Transportation Research Part A 62 (2014) 3–19

Contents lists available at ScienceDirect

Transportation Research Part A

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

Air transport liberalization and airport slot allocation: The case of the Northeast Asian transport market

Nicole Adler [a,*], Xiaowen Fu [b], Tae H. Oum [c], Chunyan Yu [d]

[a] School of Business Administration, Hebrew University of Jerusalem, Israel
[b] Institute of Transport and Logistics Studies, University of Sydney, Australia
[c] Sauder School of Business, University of British Columbia, Vancouver, Canada
[d] College of Business, Embry-Riddle Aeronautical University, USA

ARTICLE INFO

Article history:
Available online 28 February 2014

Keywords:
Airlines
High-speed rail
Competition
Network game
Slot allocation
North East Asia

ABSTRACT

We develop a differentiated Bertrand high speed rail and airline network game which analyzes the effects of international air transport liberalization, regional open skies policies, domestic inter-modal competition and airport slot allocation. The model is applied to the transport market in Northeast Asia using a counter-factual approach, demonstrating the model's capability of evaluating practical policies utilizing market data observed on the routes under investigation. Our modeling results suggest that air transport liberalization will benefit both consumers and the aviation industry in the region albeit not necessarily on an equal basis across or within groups. Much of the welfare gains are derived from higher frequency after liberalization, which increases service quality, hence consumer utility. Open skies policies that include pure cabotage which permit carriers to compete in the domestic markets of a foreign country, will increase competition, frequency and reduce fares below current levels. Airport slot allocation policies play an important role in the realization and distribution of potential welfare gains related to liberalization. Therefore, government agencies should implement liberalization and airport slot allocation policies jointly.

1. Introduction

International air transport operates within the framework of the 1944 Chicago Convention, under which airlines' commercial rights on international routes are governed by bilateral air services agreements (ASAs) between each country-pair. These ASAs regulate a wide range of conditions related to the provision of international air services, including air freedoms, capacity limitations, tariff approval and airline designation. Over the last three decades, deregulation and liberalization have become the worldwide trend, moving towards open-skies agreements or liberalized ASAs in which restrictions on price, seat capacity and entry are removed or relaxed. Numerous studies have shown that deregulation and liberalization have brought significant welfare gains and economic growth. Notable examples include Encanoua (1991), Dresner and Tretheway (1992), Pedro (1995), Mawson (1997), Dresner and Oum (1998), Oum (1998), Graham (1998), Clougherty et al. (2001), Zhang and Chen (2003) and Fu et al. (2010). However, only about 31% of the country-pairs with non-stop services had embraced liberalization by 2006 (ICAO Secretariat, 2007), though the world's first liberalized bi-lateral agreement between the Netherlands and US took place as early as 1992. The negotiations towards liberalizing ASAs involve a lengthy political process, even

* Corresponding author.
E-mail address: msnic@huji.ac.il (N. Adler).

http://dx.doi.org/10.1016/j.tra.2014.02.003
0965-8564/

among countries with strong economic and political ties. One major challenge in such a process is the different expectations of stakeholders with regard to the effects of alternative liberalization policies. Most studies on liberalization are *ex post* evaluations based on observed market data (Encanoua, 1991; Oum et al., 1993, 2000; Schipper et al., 2002; Zhang and Chen, 2003; Micco and Serebrisky, 2006; Booz Allen Hamilton Ltd., 2007; Button, 1998, 2006; Intervistas, 2006; ICAO, 2007). The studies offer valuable insights on the effects of particular policies already adopted. Nevertheless, these studies do not provide a priori guidance to governments in formulating their own policy, since each country has a unique aviation industry in terms of home carrier competitiveness, input prices, domestic market size and competition, geographic location of hub airports, and availability of alternative modes of transport. Therefore, there is a need to develop an equilibrium model with which one can quantify and predict market outcomes under alternative policies, *ex ante*.

