSA. For cities that are not part of an SMSA we use state per capita income data. The figure used in the estimation is the simple average of the origin city and St. Louis, which has a per capita income of $7,517

dollars. This is the average willingness to pay. The actual slot fee depends on the demand for slots during a particular hour of the day and the supply of slots during that hour.[1]

Our estimates of the willingness to pay for slots allow us to examine the workings of a slot market. In the following section we use our slot demand function to determine the effects of market characteristics on willingness to pay. In the fourth section, we compare the value of flights that we predict would be dropped under the FAA's allocation to the flights that we predict would be dropped if a market for slots were allowed. In the final section we use our estimates to examine the welfare loss that would occur if the prohibition of a slot market creates entry barriers in city-pair markets and hence airlines were able to maintain fares above costs.

## A-3: Market Characteristics and Slot Demand

The market characteristic data allow us to draw inferences concerning the types of flights that are most likely to obtain slots under a market. The allegation that flights in dense city-pair markets (i.e., markets with many passengers) would outbid flights in thin markets (i.e., markets with few passengers) is difficult to address since many factors determine market density. In this section we examine separately the effects of individual market characteristics that determine market density such as population, X, per capita income, Y, flight frequency, N, and distance, D, each under the assumption that all other characteristics are constant.

### Population and Income

The effect of the population is addressed by differentiating the willingness to pay function, equation (7), by population

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[1] Specifically, the slot fee would be between the value of the lowest-valued flight that buys a slot and the value of the highest-valued flight that does not buy a slot. This is given by the intersection of the demand for slots and the supply of slots. Graphically, the demand for slots at St. Louis, during any hour of the day, is obtained by ranking the willingness to pay for each flight in descending order. (See Section A-4 for our estimates of the equilibrium slot fees).

$$(11)\quad \frac{\partial PI'}{\partial X} = (P' - c)\,\frac{\partial q'}{\partial X}.$$

(Since the effect of per capita income can be examined in an analogous manner, we omit the derivative of willingness to pay with respect to income.) Since demand is increasing with population (and per capita income),[1] a larger (or richer) city would indeed be willing to pay more for its marginal slot than would a smaller (or poorer) city, all else being equal.

Flight Frequency

Larger cities usually have more flights than smaller cities. In fact, flight frequency is an endogenous variable for a city-pair and is therefore determined by, *inter alia*, city size. Thus, by holding frequency constant when we addressed the effect of city size on willingness to pay, we ignored the fact that larger cities have more flights and thus the marginal flight in a large city is not the same as the marginal flight in a smaller city. We now consider that effect. To see how flight frequency affects willingness to pay, assuming all else is constant, we differentiate equation (7) by the number of flights in the city pair to find

$$(12)\quad \frac{\partial PI'}{\partial N} = (P' - c)\,\frac{\partial q'}{\partial N}.$$

Since the demand for each flight decreases with the total number of flights in a market,[2] the presence of more flights in a market

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1 Recall from Table A-1 that the coefficients for both population and per capita income were positive and statistically significant at the 99 percent level.

2 An increase in the number of flights leads to an increase in the number of passengers. However, as long as the percentage increase in passengers is less than the percentage increase in flights the number of passengers per flight declines. DeVaney (1975) found that for markets with three or more airlines the number of passengers per flight would increase with more flights while it would decrease with more flights in markets with one or two airlines. More recent studies of monopoly markets by Olson and Trapani (1981) and Ippolito (1981) found evidence consistent with the notion of fewer passengers per flight in markets with more flights. Since we are concerned with the monopoly portion of the demand curve (recall that the willingness to pay is determined by either assuming monopoly pricing behavior or that the slot fee is at the level where the monopoly price is charged by an airline in a contestable market) and since regulated fares were set at or above the profit maximizing level (see Olson and Trapani (1981)) the evidence supports the notion of decreasing passengers per flight with more flights.

implies that the marginal flight has a lower willingness to pay for a slot than the marginal flight in a market that has few flights. This is a fairly intuitive result since the value of the marginal flight in a market in terms of improved service quality[1] is smaller for a market that already has numerous flights and hence a high level of service quality.

