Journal of Urban Economics 80 (2014) 13–27

Contents lists available at ScienceDirect

Journal of Urban Economics

www.elsevier.com/locate/jue

Airlines' strategic interactions and airport pricing in a dynamic bottleneck model of congestion

Hugo E. Silva *, Erik T. Verhoef, Vincent A.C. van den Berg

Department of Spatial Economics, VU University Amsterdam, De Boelelaan 1105, 1081 HV Amsterdam, The Netherlands
Tinbergen Institute, Gustav Mahlerplein 117, 1082 MS Amsterdam, The Netherlands

ARTICLE INFO

Article history:
Received 22 May 2012
Revised 9 August 2013
Available online 4 September 2013

JEL classification:
H21
H23
L93
R48
D62

Keywords:
Airport pricing
Congestion
Bottleneck model

ABSTRACT

This paper analyzes efficient pricing at a congested airport dominated by a single firm. Unlike much of the previous literature, we combine a dynamic bottleneck model of congestion and a vertical structure model that explicitly considers the role of airlines and passengers. We show that a Stackelberg leader interacting with a competitive fringe partially internalizes congestion, and that there are various toll regimes that induce the welfare maximizing outcome, widening the set of choices for regulators. In particular, charging the congestion toll that would apply for fully competitive carriers and that ignores any internalization, to both the leader and the fringe, yields the first-best outcome.

© 2013 Elsevier Inc. All rights reserved.

1. Introduction

As congestion at major airports worldwide continues to increase and traffic approaches existing capacities, implementing policies aimed at reducing delays effectively is becoming essential. For example, in the first half of 2007, 30% of commercial flights in US arrived more than 15 min late, and similar figures hold for European airports (Rupp, 2009; Santos and Robin, 2010). Policies to solve the congestion problem have been extensively discussed during the last decades. One alternative is capacity enlargements, but these have the drawback of bringing benefits only after a long period of time, and at a relatively high cost (see Jorge and de Rus, 2004 for a cost-benefit analysis). Another option is congestion pricing, perhaps the most discussed policy in the academic economics literature, often heavily inspired by the road pricing literature.[1] However, governments, regulators and airports have not followed this path. The current practice at many airports is to levy weight-based landing fees, a rule that has been criticized since early contributions by Levine (1969) and Carlin and Park (1970), who were the first to argue that these charges provide wrong incentives and lead to inefficiencies. Despite of four decades of theoretical and empirical contributions calling for implementation of efficient landing and takeoff charges based on economic principles, airport pricing schemes have been kept remarkably unchanged. But, as delays are reaching critical levels and other negative externalities, such as pollution and noise, are becoming more important, congestion pricing is likely to turn into a serious option for governments and regulators.[2] This policy may be specially appealing because landing fees are already in place, and only changes are needed in the way that they are charged. Moreover, in some countries, such as the US, landing fees are allowed to vary by time of the day, a fundamental feature of an efficient congestion pricing scheme.

It is now widely agreed that the vast literature on road congestion pricing may not be directly applicable to airports, because airlines are non-atomistic players, in contrast to road drivers. Carriers have market power and have non-negligible shares of the overall traffic and, as a consequence, they can be expected to internalize the congestion imposed on themselves. Daniel (1995) was the first

* Corresponding author at: Department of Spatial Economics, VU University Amsterdam, De Boelelaan 1105, 1081 HV Amsterdam, The Netherlands.

E-mail addresses: h.silvamontalva@vu.nl (H.E. Silva), e.t.verhoef@vu.nl (E.T. Verhoef), vberg@feweb.vu.nl (V.A.C. van den Berg).

[1] Quantity-based approaches to congestion management are also being discussed as an alternative. See Brueckner (2009), Basso and Zhang (2010) and Verhoef (2010) for analyses on slot sales and slot trading.

[2] Congestion pricing can be a second-best solution for environmental externalities. See, for example, Carlsson (2003) for an analysis of airport pricing with congestion and emissions, and Brueckner and Girvin (2008) for an investigation of airport noise regulation.

0094-1190/$ - see front matter © 2013 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.jue.2013.08.002

to recognize this, and Brueckner (2002) and Pels and Verhoef (2004) analyzed the problem assessing the internalization of congestion with theoretical models. Subsequent works by Brueckner (2005), Zhang and Zhang (2006) and Basso and Zhang (2007) extend the analysis. The main conclusion regarding congestion pricing, based on static models of congestion, is that carriers competing in a Cournot-Nash fashion internalize self-imposed congestion and, therefore, should be charged for the fraction of congestion that they impose on others. This leads to a congestion charge that depends on the rivals' market share at the congested airport, and, therefore, may be perceived as inequitable, as dominant airlines should face lower charges than small carriers.

The contribution of this paper is to provide clear-cut insights into and understanding of airlines' strategic interactions and airport congestion pricing in a model of dynamic congestion. We recognize the vertical nature of aviation markets, thus explicitly including the role of the airport's tolls on the airlines' behavior, and incorporating that airlines compete taking these into account, while facing the passengers' demand for trips. We use the deterministic bottleneck model of congestion developed by Vickrey (1969) and Arnott et al. (1990, 1993). This allows for an analysis that balances analytical tractability and the inclusion of behavioral decisions that we believe are essential: airlines endogenously adjust departure or arrival rates, trading off queuing delays and schedule delays, and passengers dislike queuing and schedule delays in a different manner than airlines (i.e. at different shadow prices). By combining these two modeling features, we have a structural model of dynamic congestion that allows for an analysis of the firms' inefficiency in terms of the number of flights as well as the scheduling, and, as a consequence, allows for a derivation of the optimal policy that deals with both. We focus on sequential competition between a Stackelberg leader and a competitive fringe. The model set-up is consistent with the empirical findings of Daniel and Harback (2008), who show that observed traffic patterns at most of the major US airports are consistent with the dynamic bottleneck model of congestion, and that most of the US hub airports seem best described by competition between a Stackelberg leader and a competitive fringe.

