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Airline market structure and airport efficiency: Evidence from major Northeast Asian airports

Hun-Koo Ha [a], Yulai Wan [b], Yuichiro Yoshida [c], Anming Zhang [b,d,*]

[a] Asia-Pacific School of Logistics, Inha University, Incheon, South Korea
[b] Sauder School of Business, University of British Columbia, 2053 Main Mall, Vancouver, BC V6T 1Z2, Canada
[c] National Graduate Institute for Policy Studies, 7-22-6, Roppongi, Minato-ku, Tokyo 106-8677, Japan
[d] China Academy of Financial Research, Shanghai Jiao Tong University, Shanghai, China

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A B S T R A C T

This paper investigates the impact of airline market structure on airport productivity, in which airlines are viewed as downstream users of an airport in a vertical airport–airlines structure. Our estimation is based on a sample of eleven major airports in Northeast Asia. A standard two-stage approach is employed: In the first stage, efficiency of the airports is measured by both the data envelopment analysis and stochastic frontier analysis. The resulting efficiency scores are carried over to a second-stage analysis in which Tobit regression is conducted to quantify the impact of airline concentration on efficiency, controlling for such factors as airport governance structure, airport competition and other characteristics. We find an inverse U-shaped relationship between airport efficiency and downstream airlines' market concentration: i.e., either too much or too little downstream concentration is associated with airport inefficiency. Other interesting and useful results are also obtained and discussed.

1. Introduction

A central insight of recent research on airports is that airport economics and policy should incorporate strategic interactions between airlines with market power, thereby requiring examination of airports and airline services in an integrated manner. This is in contrast to the traditional approach in which an airport directly faces the demand of final consumers (passengers and shippers), thus by-passing airlines operating at the airport. This approach is valid provided that the carrier market is perfectly competitive (Basso and Zhang, 2007). As argued by Borenstein (1991), Daniel (1995), Brueckner (2002) and others, airlines at major hub airports usually have market power. This, together with the observation that an airport usually chooses its capacity and charge prior to the airlines' decisions, lead to the vertical structure approach: as a transportation infrastructure facility, an airport reaches its final consumers both directly – via passenger and cargo terminals – and indirectly through air carriers (runways, terminals, and so on). For the latter, an airport is an input provider to the downstream firms (airlines) that compete with one another in the air travel market.[1]

In addition to the carrier market structure, the contractual relationship between an airport and its airlines is another important aspect of the airport–airlines interaction in which downstream users (airlines) can influence the airport's performance. The literature focuses on the competition and welfare implications of cooperation between airlines and airports, as the growing trend of airport commercialization and privatization may raise airports' incentives to offer exclusive or preferential terms to their dominant airlines to reduce the risk of failing to self-finance the operating and capital expenses. This in turn leads to possible anti-competitive concerns at the carrier markets. Barbot (2011) modeled three types of contracts between an airport and its dominant airline: *de facto* vertical merger, the dominant airline being the terminal operator, and two-part tariff, whereas Fu and Zhang (2010) and Zhang et al. (2010) modeled concession revenue sharing between airport and airlines. Other studies accounting for vertical airport–airline integrations include Basso (2008) and Barbot (2009), but these do not consider various clauses and terms stated in a typical airport–airline agreement.

We investigate whether and how downstream airlines' market structure at an airport explains the differences, if any, in efficiency performance of the airports. It remains unclear at the theoretical level how the market structure of downstream carriers would affect airport efficiency performance. We employ a new data set with eleven major airports in Northeast Asia for the period of 1994–2011. The airports are Tokyo (Narita and Haneda), Osaka

* Corresponding author. Sauder School of Business, University of British Columbia, 2053 Main Mall, Vancouver, BC V6T 1Z2, Canada. Tel.: +1 604 822 8420; fax: +1 604 822 9574.
E-mail address: anming.zhang@sauder.ubc.ca (A. Zhang).

[1] See Basso and Zhang (2007) and Zhang and Czerny (2012) for comprehensive literature surveys.

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(Kansai and Itami), Seoul (Incheon and Gimpo), Beijing Capital, Shanghai (Hongqiao and Pudong), Guangzhou and Hong Kong airports. A standard two-stage approach is applied: In the first stage, performances are measured by both the non-parametric method and the parametric method – with the former being data envelopment analysis (DEA) and the latter stochastic frontier approach (SFA). The obtained efficiency scores are carried over to a second-stage regression analysis for estimating the impact of airline market structure on efficiency scores. After controlling for such factors as airport governance structure, airport competition and other airport characteristics, we uncover an inverse U-shaped relationship between an airport's efficiency and the market concentration of airlines operating from the airport: i.e., either too much or too little airline concentration is associated with airport inefficiency. Other interesting and useful results are also obtained and discussed in Section 4.