Distance

The effect of distance on slot demand is somewhat more complicated than the effect of population or flight frequency. The derivative of (7) with respect to distance is

$$(13)\quad \frac{\partial PI'}{\partial D} = \left(\frac{\partial P'}{\partial c} - 1\right) \frac{dc}{dD} q' + (P'-c)\left(\frac{\partial q'}{\partial P'} \frac{\partial P'}{\partial c} \frac{dc}{dD} + \frac{\partial q'}{\partial D}\right).$$

The first term of equation (13) represents the change in profits that would result from a change in per passenger revenues (fare minus costs) as a result of the cost increase resulting from an increase in distance. The second term represents the change in profits that results from a change in the number of passengers due both to the change in fare and the change in distance.

Since a monopolist cannot pass on all of an increase in variable costs to consumers, the first term is negative. This is true, a fortiori, when we consider that a monopolist's ability to pass on any increase in variable costs depends inversely on the (absolute value of) the elasticity of demand which itself increases with distance.[2] For the sample, the first term has an average value of -.21 dollars ((dP'/dc)=.76, q'=22, (dc/dD)=.04). The sign of the second term depends on whether the change in

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1 By service quality we mean schedule convenience which depends on flight frequency. For a discussion of the components of schedule convenience and its determinants, see Douglas and Miller (1974, ch. 6).

2 Verleger (1972), DeVaney (1974), Abrahams (1980) and Ippolito (1981) all found that the price elasticity of demand increases with distance. The intuitive reason for this is that the full price of travel includes both the fare and time. Since the fraction of the full price attributable to the fare rises with distance, the effect of a percentage change in fare on the full price increases with distance and hence so does the fare elasticity.

passengers in response to the change in distance[1] is matched by the change in passengers in response to the change in price induced by the change in distance. On average for the sample, there are .03 more passengers for each mile increase in distance while there are .01 fewer passengers owing to the price increase resulting from that increase in distance ((dq'/dP')=-.36, implying a price elasticity of -3.3). The second term is therefore 1.28 dollars (p'=202, c=138), indicating that the entire expression is positive. Thus, while, *a priori*, the effect of distance or willingness to pay is ambiguous, our parameter estimates indicate that, on average, willingness to pay for slots increases with distance.[2]

Results

The assertion that dense markets would outbid sparse markets is partially supported by the empirical evidence. If density is taken to mean the number of passengers in the market, it is a function of, *inter alia*, city size, distance and the number of flights (which in turn is a function of city size). While willingness to pay is higher, *ceteris paribus*, for larger cities and longer markets, it is lower for markets with more flights.

There are two other factors that affect willingness to pay which are not incorporated in the above analysis. First, if there are long run economies of scale in aircraft size, markets with larger aircraft would exhibit a higher willingness to pay for slots. Second, one component of fixed costs is the slot fee that is paid to land at the origin airport. Hence a higher slot fee at the origin city implies a lower willingness to pay for a slot fee at the destination airport. These two factors tend to have

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1 Two factors influence the relationship between demand and distance: the total travel between two cities declines with distance because more distant cities have fewer ties, but the proportion of the travel that is by air increases with distance since the time advantage of air travel increases relative to its price disadvantage.

2 This implies that the FAA's policy of restricting the use of Washington National airport to non-stop flights of less than 1,000 miles (previously 650 miles) and Orange County's John Wayne airport's policy of restricting operations to non-stop flights of less than 500 miles result in an inefficient allocation.

opposite effects: flights in dense markets generally use larger aircraft but, under a market, they would probably pay higher slot fees at the origin airport.

A-4: The Welfare Loss Arising from a Misallocation of Slots

One welfare loss that occurs from prohibiting a slot market is that it may not be possible to rectify the initial misallocation of slots. If the airline that receives a slot is not in the best position to use it, a slot market would allow that airline to sell the slot to whoever can use it most efficiently. Such a sale benefits both the buyer and seller of slots and is therefore welfare enhancing.[1]

We can estimate this loss by comparing our estimates of the actual loss that occurred when slots become scarce at St. Louis in 1981 to our estimates of the loss that would have occurred if a market had been allowed. The third and fourth columns of Table A-3 show the number of flights for July, 1981 and the reduction in slots resulting from the PATCO strike for each one-hour interval where reductions were required.[2]

The fifth column in Table A-3 is the estimated loss that each airline suffered from reducing flights as required, assuming that each airline dropped the flights that we predict have the lowest values. It represents our estimates of the value of each airline's lowest-valued flights, as predicted by equation (7). If the airlines had not been free to choose which flights to cancel, this loss would have been even greater. If airlines can use their slots to enter city-pairs that they did not serve before the PATCO strike, but that are now more profitable than some of the flights that we predict would be served after the restrictions,

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1 The current FAA rules that allow trading of slots allows some of the loss associated with a misallocation of slots to be eliminated.

