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Is developing air cargo airports in the hinterland the way of the future?

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ABSTRACT

In this paper, we provide an analytical framework to capture the competition (and cooperation) between gateway and hinterland airports. We first investigate how airport charges at gateway and hinterland airports affect the equilibrium output in passenger and cargo markets. We further consider the Pearl River Delta region in China as a setting to conduct a numerical analysis. We find that the introduction of a hinterland airport is likely to lead to an improvement in the aggregate welfare of the gateway and the hinterland. If the connectivity between the gateway and hinterland airports is improved, then social welfare at the gateway and hinterland, benefits for shippers and passengers, and airport and airline profits at the gateway airport will increase. However, airport and airline profits at the hinterland airport will decrease.

1. Introduction

For decades, major airports around the world have predominantly served passenger markets (Mayer, 2016), and thus their operations and infrastructure were designed primarily to meet the needs of passengers.[1] Such airports are also referred to as "gateway airports".[2] Most gateway airports (and airlines) serve passengers first, with their remaining capacity serving air cargo. This phenomenon can be attributed to the fact that the volume of air cargo is not sufficiently large to reach a critical mass. To a great extent, air cargo plays a complementary role for passengers, filling the excess capacity of aircraft.

Along with cargo growth at gateway airports, costs in the gateway cities have been increasing (reality in most international cities). Consequently, manufacturing and logistics enterprises relocate further into the hinterland, resulting in a growing distance between the manufacturing base and the gateway airport.[3] The longer travel times and added complexities in logistics management are not conducive to the efficient and timely delivery of goods. This expansion creates potential problems for shippers who might look for alternative gateways, modes of transport or relocate their factories in the long run. In response, some governments have built airports in their respective hinterlands – referred to as "hinterland airports" in this paper – dedicated to the transport of airfreight,[4] as hinterland airports can leverage the comparative advantage of their proximity to shippers.[5] Because of the emphasis on freight, most airlines in hinterland airports use airfreight-

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[1] Mayer (2016) identified 17 major international primary hub airports, where cargo is produced mainly as a "by-product" of their passenger operations.

[2] Many major airports, including Hong Kong, Frankfurt and Singapore, can be considered gateway airports in that they serve as international outlets for passengers and air cargo from their regions. Such gateway airports handle two kinds of flows: gateway flows and hub flows (Zhang, 2003). Gateway flows are traffic that move between the gateway and the hinterland via surface transportation. Hub flows use the gateway airport as a hub for other airports (so-called "air to air" flow).

[3] A typical example is the relocation of the manufacturing base from Hong Kong to the PRD Region in China. Additional discussion can be found in Sung (1998) and Zhang (2003).

[4] Instead of building new airports, airfreight-dedicated airports may be transformed from some secondary passenger airports in the hinterland.

[5] In addition to the related to cross borders (see our specific case of Hong Kong-Shenzhen discussed below; and Zhang, 2002), a possible advantage for a hinterland airport to specialize in cargo business is that freedoms of air for cargo are easier to obtain in the bilateral negotiation. For example, air service agreements of Taiwan, the Philippines, Brunei, and Singapore with the US include seventh-freedom traffic rights for cargo. Given the difficulties in liberalizing of the air passenger sector, it has been suggested that the air cargo rights should be liberalized first, through the multilateral services liberalization program of the General Agreement on Trade in Services (GATS) (Zhang and Zhang, 2002a).

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dedicated aircraft (e.g., Boeing's 747-400F/ERF and 777F) but not combination flights, focusing on passenger traffic with cargo traffic as a side business. Therefore, airline operations at hinterland airports might lack synergy between their passenger and cargo businesses, and network coverage may be less comprehensive than that of gateway airports.

In this paper, we develop an analytical model to examine the social benefits of introducing hinterland airports and to analyze the competition and collaboration between the gateway and hinterland airports. The model captures the following features: demand and cost complementarities for the passenger and cargo markets, airline competition, hub/gateway premiums, and intermodal connections. A numerical analysis is conducted using real-life data from the Pearl River Delta (PRD) region in China, where the Hong Kong airport serves as a gateway airport and the Shenzhen airport serves as a hinterland airport. We investigate the following questions: What are the welfare implications of introducing a cargo-dedicated airport in the hinterland for different stakeholders? Should the gateway and hinterland airports cooperate or compete with each other from the social-welfare point of view? How do coordination and competition affect the benefits of the various stakeholders?

