Transportation Research Part B 65 (2014) 77–89

Contents lists available at ScienceDirect

Transportation Research Part B

journal homepage: www.elsevier.com/locate/trb

Airport congestion pricing when airlines price discriminate

Achim I. Czerny [a,*], Anming Zhang [b,c]

[a] WHU – Otto Beisheim School of Management, Germany
[b] University of British Columbia, Canada
[c] China Academy of Financial Research, Shanghai Jiao Tong University, China

A R T I C L E   I N F O

Article history:
Received 30 December 2013
Received in revised form 2 April 2014
Accepted 3 April 2014

Keywords:
Airport pricing
Congestion
Carrier price discrimination
Second-best

A B S T R A C T

This paper extends the literature on airport congestion pricing by allowing carriers to price-discriminate between the business and leisure passengers when operating costs are the same for all passengers. The main results are: First, the second-best discriminating business fare exceeds the first-best uniform fare (which equals the external part of the marginal congestion costs), while the second-best discriminating leisure fare is lower than the first-best uniform fare. Second, the optimal airport charge implements the first-best uniform or second-best discriminating fares. Importantly, this charge can always be higher than what would be expected when all passengers were treated as having the same time valuation. This result provides some support to the finding that the welfare losses associated with an atomistic airport congestion charge may be low.

1. Introduction

For most parts of the last decade, air travel delays have been a major problem in many countries.[1] Ball et al. (2010) studied the economic impact of air travel delays in the US, and found that the cost of flight delays in 2007 is $31.2 billion. While the causes of delays can vary from country to country, the volume of traffic relative to airport capacity (mainly runways) is a major cause. In effect, the US Department of Transport identified airport congestion reduction as its No. 2 top management challenge, only second to aviation safety (USDOT, 2008c).

To manage airport congestion, economists have advocated the use of price mechanism, under which landing fees are based on a flight's contribution to congestion.[2] The early congestion-pricing models by, for example, Levine (1969), Carlin and Park (1970) and Borins (1978) were developed along a line similarly to dealing with road congestion. As such, flights (individual drivers) were treated as atomistic. The more recent literature recognized that the "atomistic" assumption may not hold for flights, since a congested airport is usually dominated by a few carriers, each of which runs a large number of flights at the airport and has market power. With the non-atomistic assumption the literature showed that carriers may themselves internalize congestion, and so the welfare-optimal airport charge should be reduced relative to the level where carriers were treated as atomistic (e.g., Daniel, 1995; Brueckner, 2002; Pels and Verhoef, 2004; Zhang and Zhang, 2006; Basso, 2008; Silva and Verhoef, 2013). Essentially, unlike each individual road driver who does not take external congestion (the congestion she imposes on other drivers) into account in her driving decision, a large airline might, in its flight decision, take into account

* Corresponding author. Tel.: +49 2616509223.
E-mail addresses: achim.czerny@whu.edu (A.I. Czerny), anming.zhang@sauder.ubc.ca (A. Zhang).

[1] Twenty percent of airline flights in the United States were delayed between 2000 and 2007. (A flight is considered as delayed when the actual arrival time exceeds the scheduled arrival time by more than 15 min.) Similar delays have plagued European and Asian airlines and airports. In China (the world's second largest air transport market behind the US) for example, more than thirty percent of its domestic flights were delayed in recent years.

[2] The US Department of Transport has, since 2008, allowed US airports to charge peak-period landing fees in addition to weight-based fees (USDOT, 2008a,b).

http://dx.doi.org/10.1016/j.trb.2014.04.004

the fact that scheduling one more flight generates extra congestion costs to its other flights and its passengers. Further, the larger a carrier's market share is, the greater it internalizes such flight congestion, leading to an inverse relationship between the optimal airport charge and market concentration (carrier market shares).

While these studies concentrate on uniform time valuations by passengers (and uniform airline fares), Czerny and Zhang (2011) and Yuen and Zhang (2011) recognize that passengers may have different time valuations. Particularly, Czerny and Zhang consider two passenger types: business passengers and leisure passengers, with business passengers exhibiting a high time valuation relative to leisure passengers.[3] They derive the welfare-optimal airport charge in this environment for uniform airfares.[4] A major insight of their analysis is that the incentive to internalize self-imposed congestion may be too low from the social viewpoint because the carriers are concerned with the "marginal" passenger's time valuation (i.e., the average time valuation of incremental passengers) rather than the average time valuation.[5] Importantly, this implies that the optimal airport charge can be higher than what would be expected when all passengers are assumed to have the same time valuation. Basically, an increase in the airport charge can improve welfare by protecting the high-time-value passengers from excessive congestion caused by the low-time-value passengers.