Three general approaches have been adopted to model airline competition and network rivalry, namely the analytical, econometric and computational network approaches. The analytical approach typically models airline competition over a single origin–destination (OD) pair or simplified/stylized networks, such that closed form solutions can be obtained. Sample studies include those on airline network rivalry and price competition (Brueckner et al., 1992; Zhang and Wei, 1993; Oum and Yu, 1995; Zhang, 1996; Hendricks et al., 1997, 1999; Adler and Hanany, 2013), on airport competition and airport pricing (Pels et al., 2001; Fu et al., 2006) and on airline scheduling (Brueckner, 2004; Schipper et al., 2007). These analytical models are mathematically tractable in order to draw clear intuition. However, mathematical tractability often limits the applicability of these models to large-scale, complex networks. Gillen et al. (2002) apply this approach to develop an economic model in which the market outcomes are simulated over alternative liberalization policies. However, their model is derived under restrictive assumptions such as perfectly competitive markets and homogeneous airline services. Furthermore, as with most analytical studies, their model solves each OD pair individually, thus network effects are not explicitly considered.

When detailed data are available, the econometric approach can be applied to estimate dynamic oligopoly models. Sample studies on the aviation industry include Berry (1990, 1992), Berry et al. (2006), Lederman (2007) and Aguirregabiria and Ho (2012). Since parameters are empirically estimated for airlines competing over aviation networks, these models reflect the reality in the market with minimal regularity assumptions. Therefore they are ideal modeling tools for practical policy investigation. However, econometric estimation requires extremely rich and detailed data, which are rarely accessible other than in the US domestic market.[1] As a result, few liberalization studies using this approach are available in the public domain. In addition, since there is no data for potential entrant airlines prior to serving the routes under investigation, it is not straightforward to use such models to investigate the effects of liberalization *ex ante*.

The computational network approach, as adopted in this paper, follows similar modeling principles as the analytical approach. However, with the integration of optimization leading to numerical solutions, this approach is capable of handling relatively large scale airline networks. Example studies include those proposed by Hong and Harker (1992), Dobson and Lederer (1993), Lederer and Nambimadom (1998), Adler (2001, 2005), Yan and Wang (2001), Hsu and Wen (2003), Adler and Smilowitz (2007), Yang (2008) and Adler et al. (2010). In particular, Hansen (1990) developed an *n*-player, non-cooperative game in which the airline's sole strategy set is frequency of service. The airlines are split into two categories: hub airlines and point-to-point (or fully-connected) airlines. Hansen could not prove the existence of equilibrium and his application to the US air transportation industry showed 'quasi-equilibrium'. Hong and Harker (1992) developed a two-stage, game-theoretic representation of an air traffic network market mechanism that analyzes slot allocation issues. Using a quasi-variational inequality approach to solve a Cournot–Nash model analyzing oligopolistic airlines, they prove the existence of a unique solution and solve for a three-node example. Dobson and Lederer (1993) developed a mathematical program to study the competitive choice of flight schedules and route prices by airlines operating in a single hub system. Utilizing a sub-game perfect Nash equilibrium for a two-stage game, they found equilibrium in a five-node network example. Adler (2001) evaluates an airline profit function via a two-stage, Nash, best-response game. The research develops a methodology that searches for equilibria in the air-transportation industry and attempts to evaluate the most profitable hubs for an airline to survive in a deregulated environment. In Adler (2005) and Adler et al. (2010), an airline profit maximizing objective function was developed containing a discrete choice model, in which each airlines' market share was computed based on a function of frequency, airfare, value of time and the decision variables of the other airlines. In particular, Adler et al. (2010) extend the method to examine the European-wide high speed rail network where competition with airlines are possible, reaching the conclusion that a network based study is important to increase the accuracy of cost-benefit analyses.

The most recent, and the only network based study on air transport liberalization we are aware of, is proposed by Li et al. (2010). This paper develops a model for optimizing the allocation of additional routes in a liberalizing airline market in the presence of airport capacity constraints. The model captures the interactions among three types of agents: a regulator who maximizes social welfare by allocating additional routes to competing carriers, airlines who compete for demand using flight frequency and airfare, and passengers who minimize travel disutility. The route allocation model is formulated as a binary integer program and is solved by an implicit enumeration heuristic for a three node market. The paper is useful to analyze government policy and airline competition in a progressively liberalized aviation market, however, the assumption of a single regulator maximizing overall social welfare across all countries involved is not sufficiently accurate when analyzing international markets. Moreover, while airport capacity constraints are considered in the model, the quasi-variational inequality approach implies that all airlines receive the equivalent marginal value from airport slots in equilibrium. This does

[1] Virtually all research quoted here have used data drawn from the U.S. domestic market.