2 The calculations are based on each airline reducing its hourly arrivals according to FAA requirements (48 FR 44426). There was an eighth hour of the day that was restricted. However the 12 percent restriction for 7:00 a.m. flights does not affect any of the carriers according to the FAA's rules since no carrier had more than three flights and reductions could be rounded to the nearest whole number.

TABLE A-3

The Welfare Loss Arising from Slot Misallocation
(in dollars per day)

| Time CDT | Airline | Initial Slots | Reduction in Slots | Loss without Market | Loss with Market | Loss Due to Market Prohibiion | Slot Price |
|---|---|---|---|---|---|---|---|
| 8:00 am | TW | 15 | 7 | 2,495 | | | |
| | OZ | 18 | 8 | 814 | | | |
| | RC | 1 | 0 | | | | |
| | DL | 1 | 0 | | | | |
| | AA | 4 | 2 | 602 | | | |
| | EA | 1 | 0 | | | | |
| | total | 40 | 17 | 3,911 | 3,511 | 400 | 412 |
| 11:00 am | TW | 14 | 5 | 4,213 | | | |
| | OZ | 1 | 0 | | | | |
| | DL | 1 | 0 | | | | |
| | AL | 1 | 0 | | | | |
| | TI | 1 | 0 | | | | |
| | EA | 1 | 0 | | | | |
| | total | 19 | 5 | 4,213 | 2,722 | 1,491 | 918 |
| 12:00 noon | TW | 3 | 0 | | | | |
| | OZ | 7 | 1 | 313 | | | |
| | RC | 1 | 0 | | | | |
| | DL | 1 | 0 | | | | |
| | EA | 2 | 1 | 973 | | | |
| | total | 14 | 2 | 1,286 | 703 | 583 | 389 |
| 1:00 pm | TW | 11 | 4 | 3,923 | | | |
| | RC | 1 | 0 | | | | |
| | NW | 1 | 0 | | | | |
| | AA | 5 | 3 | 3,750 | | | |
| | OZ | 15 | 7 | 2,495 | | | |
| | total | 33 | 14 | 10,168 | 7,158 | 3,010 | 854 |
| 3:00 pm | TW | 14 | 8 | 7,672 | | | |
| | OZ | 10 | 7 | 2,325 | | | |
| | DL | 2 | 1 | 462 | | | |
| | EA | 1 | 0 | | | | |
| | RC | 1 | 0 | | | | |
| | total | 28 | 16 | 10,459 | 8,959 | 1,500 | 997 |

TABLE A-3--(continued)

| Time CDT | Airline | Initial Slots | Reduction in Slots | Loss Without Market | Loss With Market | Loss Due to Market Prohibition | Slot Price |
|---|---|---|---|---|---|---|---|
| 5:00 pm | TW | 19 | 12 | 18,000 | | | |
| | NW | 1 | 0 | | | | |
| | DL | 3 | 2 | 1,823 | | | |
| | OZ | 3 | 2 | 1,257 | | | |
| | AA | 6 | 4 | 3,959 | | | |
| | EA | 1 | 0 | | | | |
| | TI | 1 | 0 | | | | |
| | total | 34 | 20 | 25,039 | 20,120 | 4,919 | 1,621 |
| 6:00 pm | TW | 10 | 5 | 4,942 | | | |
| | RC | 2 | 1 | 599 | | | |
| | FL | 1 | 0 | | | | |
| | EA | 1 | 0 | | | | |
| | AL | 2 | 1 | 144 | | | |
| | DL | 1 | 0 | | | | |
| | OZ | 6 | 2 | 426 | | | |
| | total | 23 | 9 | 6,111 | 3,733 | 2,378 | 816 |
| city total | | | | 61,187 | 46,906 | 14,281 | |

Airlines:
AA - American
AL - U.S. Air
DL - Delta
EA - Eastern
FL - Frontier
NW - Northwest Orient
OZ - Ozark
RC - Republic
TI - Texas International
TW - Trans World

this loss would be less. The total loss for all airlines in the market is the value of all n flights that are cancelled. It is also given in the fifth column. The loss that would have occurred if a slot market had been allowed is the value of the n least valued flights, as predicted by equation (7), during the interval in question, regardless of airline. The estimate of this loss is given in the sixth column. The difference between columns 5 and 6 is the estimated welfare loss inherent in preventing slot sales. It is given in the seventh column.

