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Airlines' competition in aircraft size and service frequency in duopoly markets

Wenbin Wei [a,*], Mark Hansen [b]

[a] *Department of Aviation and Technology, San Jose State University, One Washington Square, San Jose, CA 95192-0061, United States*
[b] *Institute of Transportation Studies, National Center of Excellence in Aviation Operations Research, University of California, Berkeley, Berkeley, CA 94720, United States*

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Abstract

We are interested in how airlines make decisions on aircraft size and service frequency in a competitive environment. We apply three game-theoretic models to analyze airlines' choices in duopoly markets: one short-haul market and one long-haul market. We study how airlines' choices in a competitive environment may vary with flight distance, and also do sensitivity analysis to explore how the equilibrium results may change when air travel demand is higher, as it may happen in the future.

Our research considers the competition factor in airlines' decisions on both aircraft size and service frequency, and the impact of these decisions on both the cost and demand sides of airlines' business. Different from previous studies, our research is based on cost, market share and demand models derived from empirical studies.

Keywords: Aircraft size; Service frequency; Game-theoretic; Competition

1. Introduction

The airline industry has been changed significantly after the September 11th of 2001. Due to the current economic uncertainties, security concerns and major carriers' reconstruction and reorganization progress, it is still not clear how the airline industry will look like in the near future. But there is no doubt that air travel demand will keep growing and the constraint of airport capacity will still be a challenge to the aviation industry. Since the last decade of the 20th century, passengers, airlines and airports have all been complaining about congestion and delay at major airports in the US. As most airports are already saturated, it's hard to imagine that the congestion problem could be resolved quickly and easily in the next one or two decades in the new millennium.

* Corresponding author. Tel.: +1 408 924 3206; fax: +1 408 924 3198.
E-mail address: wenbin.wei@sjsu.edu (W. Wei).

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Most airlines and airports expect and demand that more new runways should be built to improve airport capacity and to reduce airport congestion and delay. But physical runway expansion is very expensive, difficult and sometimes infeasible due to land use, environmental and economic concerns. In the meantime, there is an alternative often overlooked by the airlines, airport and the policy makers: the airport throughput will be increased if airlines choose, or somehow are forced, to increase aircraft size, rather than increase service frequency, to accommodate the air travel growth. If airlines use larger aircraft, with the same number of service frequency, an airport can serve more passengers. Without any physical runway expansion, flight delay can be reduced through airlines' adjustment of their choices in aircraft size and service frequency, i.e., larger aircraft and less frequency. But currently, the majority of total operations by all jet aircraft in some major airports are by aircraft with fewer than 150 seats, especially in the very high-density markets such as Los Angles–San Francisco.

Boeing and Airbus, the two main aircraft providers, have two different perceptions of future aircraft size. In Boeing's (2005) "Current Market Outlook", the company emphasizes that, to accommodate future air travel growth, airlines will offer more frequencies as a primary form of non-price competition. They forecasts that "the single-aisle airplanes dominate future deliveries", and "the share of 747 and larger airplanes will fall from 6% to 4%" at the end of 2024. At the same time, Airbus's (2005) "Global Market Forecast 2004–2023" predicts that, at the end of 2023, "the very larger aircraft will account for 6% of the world passenger fleet, the same percentage as represented by 747s today", and the "twin-aisle and large aircraft will take a bigger role" in the future. And therefore, the "average seats per aircraft will increase 20% from 181 to 215". Airbus emphasizes that airlines could be forced to use larger aircraft if planned and required airport facilities cannot be completed on time to meet future demand. In practice, Airbus has just delivered their A380, the aircraft with more than 500 seats, while Boeing already gave up their plan of the 747 Jumbo Jet called 747X in year 2002, and is now focusing on its development of the 787, a cost-efficient but conventional jet with 200–300 seats. But we cannot find any description of research methodology that Boeing and Airbus apply in their forecasts of future aircraft size.

In our research, we are interested in exploring how airlines make decisions on aircraft size and service frequency, especially in a competitive environment. The two bases of our research are a cost model and a market share model for airlines using different combinations of aircraft size and service frequency in their operations. Then, we apply game-theoretic models to investigate airlines' choices of aircraft size and service frequency in competitive markets.

Correspondingly, previous literatures on this subject can be classified in three categories: the cost side, the demand side and competition analysis. On the cost side, such literatures as Miller and Sawers (1970), Keeler (1972), Douglas and Miller (1974), Meyer and Oster (1984), Morrison (1984), Bailey et al. (1985), Morrison and Winston (1986), Kirby (1986), and Hansen and Kanafani (1989) study cost economics of aircraft size and focus on how airlines' operation costs vary with different size of aircraft. More recently, based on a translog model, Wei and Hansen (2003) develop an econometric cost function for aircraft operating cost and find that "economies of aircraft size and stage length exist at the sample mean of their data set, and that for any given stage length there is an optimal size, which increases with stage length". The scale properties of the cost function are changed considerably if pilot unit cost is treated as endogenous, since it is correlated with size. And they conclude that "the cost-minimizing aircraft size is therefore considerably smaller, particularly at short stage lengths, when pilot cost is treated as endogenous".

On the demand side, Eriksen (1977), Abrahams (1983), Viton (1986), Russon and Hollingshead (1989), and Coldren et al. (2003) study the role of aircraft size and service frequency in airlines' demand and market share. More recently, Wei and Hansen (2005) build a nested logit model to study the roles of aircraft size, service frequency, seat availability and fare in airlines' market share and total air travel demand in non-stop duopoly markets. They find that "airlines can obtain higher returns in market share from increasing service frequency than from increasing aircraft size".

In general, if there is more than one airline in the market, one carrier's market share and revenue depend not only on its own service but also on the services provided by all other airlines in the market. Thus we need to systematically study airlines' choices of aircraft size in a competitive environment. Researchers started to use theoretical models to analyze airlines' competition in 1970s. Douglas and Miller (1974) study market equilibrium and pinpoint the effect of regulated price on total capacity provided by airlines, and the relationship between price and market structure. Schmalensee (1977) explores further the basic properties of theoretical