Transportation Research Part E 48 (2012) 1032–1048

Contents lists available at SciVerse ScienceDirect

Transportation Research Part E

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

Impact of operational performance on air carrier cost structure: Evidence from US airlines

Bo Zou *, Mark Hansen

Institute of Transportation Studies, National Center of Excellence for Aviation Operations Research, University of California, Berkeley, CA 94720, USA

ARTICLE INFO

Keywords:
Operational performance
Airline cost structure
Translog model
US airlines

ABSTRACT

The impact of operational performance on airline cost structure is empirically investigated using an aggregate, statistical cost estimation approach. Two distinct sets of operational performance metrics are developed and incorporated into the airline cost models as arguments. Results from estimating a variety of airline cost models reveal that both delay and schedule buffer are important cost drivers. We also find that flight activity outside schedule windows increases cost, whereas flight inactivity within schedule windows does not. Using the estimated cost models, we predict the cost savings to airlines of "perfect" operational performance, obtaining an estimate in the range of $7.1–13.5 billion for 2007.

1. Introduction

Flight delay is a serious problem that has garnered increasing attention in the United States. In 2007, nearly one in four US airline flights arrived at its destination over 15 min late (BTS, 2009). About a third of these late arrivals were a direct result of the inability of the aviation system to handle the traffic demands that were placed upon it, while another third resulted from airline internal problems. Most of the remainder was caused by an aircraft arriving late and thus having to depart late on its next flight (BTS, 2009). Between 2002 and 2007, as the air transport system recovered from the 9/11 attacks, scheduled airline flights increased about 22%, but the number of late-arriving flights more than doubled. Since 2007, traffic and delays have declined somewhat because of the recession, but the Federal Aviation Administration (FAA) expects growth to resume, with air carrier flight traffic reaching 2007 levels by 2012, and growing an additional 30% by 2025.

Substantial investments are required in order to modernize and expand the aviation infrastructure so that it can accommodate anticipated growth without large increases in delay. In the US, the Next Generation Air Transportation System (NextGen) will deploy improved systems for communications, surveillance, navigation, and air traffic management, and require flight operators to invest in new on-board equipment. The NextGen development and capital costs are estimated to be $30–40 billion, about half for the infrastructure and half for aircraft equipage, through 2025. Substantial improvements in air transportation capacity also require airport infrastructure enhancement. Over the next 5 years alone, airports report a need for $19 billion in airport capacity expansion investments. If airport capacity investment continued at that rate, then combined NextGen and airport capacity investment could reach $100 billion over the next 15 years (Hansen, 2010).

To justify the huge investment, an understanding of the return to the investment is of critical importance. It is well recognized that much of the benefits from NextGen and airport capacity investments will take the form of increased capacity and reduced delay. The business case for these large expenditures rests largely on the value of reducing delay and its associated costs. The cost of delay includes many elements. Passengers are inconvenienced when their flight arrives late, diminishing their willingness to pay for the air travel product and discouraging some from flying altogether. Adaptations to avoid

* Corresponding author. Tel.: +1 510 965 8628.
E-mail address: bzou@berkeley.edu (B. Zou).

1366-5545/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.tre.2012.03.006

or mitigate delay—such as leaving early for a business meeting to make sure it is not missed, or scheduling flights at less ideal times to avoid congestion—also entail costs. However, the element that receives the most attention is that incurred directly by airlines through increased operating expenses. Many in the community perceive that, since airlines must pay these costs with "real money", they merit stronger consideration than the cost of passenger time loss.

Despite a large volume of literature on estimating delay cost to airlines, current knowledge and thinking about the impact of delay on airline cost structure remain limited. The prevailing estimation methods often involve assumptions that are rarely acknowledged or justified. Moreover, the majority of existing studies ignore the fact that delay is measured against flight schedule, which has been padded by airlines in order to improve their official on-time performance statistics. The costs of this practice represent an integral part of the total delay cost; however, it is largely missed in existing research.

The goal of this paper is to address these concerns. We contribute to the airline delay cost literature by developing alternative metrics for what we term "operational performance," a concept that is broader than but includes the traditional concept of delay against schedule. Multiple metrics sets are developed, providing alternative means of gauging the operational performance of airlines. We employ an aggregate, statistical cost estimation methodology to quantify the impact of operational performance on airline cost structure. Using published, quarterly, airline-level data, we estimate the relationship between airline cost, output, factor prices, and other variables. Included among the latter are airline operational performance variables. Such models are capable of establishing the empirical basis for translating operational performance into monetary terms, and involve a minimum of assumptions about the mechanisms through which operational performance affects cost.

The remainder of the paper is organized as follows. Section 2 performs a critical review of current airline delay cost estimation methodology, based upon which an alternative approach for airline delay cost estimation is proposed. To implement this approach, in Section 3 we characterize airline operational performance by developing two sets of metrics: one considers delay against schedule and schedule buffer; the other rests on the relationship between scheduled and actual flight times. The specification and estimation of airline-level cost models that explicitly incorporate the above operational performance metrics are discussed in Section 4. Section 5 presents the estimation results from different model specifications, with particular focus on the implication from the model coefficients for the operational performance variables. In Section 6, we apply the estimated models to assess the potential cost impact of imperfect operational performance. Section 7 offers further discussion and concludes the paper.

2. Current practice of estimating delay cost to airlines

2.1. Cost factor approach

Current practice of estimating the cost impact of imperfect operational performance on airlines can be classified into two approaches: cost factor approach and aggregate cost approach. The cost factor approach is based upon assigning unit costs to different categories of delay based on estimates of the resources consumed when a given category of delay occurs. The total cost of delay, C, is equal to the sum of delay cost in each category:

$$C = \sum_i P_i \cdot X_i \tag{1}$$

where P_i denotes the unit cost per minute for delay in the ith category, and X_i represents the corresponding total delay minutes. Many possibilities for classifying delay exist. One is based upon the phase of flight, such as gate, taxi, and airborne delays (JEC, 2008). Another could be original vs. propagated delay (ITA, 2000; Cook et al., 2004). Depending upon whether a propagated delay is caused by delay on the same airframe but previous legs, propagated delay can be further distinguished as rotational and non-rotational. Since the cost per delay minute varies by aircraft type, differentiation by aircraft type also applies to Eq. (1) (Cook et al., 2004). Despite these many possibilities, implementation of the cost factor approach faces several issues. The major ones are: delay measurement, cost factor determination, linearity assumption, and indirect effects.

2.1.1. Delay measurement

Quantifying delay is often constrained by measurement uncertainties and the availability of data. For instance, if delay is decomposed by flight phase, identifying delay for each phase requires comparing the actual time spent and the nominal or unimpeded ones. The unimpeded taxi time is affected by airfield geometry and gate location, the information of which is difficult to obtain. Even the proper definition of nominal taxi time is unclear: FAA calculates nominal taxi time that allows sufficient time for a plane to wait for one aircraft ahead in the take-off queue, while others assume no interference from other aircraft in the nominal scenario (JEC, 2008). The unimpeded airborne time depends critically upon the optimal flight trajectory, winds, aircraft type, and the relative importance airlines attach to fuel and time, but such detailed information is rarely available. Distinguishing primary and propagated delay is also difficult.[1] As pointed out by Cook and Tanner (2009), if an aircraft arrives 30 min late inbound at the gate, and then leaves 45 min late on the next outbound leg, the portion in the 45 min that should be counted as delay propagation from the last leg is generally not known.

[1] To our knowledge the only database that allows this distinction is the European Central Office for Delay Analysis (CODA) database.