Relaxing two of our assumptions would likely have significant effects on these results. First, if passengers are less sensitive to arrival time than is assumed here, both the actual and hypothetical losses arising from the slot restrictions would be lower since many passengers would shift from peak to off-peak flights and would incur only the losses associated with the less convenient arrival time. If passengers are completely indifferent to arrival time and all passengers could be accommodated at some time of the day, there would be no loss at all.[1] Second, we have ignored international flights, commuter flights and cargo flights. The estimated welfare loss from prohibiting sales would be even greater if these types of flights were included in our analysis, especially if their willingness to pay differs, on average, from the flights in our sample. Thus, if the roughly 18 percent of the flights that are excluded from our sample were, on average, the same as the flights in our sample, the welfare loss would be 18 percent higher that our estimates. If, on average, the willingness to pay of the omitted flights differ from the willingness to pay of the flights in our sample, the gains from sales would be more than 18 percent greater than our estimates since the average

[1] The fact that reductions were needed during only seven hours of the day indicates that the problem was not necessarily one of inadequate daily air traffic control capacity. Rather, the problem was primarily one of providing air traffic control during the peak hours of the day. Of the 309 flights in the sample, 191 of them were scheduled during the seven busiest hours. Even with the reduction, the St. Louis airport handled between 12 and 23 arrivals per hour by the carriers in our sample during the restricted periods.

difference between the value of a slot to the selling airline and its value to the buying airline would be greater.[1]

The last column in Table A-3 is the estimated value of the most valuable flight that would have been dropped, if a slot market had been allowed. This would be roughly the market price for slots (on a daily basis).[2] This price would provide two important signals. First, the higher fees during the restricted periods would encourage airlines to shift flights to less congested periods[3] and; second, it would indicate which airports and which times of the day suffer from the greatest scarcity and thereby aid the FAA in allocating resources to the expansion of the Air Traffic Control system.

We can estimate the revenues that would be earned with a slot market by multiplying the slot fee during each hour by the number of flights, after the reduction, during that hour. We find that airlines would pay 89,304 dollars per day in slot fees. Since, under our contestability assumption, there are 6,978 passengers during restricted periods, the slot fee would represent an average of 13 dollars per peak period passenger.

A-5: The Potential Welfare Loss Arising from Entry Barriers

We demonstrated above that willingness to pay for slots is the same under both the monopoly and contestability assumptions. However, except for the marginal flight (i.e., the one that actually pays the maximum fee that it was willing to), price and quantity differ under the two assumptions. In the long run, price

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1 Since commuter airlines were net sellers of slots during the six week period when slots could be sold we believe that there is a difference in willingness to pay between the various types of airlines.

2 Actually, the price would fall somewhere between the value of the highest valued flight that is dropped and the lowest valued flight that is kept.

3 Our analysis is a partial equilibrium study since we assume that passengers are highly sensitive to arrival time. A general equilibrium approach would account for a shift of flights due to differences in slot fees. If such a shift occurs, slot prices during the hours that flights shift from would tend to be lower than we estimate while slot prices during the hours that flights shift to would be higher.

equals average cost (including scarcity) in contestable markets and exceeds average cost in monopoly markets.

In a city-pair market where one or both airports is slot constrained, incumbent airlines would be free from the threat of entry if no other airline could obtain the necessary slot(s). If there were a market for slots, any airline could obtain slots, at the market price. To the extent that the incumbents in the market have some monopoly power, the imposition of an entry barrier due to the prohibition of a slot market results in a welfare loss. This is in addition to any loss arising from a misallocation of slots.

We estimate the potential welfare loss arising from the imposition of entry barriers to airline markets by comparing the monopolist's long run price, as given by equation (6), and the price that would be charged in a perfectly contestable market, which is the average cost, including scarcity. The linear approximation of this dead weight loss, W, that results from a movement from contestability to entry free monopoly would be[1]

(14) $$W = \frac{1}{2}\left(P' - c - \frac{F}{q}\right)\left(q\left(c + \frac{F}{q}\right) - q(P')\right)$$

We estimate this loss for each of the restricted hour flights that we predict would fly if there were no initial misallocation of slots (i.e., if the FAA allocation is the market allocation). With no slot misallocation, the scarcity value of each slot would be its market price (see Table A-3). In the second column of Table A-4 we present the welfare loss that results due to the imposition of insurmountable entry barriers for each of the seven restricted hours. The total welfare loss for all restricted hour flights to St. Louis would be $84,468 per day.

