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Flight delay impact on airfare and flight frequency: A comprehensive assessment

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ABSTRACT

This paper presents a comprehensive empirical analysis of flight delay impact on airfare and flight frequency in the US air transportation system. We model airfare and flight frequency as functions of cost and demand characteristics, competition effects, and flight delays at origin, destination, and intermediate hub airports. Estimation results confirm that airlines tend to pass delay cost onto passengers through higher fare, whereas delay has an upward effect on flight frequency. We find that proportionate airport delay reduction across the system can result in annual fare reduction in the order of billion dollars.
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1. Introduction

Understanding supply side behavior in the air transportation system has traditionally been an important area and studied extensively in empirical airline economics research. Since the deregulation of U.S. airlines in 1978, continuous air traffic growth, along with market driven competition, has spurred a large body of literature on evaluating factors that affect airfare and flight frequency—two of the most important supply variables in the air transportation system. On the other hand, with world air traffic more than quadrupled between 1978 and 2010 (World Bank, 2013), significant delays have emerged in many places around the globe, and caused airlines and passengers billions of dollars each year (Ball et al., 2010; JEC, 2008; Cook et al., 2004). Air traffic congestion and delay will likely become even more prominent given the projected demand growth in the coming decades (Boeing, 2011). In contrast, how air transportation supply responds to flight delay remains an area with limited empirical investigation.

Flight delay requires the consumption of extra fuel, labor, capital, and other inputs necessary in the airline production process, resulting in higher operating cost to airlines. Hansen et al. (2000, 2001), by developing econometric airline cost functions, for the first time statistically confirm and measure the cost effects of flight delay. Their findings have been further extended by Zou and Hansen (2012a, 2013), which estimate the cost impact of flight delay in a more comprehensive manner. Airlines respond to flight delay and consequent operating cost increase by adjusting fare, flight frequency, and aircraft size. While it is tempting to speculate that airlines transfer their delay cost entirely to passengers through higher fare, theoretical analysis shows that airlines strike a balance between recovering operating cost increase and maintaining demand with travelers' decreased willingness-to-pay due to service quality degradation (Zou and Hansen, 2012b). Similarly, decisions

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on frequency adjustment in response to excessive delays must be weighed against market profitability, aircraft size economics, interactions between demand and frequency (e.g. the Mohring effect and the S-curve relationship), potential loss in pricing power, and network considerations such as fleet assignment and aircraft rotations. It is of critical importance for policy makers to be cognizant of these factors, and able to quantitatively gauge airlines' pricing and frequency scheduling responses to delay and delay mitigation strategies.

The purpose of our study is to enrich the current knowledge base of such responses, through a comprehensive, empirical assessment of the airfare and flight frequency determination in the U.S. air transportation system. Multiple econometric models are developed that enable quantifying the causal effects on fare and frequency of cost and demand characteristics, and market structure, the latter of which encompassing traditional market concentration measures as well as the presence of low-cost carriers (LCCs) and multiple airport systems (MASs). To this end, this study specifies and estimate structural fare and frequency models. A key contribution of our study is the incorporation of flight delays at origin, destination, and connecting airports. In addition, our airfare and flight frequency models are built upon a more inclusive and up-to-date set of routes and flight segments than many existing studies.[1] The estimated results, therefore, are expected to offer a more complete picture of delay impact on airline pricing and frequency scheduling.

One novelty of our study lies on the choice of observation units. While it is straightforward to consider each flight segment as one observation in frequency modeling, in this study we develop airfare models at the itinerary level, for direct and connecting routes separately. This attempt is, to our knowledge, first of its kind.[2] Choosing individual itineraries as the observation units recognizes the intrinsic differences in fare determination—including the impacts of airport delays—between the two types of routes (Belobaba, 2009a). Doing this also allows the impact of economies of segment and hub airport density, competition impact on airfare at the route and market levels, and routing circuity, the latter an important feature of one-stop routes that in effect penalizes airlines for exploiting economies of density, to be explicitly investigated. Therefore, this innovative approach is able to provide more nuanced insights into how various factors affect fare determination, and the extent to which airlines transfer operating cost increase due to delay to passengers through high fare.

Among the many findings, of particular interests are several conclusions about the flight delay impact on airfare and flight frequency. We find that flight delays at origin and destination airports exert statistically significant effects on non-stop route airfare. For connecting routes, only intermediate hub airport delay has an upward effect on airfare. In addition, our estimation results suggest that, controlling for demand, cost, and competition effects, segments with larger airport delays are associated with greater flight frequency. The magnitudes of these effects, however, are rather small, with corresponding elasticities less than 0.06 in all cases. Fare on direct routes is relatively sensitive to airport delays compared to fare on connecting routes, justifying separate consideration of the two types of routes. By analyzing the potential fare response to various counterfactuals with less delay, we also find that fare reduction benefits can accrue to billion dollars per year, the bulk of which result from fare change on non-stop routes.

The paper continues with a review of the key factors in the determination of airfare and frequency, based on which contributions made in this paper are highlighted. Fare and flight frequency models are specified in Sections 3 and 4, respectively, with discussion also covering data, econometric issues, and estimation results. Section 5 carries out counterfactual analysis to examine potential fare reduction benefits to passengers under a set of delay reduction scenarios. Summary of key findings and directions for future research are offered in Section 6.

2. Literature review and contribution of the research

2.1. Fare

The majority of the previous research on airline pricing behavior has been focused on the relationship between average fare and market structures (Gillen and Hazledine, 2010). Factors considered include individual airlines' market share, route and endpoint airport concentration (impacts of which are sometimes referred to as "hub premiums"), and LCC competition (e.g. Bailey et al., 1985; Borenstein, 1989; Brueckner, 1992; Dresner et al., 1996; Morrison, 2001; Hofer et al., 2008; Goolsbee and Syverson, 2008; Chi and Koo, 2009; Brueckner et al., 2013; Zou et al., 2011, to name a few). In addition to market structure, demand and cost characteristics are also considered in structural fare model specifications. Instrumental variable regression and simultaneous equation estimation are the commonly used techniques to account for the simultaneity between demand and airfare. On the cost side, the straightforward link between fare and distance has been widely acknowledged. In addition, fuel presents an important component in airline overall cost structure, especially given recent fuel price hikes. Researchers have also paid attention to the existence of the economies of density and its impact on airfare, heretofore at the airline-route level (Brueckner and Spiller, 1994; Berry et al., 1996; Brueckner et al., 2013).

On the other hand, there have been few empirical investigations of how delay affects airfare. Theoretically, flight delay causes aircraft to spend more time either on the ground or in the air, increasing fuel consumption and crew time, resulting

[1] In the present paper, we use "route" to refer to a specific travel itinerary, or path. Therefore, a route includes information about the origin and destination airports, and the connecting airport in the case of a one-stop itinerary. On the other hand, there seems no uniform usage of "route" in the literature. In some other studies (e.g. Borenstein, 1989; Dresner et al., 1996; Hofer et al., 2008), a route denotes an airport pair or a city pair.

[2] Independent of our modeling, we find a recent study by Brueckner et al. (2013), which focuses on the impact of airline competition on airfare, also gives separate consideration to non-stop and connecting markets. However, their definition of "markets" is different from that in the present paper.

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