Assessment of airport productivity has become the focus of numerous studies. Different methodologies have been used to measure productivity of airports, including the widely used the DEA and SFA approaches.[2] Liebert and Niemeier (2013) provide a comprehensive literature review on various methods for airport efficiency measures, including both DEA and SFA. They list major influential factors of airport efficiency studied so far, including airport governance structure, airport competition, outsourcing, non-aeronautical activities, hub or scale effects and traffic composition. However, none of the existing efficiency studies have explicitly investigated the impact of carrier market structure on airport efficiency.[3]

2. Methodology

We start with a simple model to illustrate how airport efficiency can be linked to airline market structure. Consider one congestible airport at which n identical airlines provide homogenous flight service. The passenger (inverse) demand faced by airlines is a function of air travel quantity: $\rho = a - \gamma \cdot Q$, where $Q = \sum_{i=1}^{n} q_i$, the sum of quantities across all airlines. At the demand equilibrium, ρ must equal the "full price" paid by traveling passengers which is the sum of airfare P_i and the cost of congestion delay which is given by $D = \theta Q/K$, where K is the airport's capacity. That is, $\rho = P_i + D$.

Individual airline's profit is: $\pi_i = (P_i - t - c) \cdot q_i$, where t denotes airport charge and c is an airline's operating cost per unit of output. Substituting the passenger demand function into airline's profit, we have

$$\pi_i = (\rho - D - t - c) \cdot q_i. \quad (1)$$

Each airline chooses its quantity to maximize its profit, which leads to the Nash equilibrium airfare as:

$$P_i^* = t + c + \frac{Q}{n}\frac{\theta}{K} + \frac{Q}{n}\gamma. \quad (2)$$

The airport's profit is: $\Pi = (t - c_a) \cdot Q - r \cdot K$, where c_a is the airport's operating cost per unit of output and r is the unit investment cost. Assuming the airport maximizes profit by choosing the airport charge and capacity level, it has been shown in the literature (e.g., Zhang and Zhang, 2006) that at the equilibrium:

$$t^* = c_a + \left(1 + \frac{1}{n}\right) Q \frac{\theta}{K} + \left(1 + \frac{1}{n}\right) Q \gamma, \quad (3)$$

$$\left(1 + \frac{Q}{n}\right) \frac{\theta Q}{K^2} = r. \quad (4)$$

Since the last two terms in (3) are both positive, the airport charges airlines a markup above its operating cost. In equation (2), if $n \to \infty$, i.e. the carrier market is perfectly competitive, airfare will only cover the airlines' operating costs and the airport charge, leaving airlines with zero profit. However, if airlines have market power (i.e. n does not go to infinity), the last two terms in (2) will be positive, leaving airlines with positive profit. As a result, the double-marginalization problem emerges and passengers pay more than they would under the perfect competition scenario, leading to lower airport output level. Regarding capacity investment, however, given a certain output level Q, the equilibrium capacity is the lowest and reaches social optimum when $n \to \infty$, while airlines will over-invest when they have market power. Therefore, when there is no downstream market power, the airport will have a high output level with socially optimal capacity investment. On the other hand, when there is strong downstream market power, the airport's output level would be reduced but it would over-invest in capacity. Airport efficiency thus appears to decrease in airline market power.

Other considerations may however suggest a more complicated relationship between airline concentration and airport efficiency. First off, dominant airlines may help improve airport efficiency by internalizing self-imposed congestion costs. The third term on the right-hand side of equation (2) implies that the level of marginal congestion costs internalized by a carrier is proportional to the carrier's market share. Thus, when an airport is dominated by a small number of large carriers, those carriers may have a strong incentive to reduce congestion which may in turn improve the airport's efficiency.[4] Second, when an airport serves a small number of large airlines, long-term collaboration between the airport and those major airlines is easier to reach and manage than would be if it serves many small airlines. Such close collaboration can effectively reduce the problem of "double marginalization" and consequently, airport charges would be kept low and more traffic would be induced (e.g., Zhang and Zhang, 2006; Basso, 2008; Barbot, 2009). Basso (2008) has further shown that airline-airport coordination is more efficient than non-coordination in the sense that coordination induces more traffic for a given level of capacity but requires less investment to produce a given level of traffic. Third, high airline concentration may facilitate coordination between the carriers and the airport, which in turn allows them to take a larger part in the airport's decision-making. Whether such downstream influence is positive or negative is not immediately clear however, because the alignment of incentives between the airport and its users plays a role as well. When there is a huge conflict of interests, the downstream power may reduce efficiency of the upstream party (airport). In effect, it is the contracts between individual airlines and the airport that determine the impact of downstream users on airport efficiency (Zhang et al., 2010). Fourth, when the carrier market is highly concentrated, by threatening relocating to an alternative airport, large carriers may have strong power which countervails the "monopoly power" of the airport,

[2] Lam et al. (2009) and Adler et al. (2013) offer literature reviews on DEA studies of airport efficiency.

[3] [3] Just prior to the submission of our paper to the Journal, we came across a related paper by Chang et al. (2013). Using the DEA method, Chang et al. examined the technical efficiency of 41 Chinese airports in 2008 and then regressed on factors that affect airport efficiency. The two papers represent independent work. The comparison between our results and their results are given in Section 4.

[4] For example, in the case of runway congestion, when trading off between the number of flights and the aircraft capacity or load factor, the carriers may have an incentive to move more passengers with fewer flights than small carriers, since large carriers save more by cutting back self-imposed congestion. As a result, the airport achieves higher passenger volume without increase capacity.