Of course, slot constrained airports are not free from actual and potential competition nor would they necessarily be perfectly

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[1] Since the demand curve, equation (2) is ordinary, as opposed to compensated, this expression actually represents an approximation of either the equivalent or compensating variation, depending on the direction of the price change. However, Willig(1976) found that the change in consumer's surplus is between, and very close to, the equivalent and compensating variations when the change is small relative to income.

TABLE A-4

The Potential Welfare Loss Arising from Entry Barriers

| Time CDT | Welfare Loss due to Insurmountable Entry Barriers | Welfare loss due to Moderate Entry Barriers |
|---|---|---|
| 8:00 am | 6,468 | 749 |
| 11:00 am | 10,799 | 1,452 |
| 12:00 noon | 3,524 | 409 |
| 1:00 pm | 17,810 | 2,624 |
| 3:00 pm | 16,380 | 2,181 |
| 5:00 pm | 10,338 | 2,069 |
| 6:00 pm | 19,144 | 2,386 |
| Total | 84,468 | 11,844 |

contestable with slot markets. In fact, if we relax our assumption that passengers are highly sensitive to arrival time, an important source of actual competition for restricted period flights is non-restricted period flights. Hence, the figures in the second column of Table A-4 represent the upper bound of the welfare loss that occurs when entry barriers are created. If the prohibition of a slot market imposes moderate, and not insurmountable, entry barriers, the welfare loss would be less. If barriers to entry were high enough to enable the airlines to maintain fares that are 10 percent above costs (or the monopoly price in which entry barriers are insurmountable, whichever is less) the linear approximation of the welfare loss would be given by the figures in the third column for Table A-4, implying a total (for all restricted periods) welfare loss of 11,844 dollars.[1]

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[1] Our implicit assumption that barriers to entry might occur only for flights during restricted hours probably understates the welfare loss estimates. Flights that arrive in St. Louis during unrestricted periods may also be able to elevate fares above costs if the flight landed at the origin city during a restricted period for the origin airport. In other words, if restrictions exist for either end of a city-pair market, entry may be made more difficult.

APPENDIX II

The Development of Airport Slot Regulation

The Federal Aviation Administration (FAA) currently regulates landing rights (slots) at 20 U.S. airports.[1] In broad outline, this regulation consists of restricting the number of landings below that desired by the airlines at the existing low landing fees,[2] making an initial allocation of those slots to the individual carriers, and limiting the ability of airlines currently using slots to transfer them to other airlines. This general form of regulation began on a relatively small scale in the late 1960's, but was greatly expanded in 1981, in response to the air traffic controllers' strike.

In sum, FAA slot regulation has been designed to achieve three goals: restriction, initial allocation, and reallocation. The agency has reduced the total number of slots available per hour at certain airports. It has also specified the ways in which the reduced number of slots would be initially assigned to carriers. Finally, it has controlled the slot transactions between those carriers.

Restrictions on the Total Number of Slots

Overall slot restrictions have been imposed by the FAA both to reduce congestion and to maintain safety in the available airspace. In the late 1960's the agency promulgated the High Density Airport Rule, in response to increasing airport congestion (14 CFR 61.1). Under certain conditions, this regulation imposed limits on the takeoffs and landings per hour at four airports:

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1 Following the 1981 air traffic controllers' strike, slots were restricted at 22 airports. The FAA plans to reduce the number of restricted airports to 14 by August, 1983. The FAA's restrictions at the 20 air route traffic control centers are also being relaxed. However, even when the slot restrictions are removed, the FAA plans to continue its "flow-control" procedures to hold aircraft on the ground until the air traffic control system can handle them in the air.

2 The height of airports' landing fees is constrained by the Airport and Airway Development Act of 1970 (49 U.S.C. sections 1701-49). Landing fees are generally set to cover accounting costs and are often well below the level that would limit the number of flights to existing airport capacity. For a description of airport financing see Levine (1969).

Kennedy, LaGuardia, National, and O'Hare. Operations that did not involve these four airports were not restricted.