Our main result is that, while the (untolled) equilibrium is fully consistent with what previous literature with static congestion suggests, first-best congestion pricing is not. In particular, when a Stackelberg leader faces a competitive fringe, the equilibrium is fully consistent with static models in that the fringe does not internalize any congestion, and in that the leader's ability to exert market power and to internalize self-imposed congestion depends critically on the assumed substitution pattern (just as in Brueckner and Van Dender (2008)). On the other hand, we find that the first-best optimum can be decentralized with a pricing policy that consists of a market power subsidy for the leader, that is indeed a function of the assumed substitution pattern, and a congestion toll for both agents that is independent of whether internalization occurs in the untolled setting. We show that charging the congestion toll that is derived for the fully atomistic carriers to both leader and fringe always yields the first-best outcome. This is because the subsidy deals with the leader's overpricing due to market power, and the time-varying congestion toll eliminates queuing and provides the right incentives to take into account the delays imposed on the rival airlines. We further show that there are various alternative toll regimes that also attain the first-best, dealing with the congestion inefficiency in yet different ways, while still correcting for the market power exertion. Again, the congestion component of all toll regimes is independent of the degree of internalization by the leader in the unregulated equilibrium.

The results of this paper suggest that optimal congestion pricing may have a more significant role on airports than what has been suggested in the literature before. The congestion pricing scheme that is obtained for fully atomistic carriers induces the first-best outcome, and results in a revenue for the airport that restores the well known self-financing result for congested facilities: the ratio between first-best capacity investment costs and total revenue from congestion pricing equals the degree of economies of scale in capacity provision (Mohring and Harwitz, 1962).[3] In addition, our results suggest that the political feasibility of optimal congestion pricing would be enhanced, as the (first-best) atomistic congestion charges do not vary across airlines and therefore are less likely to be perceived as inequitable. Finally, the fact that there are several tolling regimes that yield the social welfare maximizing outcome widens the set of choices for regulators.

Our analysis contributes to the policy analysis on congested airports and extends previous literature that considers dynamic congestion at airports. Works such as Daniel (1995, 2001) and Daniel and Harback (2008, 2009) focus on cost minimization of scheduling flights, hence ignoring the passengers' role in the problem, or at least treating that role only implicitly. Moreover, most of these papers aim at testing whether the observed patterns of arrivals and departures of flights support the internalization hypothesis. Daniel (2009) analytically studies the conditions under which dominant airlines internalize self-imposed congestion with a deterministic bottleneck model, focusing on Stackelberg-fringe competition, but omits the passengers in the model, hence ignoring the fact that airlines use the airport as an input to sell an output in a downstream market. By combining the bottleneck congestion model with the explicit consideration of two groups of agents (airlines and passengers) in a theoretical model, we are able to study key elements that were not present in previous exercises with dynamic congestion. These include an analysis on how airlines set the ticket price according to the time of departure, a derivation of an explicit relation between the internalization of congestion and the assumed passengers' demand substitution pattern between airlines, and a clear comparison between the results derived in models of static congestion and the results obtained with dynamic congestion. We are also able to study the implications, for the optimal pricing policy, of the strategic interaction between the leader and the fringe, finding that there is a set of various pricing schemes that maximize social welfare, as opposed to a single optimal congestion toll .[4] Finally, our analysis complements the findings of Brueckner and Van Dender (2008) and Silva and Verhoef (2013) who show that congestion charges can be optimally close to the atomistic charges depending on the assumptions on the prevailing market structure.

Our results have to be qualified according to our assumptions. Naturally, the dynamic bottleneck model is not directly applicable when queuing is not necessary or helpful for airlines in order to obtain a certain arrival time, as in fully slot-constrained airports. This is because the airport's regulator directly controls the timing through slot allocations. For this case, more common in European airports, an analysis of slot sales and slot trading is more pertinent (see Brueckner, 2009). We also assume that airlines and passengers share a most desired time of arrival or departure, and that airlines are homogeneous in values of time. The model can be straightforwardly extended in these directions following the road pricing literature.[5] Lastly, we use the deterministic version of the bottleneck model for analytical simplicity. A stochastic version that does not require at-

[3] We also show how the market-power exertion has to be corrected, finding insights that are consistent with those in the previous literature, and that this overturns the self-financing result if market-specific subsidies are drawn from the airport budget.

[4] Daniel (2009) recognizes that the dynamic atomistic toll charged to all airlines induces the welfare maximizing output in his scheduling model, but he does not analyze the leader's response to the fringe behavior when facing the toll, and therefore does not find alternative schemes. He also omits the passengers' role in the analysis, and our behavioral model seems to match his set of assumptions only when leader and fringe serve independent markets whose demands are related only through congestion.

[5] The original model by Vickrey (1969) analyzes heterogeneity in desired arrival time. For heterogeneity in values of time see e.g. Vickrey (1973), Arnott et al. (1994) and van den Berg and Verhoef (2011).

Download English Version:

https://daneshyari.com/en/article/970740

Download Persian Version:

https://daneshyari.com/article/970740

Daneshyari.com