From the analytical results, we find that an increase in the charges of an airport decreases its air cargo output but increases the output of the other airport. Furthermore, an increase in gateway airport charges, imposed on either passengers or cargo, decreases passenger output. However, an increase in the cargo airport charge at the hinterland airport increases passenger output at the gateway airport. In the numerical analysis with data for the Hong Kong and Shenzhen airports, we find that the introduction of the hinterland airport likely leads to an improvement in the aggregate welfare of both the gateway and the hinterland. However, after the introduction of a hinterland cargo airport, shippers may be either better off or worse off, depending on a number of factors, including transportation costs, airport charges, demand complementarity between passengers and cargo, scale and scope economies of cargo and passenger operations. Finally, we find that if coordination between gateway and hinterland airports leads to improved connections between the two regions, the social welfare is also improved. In particular, with respect to the gateway and hinterland airports, the shippers and passengers and the airports and airlines at gateway airports will benefit from it, while the airport and airline profits at hinterland airports will decrease. In addition, there will be an increase in the gateway cargo output and the total cargo output, while the hinterland cargo output will decrease.

The remainder of this article is organized as follows. Section 2 reviews the literature. Section 3 sets up the general analytical model, and Section 4 derives analytical results for the gateway and hinterland airport networks using specific functional forms. Section 5 conducts the numerical analysis, and Section 6 discusses policy and managerial implications from the numerical analysis. Finally, Section 7 contains concluding remarks.

2. Literature review

Our work is related to three branches of literature. First, the operation of combination flights has attracted a significant amount of attention in the literature (e.g., Zhang and Zhang, 2002b; Slager and Kapteijns, 2004; Zhang et al., 2004, 2007; Sandhu and Klabjan, 2006; Tang et al., 2008; Wong et al., 2009). In particular, the benefits of operating combination flights have long been recognized (e.g., Gillen et al., 1990; Antoniou, 1991; Zhang and Zhang, 2002b; Hong and Zhang, 2010; Hofer and Eroglu, 2010; Kupfer et al., 2014, 2016). Accordingly, passenger airlines' profitabilities increase with cost volumes, suggesting that complementarities between passenger and cargo may exist (Antoniou, 1991). Hong and Zhang (2010) found that airlines with a high share of cargo business in their overall operations are significantly more efficient than airlines with a low share of cargo business. Kupfer et al. (2014) found that compared with all-cargo carriers, the combination flighters are less impacted by the economic crisis. Given the imbalances between some incoming and outgoing cargo flows (due to trade imbalances), a potential solution is flying in triangles or using belly capacity (Kupfer et al., 2016). However, the role of airports is minimized in these studies, in which only airline operations were considered. Because airlines at the gateway airport provide both passenger and cargo services, the role of airports in supporting combination flights will be addressed in this paper.

Second, our work is also related to the role of air cargo in airline and airport operations; this area has received less attention in the literature (Mayer, 2016), but it has had more attention recently. Jiang et al. (2003) conducted an analysis of future air cargo demand in China and its implications for system infrastructure. Kupfer et al. (2009) used the bankruptcy-forecasting model to analyze the financial health of full freighters, such as Cargolux. Several other studies identified the role of air cargo in airport operations. Mayer (2016) used a hierarchical cluster analysis to identify eight distinct clusters for airports in terms of their cargo activities. Five out of 114 airports were identified as “Cargo-Dependent Europeans” or “North American Cargo Primaries”.[6] Merkert and Ploix (2014) revealed a significant relationship between international freight volumes, terminal organisation and freighter operations at airports. There are also few studies (e.g., Schwieterman, 1994; Zhang, 2003; Gardiner et al., 2005; Ohashi et al., 2005; Bowen, 2004; Chao and Yu, 2013) to look at airport competitiveness, in terms of air cargo. Although the importance of airport in air cargo operation has been identified, there is a lack of theoretical models to investigate the interrelations between airport and air cargo operations. However, it is common for airports to compete with each other for passenger and cargo in the same catchment area, but less research looks at the impact of airport competition on the air cargo industry. This paper aims to address this issue in a theoretical model, which is supplemented with numerical simulations. Our work may also sheds some lights on demand forecast for airport infrastructure facilities for cargo.

Third, the gateway-hinterland infrastructure competition has also been examined in the literature (e.g., Zhang, 2007; De Borger et al., 2008; Yuen et al., 2008). This strand of literature focuses mainly on capacity investment and the pricing of congestible facilities, which serve only passenger traffic. We extend this literature by considering the interaction between the passenger and cargo markets. To the best of our knowledge, no study provides an explicit analysis of the gateway-hinterland airport competition and explicitly considers the two markets and welfare implications for stakeholders.

3. Coordination and competition between gateway and hinterland airports

It is important to investigate how gateway and hinterland airports interact with each other, and what types of interaction would be socially beneficial. Generally speaking, coordination between the two airports could avoid duplication in facility building and improve the utilization of existing facilities. Thus, coordination (or central planning) could achieve the first-best outcome in terms of

[6] The five airports are LEJ, LGG, ANC, MEM and SDF. The mean of cargo as a percentage of the total Work Load Unit (WLU) for the two clusters are 87.5% and 86.7%, respectively.

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