In 1981, in response to the air traffic controllers' strike, the agency established reduced schedules for 22 airports, including the four that had been constrained under the High Density Rule (46 FR 44424, 9/4/81). The number of slots per hour was reduced by a percentage chosen by the FAA, which varied across airports and by time of day. While off-peak hours appear to have been largely unaffected, reductions for busier hours ranged up to 67 percent of pre-strike schedules. As the air traffic control system's capacity recovered from the strike's impact, the FAA increased the number of slots available at the 22 airports.

Initial Allocation of Slots

Several methods have been used for the initial allocation of slots, following either a reduction in their total number or an increase as new slots became available. Under the High Density Rule, initial allocation was delegated to a carrier committee at each restricted airport.[1] These committees originally consisted of all certificated carriers permitted by the CAB to serve that airport. When entry into city-pair markets was deregulated, any certificated carrier wishing to serve a restricted airport could sit on the committee for that airport. The committees allocated slots using a rule of unanimity--all members had to vote in favor of an allocation for it to be adopted. As a result, each carrier had veto power over the slot allocation choice. If an airline vetoed the slot allocation proposal developed by the committee, the slot allocation decision would be made by the FAA. This veto power may have been marginally useful to potential entrants, because they expected at least some slots in an FAA decision. To avoid uncertainty about the number of slots they would have to give up if the FAA made this decision, incumbent carriers might be induced to compromise by giving new entrants a few slots and making marginal adjustments to their own holdings.

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[1] This analysis of the committee process is taken from Grether, Isaac, and Plott (1981).

In response to the air traffic controllers' strike in 1981, the FAA made an initial allocation of the reduced number of slots on the basis of carriers' pre-strike schedules, as published in the Official Airline Guide (46 FR 44424, 9/4/81). In other words, each carrier was given slots approximately in proportion to its pre-strike schedule. Although the FAA promised some slots to new airlines, no policy to implement that promise was spelled out, and the agency invited comments on the issue.

As the FAA expanded the air traffic control system's capacity, after the initial reduction caused by the strike, the agency instituted a system of 22 lotteries to be held periodically to allocate the newly available slots at each of the restricted airports (47 FR 7816, 2/22/82). New entrants were given priority in these lotteries; within defined limits, they were allocated slots before incumbent carriers' requests were considered. However, new entrant status was limited to carriers that had filed for operating authority prior to the August 1981 strike, but had not begun operations as of mid February 1982.

Later, a single one-time lottery was substituted for the 22 individual-airport lotteries that had been held periodically (47 FR 35156, 8/12/82). This lottery was to determine priority for carriers in all future slot allocation periods. Preference was to be given to a broader class of new entrants: those carriers that were not operating by August 1982, but which had CAB authority and had applied for an FAA certificate by that date.[1]

Reallocation of Slots

Various proposals to permit transfers of slots from one carrier to another have been advanced from time to time. Some of these proposals would only have permitted an airline to trade slots it held for slots held by another airline. Other proposals would have permitted slots to be bought and sold for money. All of these proposals have initially been opposed by the FAA. For

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1 New airlines must be approved by both the CAB, which examines financial fitness, and the FAA, which regulates safety.

example, the agency opposed a proposal before the CAB to grant antitrust immunity to discussions between carriers concerning slot trades (47 FR 7816, 2/22/82). Later, however, the FAA dropped its opposition to trades held under the auspices of the Air Transport Association (ATA), a carrier trade group (47 FR 19989, 5/10/82). These exchanges were to be one for one, and the anonymity of the traders had to be maintained. To do this, requests for slots were encoded and submitted to the ATA, thereby eliminating direct contact between the trading airlines.

Still later, at the direction of the Department of Transportation, the FAA permitted slot sales on an experimental basis (47 FR 29814, 7/8/82). Originally announced as a one-month trial to evaluate the long term policy consequences of such transactions, the market was extended for an additional two weeks. At the end of that period it was suspended, with the FAA citing opposition from carriers, airports, and public officials (47 FR 29814, 7/8/82).

After ending the cash market for slots, the FAA liberalized the rules it imposed on slot trades (47 FR 34363 8/9/82). For example, it permitted slots to be traded in any ratio, rather than solely one for one. However, the agency has informed carriers that slot sales are prohibited and has instituted a requirement that carriers obtaining a slot submit a statement that the transaction did not involve consideration other than slots (47 FR 43278, 9/30/82).

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