The literature on airport congestion pricing has so far assumed away the possibility that airlines may engage in price discrimination. Airlines nonetheless are a frequently used example for markets where price discrimination is prevalent (e.g., Borenstein, 1985; Dana, 1999a,b; Cowan, 2007). In a recent study, Lazarev (2013) found that leisure passengers start searching for a ticket at least six weeks prior to flight departure, while business passengers typically search in the last week. Thus airlines can use advanced-purchase rebates to price-discriminate between the business and leisure passengers, and charge business passengers a high fare relative to leisure passengers (e.g., Stavins, 2001; Hazledine, 2006). Czerny and Zhang (2014) developed a model that captures carrier third-degree price discrimination between the business and leisure passengers when their demands are interdependent because of airport congestion. They pointed out that a uniform fare is needed to implement the first-best solution. The economic intuition is that a passengers's congestion effect on all the other passengers is independent of her own time valuation. Consequently, the congestion externality to be internalized by fares is independent of the passenger type.

The present paper derives the socially optimal airport charge when airline price discrimination is allowed and all markets are covered. It further compares the first-best outcomes (under uniform pricing) with the second-best outcomes when carriers price-discriminate between the business and leisure passengers.[6] To accomplish these objectives, Czerny and Zhang's (2014) model, which concentrates on a monopoly airline, is extended in order to analyze the following two-stage game: the airport chooses its charge to maximize welfare in the first stage. In the second stage carriers compete, in a Cournot fashion, in the business-passengers and leisure-passengers markets subject to a *price-difference constraint*. This constraint implies that business passengers are charged with an exogenous premium on the leisure fare, and a simple comparative-static analysis between business and passenger fares in the premium added to the leisure fare can be used to identify the effect of price discrimination on business and leisure fares relative to the uniform fare. While the price-difference constraint is commonly used to compare the pricing behavior under uniform pricing and third-degree price discrimination (e.g., Leontief, 1940; Schmalensee, 1981; Varian, 1985; Holmes, 1989; Aguirre et al., 2010), to our best knowledge it has yet been used in a framework where firms compete in a Cournot fashion.

Two main insights are derived from this analysis: First, the second-best discriminating business fare exceeds the first-best uniform fare, while the second-best discriminating leisure fare is below the first-best uniform fare. Second, the second-best fares can be implemented by the right choice of the airport charge, while carrier price discrimination has no direct effect on the structure of the optimal airport charge. This second result is true in the sense that the effect of the time-valuation difference on self-internalization and thus the optimal airport charge is largely independent of whether carriers engage in price discrimination or just charge uniform fares. With or without price discrimination, therefore, an increase in the airport charge can improve welfare by protecting the high-time-value passengers from excessive congestion caused by the low-time-value passengers. The result is important as it shows that the relationship between airport charges and time valuations found in Czerny and Zhang (2011)—who abstracted away airline price discrimination—is robust with respect to the carriers' pricing behavior. Furthermore, this result provides some support to Daniel (1995, 2001, 2011), Daniel and Pahwa (2000), Daniel and Harback (2009) and Morrison and Winston (2007), who find that the welfare losses may be low if policy makers just implement the atomistic airport charge (i.e., the optimal airport charge that would be chosen as if carriers were atomistic).

The paper is organized as follows. Section 2 presents the main model specifications. Section 3 analyzes the social maximizer's pricing behavior. Specifically, this section introduces the price-difference constraint in order to analyze the relationship between the first-best uniform and second-best discriminating fares. The carrier's equilibrium pricing behavior

[3] For empirical evidence of this time-valuation difference, see e.g. Morrison (1987), Morrison and Winston (1989), USDOT (1997) and Pels et al. (2003).

[4] Yuen and Zhang (2011) assume that time valuations are positively correlated with the passengers' willigness to pay and consider the peak and off-peak periods, while Czerny and Zhang (2011) concentrate on a static framework. In addition, Daniel (2001) captures that time valuations may be different between aircraft.

[5] Note that the marginal passenger's time valuation refers to the average time valuation of incremental passengers. Since delays can be considered as a quality dimension for passengers, this is consistent with the analysis by Spence (1975) and Sheshinski (1976), which shows that monopoly suppliers are concerned with the marginal consumer's quality valuation, while the social maximizer is concerned with the average quality valuation (Zhang and Czerny, 2012).

[6] Second-best congestion pricing for roads has been investigated by, for example, Verhoef et al. (1996).