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Impact of landing fees on airlines' choice of aircraft size and service frequency in duopoly markets

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Abstract

A one-shot simultaneous game-theoretic model is applied in a duopoly market to investigate how airport landing fees could influence airlines' decisions on aircraft size and service frequency. It is found that higher landing fees will force airlines to use larger aircraft and less frequency, with higher load factor for the same number of passengers. It is also found that airlines will be better off if some of the extra landing fees are returned to airlines as a bonus for airlines using larger aircraft, which consequently reduces airport congestion.

Keywords: Landing fee; Aircraft size; Airport congestion; Airline competition

1. Introduction

Delays caused congestion are a major problem at many airports. The traditional method of dealing with the problem focused on airport capacity expansion, but this is expensive and often only generates more traffic. Installing more advanced air traffic control systems can also enhance capacity, but this tends to be marginal compared with costs involved. Therefore, more attention has been paid to applying administrative and economic methods to the reduction of airport congestion without large investments.

Concepts of slot (i.e. right of departure or arrival during a specific period at an airport) and congestion pricing (i.e. using price to ration capacity and divert traffic from peak periods to off-peak periods) are forms of administrative and economic controls. To this end, Geisinger (1989) proposes an administrative method to allocate airport runway slots among airlines and Morrison (1982) examines a simple two-part pricing model for uncongested airports. Brander and Cook (1986) find that the airport will be more efficiently operated and social costs will be reduced under congestion management, and argue that the slot auction approach—each slot goes to the highest bidder—would solve the slot shortage problem. In practice, the principal part of the landing fee in all major international airports is based on aircraft weight, and no airport in the US has adopted the time-varying landing fee policy (de Neufville and Odoni 2003). London Heathrow has in the past adopted 'punitive peak-hour tariffs' to encourage airlines to transfer operations from Heathrow to Gatwick and to move operations from the peak period. Given the particular situation at Heathrow and Gatwick this approach did not prove very successful (Ashford et al., 1995).

Some of the more recent work has focused on applying pricing regulation and landing fee policies at airports to optimize social benefits.[1] Most of these theoretical studies develop airport pricing policies from the airport's perspective and consider the airport as a public entity that maximizes social benefits. In reality, airlines, the users of airports, play a very important role in airport pricing policy, since the structure of landing fees influences airlines' operational and management decisions. Lack of consideration of airlines' perspectives on such issues as practical scheduling constraints and influence on their competitive

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[1]Forsyth (1997) incorporates principles of efficient pricing into a price-cap regulatory framework, and Martin-Cejas (1997) proposes Ramsey pricing models for Spanish Airports. Starkie (2001), Zhang and Zhang (1997) and Oum et al. (2004) argue that the dual-till or two-till (considering both the runways and retailing) regulation is better than the single-till price-cap regulation for airport management.

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situations makes airport congestion management policy difficult to implement. Allen (1994) finds that congestion pricing policy may alter aircraft mix which favors larger aircraft and large airlines. Pels et al. (1997) explore the implications of airport pricing as possible influence on the choice of hub location for airlines. Niemeier (2002) advocates that regulatory reform should be combined with reforms to intensify competition such as slot auctioning among airlines.

New York's LaGuardia Airport (LGA) has been a flagship airport in applying administrative and economic measures to restrict traffic in the US. Since 1968, LGA has applied the high-density rule (HDR) to limit hourly slots to reduce airport congestion and delay. With some minor adjustment, this policy has been implemented in practice at LGA for more than 30 years. In April 2000, the congress passed the Wendell H. Ford Aviation Investment and Reform Act for the 21st Century (AIR-21), which requires that the slot restrictions at LGA should be eliminated after January 1, 2007 and the exemption of slots should be granted immediately to some special flights such as those provided by regional jets with less than 72 seats. Very shortly after this new policy was taken into action, FAA believed that the elimination of slots would cause severe delay problem in LGA and the whole national airspace system, and therefore withdrew the slot exemption policy and redistributed the available slots through a lottery system on December 4, 2000 (Hansen and Zhang, 2005). But today, the US congress still requires that the current slot-based demand management policy adopted at LGA should end in January of 2007. Therefore, a set of new rules and ideas have been proposed to develop the next generation of policies for pricing and slot allocation at LGA. But the critical challenge in designing new pricing and slot allocation rules, such as "slot auction," is the lack of a mechanism or model for predicting airlines' behavior in response to various landing fee polices and this behavior's consequences on airport congestion and delay.

To fill in this gap, this paper uses a set of analytical models to study how landing fee policies may influence airlines' choice of aircraft size and service frequency in a competitive environment. Setting aside political factors that might influence airport pricing policy, we study airport pricing policy from the operational and economic perspectives of airlines. Since airport throughput depends on both aircraft size and service frequency provided by airlines, if airlines choose, or are economically forced by the landing fee policy, to use larger aircraft, then an airport can serve more passengers without any physical expansion of airport capacity, and the congestions and delay at airport can be reduced.

The analysis here differs from previous studies in several aspects: we investigate the relation between airport pricing and airline management under the deregulated civil aviation umbrella, and study how landing fees may influence airlines' decision on both aircraft size and service frequency, which has a significant impact on airport congestion and delay; we take into account competition among airlines, especially their choices of aircraft size and service frequency as competitive strategies. Since most of the US domestic markets are served by two or three major airlines, a game-theoretic model is applied to predict airlines' behavior in response to changes of landing fees in duopoly markets; and this study is based on previous empirical studies of airlines' cost function and market share model, both of which are derived by using the real data of the airline industry in the US.

2. Research methodology

We investigate if different landing fees per flight are charged to airlines, how the airlines may adjust their service frequency and aircraft size in a duopoly market, and whether it is possible that airlines may choose to use larger aircraft and less service frequency so that airport congestion and delay could be alleviated. Our research is confined to airlines' strategic decisions at a market level, which is different from airlines' decisions for daily operations in the network level.[2]

Airlines are assumed to be profit maximizers—they make their own best operation decisions to achieve the maximum profit. We consider competition as an important factor, and build our model in a market setting with two airlines competing with each other. Our analysis framework is based on a game-theoretic competition model, which has two basis: the cost function and the market share model, together capturing the differences in cost and in market share for airlines using different aircraft size and service frequency when different landing fees are charged. The impact of landing fees on airlines' decision of aircraft size and service frequency is determined by both the cost function and the market share model. We directly apply the cost function and the market share model derived from previous studies of the cost economics of aircraft size (Wei and Hansen, 2003) and of market share modeling (Wei and Hansen, 2005) for airlines that use different aircraft size and service frequency in a competitive environment.

2.1. Cost function and market share model

A de-mean translog model is used by Wei and Hansen (2003) to specify the airline cost function, which relates airlines' direct operation cost per flight to aircraft size, stage length, unit fuel cost and unit labor cost. The model is calibrated using the data from the first quarter of 1987 to the fourth quarter of 1998 for the 10 largest US airlines in

[2]For daily operations, most airlines make decisions on aircraft size and service frequency for each segment based on the computer models of "fleet assignment" and "capacity planning". The core of "fleet assignment" is an optimization model for maximizing airlines' profit constrained by aircraft availability and scheduling feasibility. The core of "capacity planning" is a forecasting model for airlines to evaluate the effect of their market share and revenue resulting from certain aircraft type, service frequency, and type of service (non-stop vs. connection) in each market.