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The impact of hubbing concentration on flight delays within airline networks: An empirical analysis of the US domestic market

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ABSTRACT

This paper explores the relationship between hubbing activities and flight delays in the United States from an airline-specific network perspective. Airline hubbing is measured with the Hubbing Concentration Index. We estimate the impact of hubbing behavior on delays, using three measures of delay, two based on delay against schedule, and the third based on buffer-corrected excess travel times. A significant (and positive) influence of hubbing concentration can only be found for the latter delay indicator. We conclude that airlines use buffer times to mitigate passenger-perceived delays against schedule that would, without buffers, arise from more complex network operations.

1. Introduction

Air traffic delays are receiving considerable attention in the United States and have become one of the most common reasons for passenger complaints (U.S. Department of Transportation, 1998–2012). From 2003 to 2010, on average, more than one fifth of all domestic flights arrived at least 15 min behind schedule and were therefore designated as delayed by the Federal Aviation Administration (FAA). Since 2003, the main domestic carriers have been reporting the causes of flight delays to the Bureau of Transportation Statistics (BTS). In 2010, for example, flights delays were classified as follows: aircraft arriving late (35.77%), national aviation system (NAS) delays (32.04%), air carrier delay as a result of crew, baggage loading or maintenance problems (28.85%), extreme weather conditions such as hurricanes or blizzards (3.07%) and security-related delays (0.27%).[1]

Detailed information on airline-specific flight delays is frequently published by the FAA and therefore attracts both the attention of passengers and airlines. In these statistics, delays are commonly measured as the difference between scheduled and actual flight times, denoted as ‘delay against schedule’ (DAS). For passengers, delay against schedule causes unanticipated additional travel time, creating opportunity costs both for business and leisure activities.[2] For airlines, delays against

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[1] Note that some non-severe weather-related delays are also subsumed under both the NAS-, and the late-arriving aircraft category. In total, weather accounted for 38.1% of all delays in 2010 (BTS, 2014).

[2] It should be noted that connecting passengers travelling in hub and spoke networks might experience delays that differ from delays experienced by airlines. On the one side, passengers missing their connection as a result of a delayed previous flight will face a longer delay compared to the airline delay. On the other side, passengers on a delayed flight that still reach the connecting flight will experience no overall delay.

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schedule have a direct impact on revenues and costs. Delays increase the costs of staffing, fuel, maintenance and potential rebooking (Peterson et al., 2013). Passengers missing their connection may lead to the connecting aircraft not being filled to its break-even load factor (Ruehle et al., 2006). Moreover, inferior delay records might result in passengers switching to airlines with better on-time performance (Cook et al., 2012).

Due to the high costs arising from delays, airlines have a strong financial interest in ensuring the timeliness of their operations and hence devote considerable time and effort to the development of reliable route networks and flight schedules (Dunbar et al., 2012). General optimization approaches might not provide sound solutions for actual operations, so that experienced planners need to revise the route networks and schedules in order to improve their practical implementation. One measure in this context is to add in buffer times in order to reduce the risk of propagating delays through the network (Wu, 2006). However, schedule padding practices also come at a cost for passengers and airlines, as these extra times put into schedules incorporate longer scheduled flight times and if remaining unused, could lead to the underutilization of aircraft capital and crews (Villemeur et al., 2005) as well as to additional travel time.[3] Total delay costs in the US, including both delays against schedule and buffer costs have been estimated as ranging from $31.2 billion to $40.7 billion for 2007 (JEC, 2008 and NEXTOR, 2010).[4]

There is a clear relationship between route network and flight schedules on the one hand and delays on the other. This is particularly relevant in the context of airline hubbing strategy. Hub and spoke operations involving flights that arrive and depart in 'banks' or 'waves' can intensify congestion problems at peak times, depending on the available airport capacity. Infrastructure resources are used by more planes during banks and thus the overall complexity of airport and airline operations increases, leading to additional delays within the network (Grove and O'Kelly, 1986; Button, 2002; Franke, 2004; Wu, 2010).

While recent studies on air traffic delays focus primarily on the relationship between airport concentration, airport capacity constraints and related flight delays (see, for example, Daniel, 1995; Brueckner, 2002; Mayer and Sinai, 2003; Rupp, 2009; Santos and Robin, 2010; Ater, 2012) we are interested in an airline network perspective. Specifically, we consider whether hubbing intensity impacts on delays within an airline's network, an issue which has not been investigated by scholars so far. We are especially interested in investigating the relationship between hubbing intensity and delays observed by passengers and airlines (delays against schedule), as well as delays only observed by airlines in the form of inefficient schedules (excess travel time). By doing so, we can gain insight into airline procedures used to absorb disruptions in the network due to hubbing behavior. Moreover, our network-specific analysis provides additional guidance on whether delay costs are within the control of carriers and can therefore be considered partially as internal. The results provide additional insights into the question of whether delay costs are already internalized by air carriers.

To quantify airline hubbing concentration, we use the 'Hubbing Concentration Index' (HCI) introduced by Martín and Voltes-Dorta (2008). Delay is measured with two different metrics. The first is the traditional concept of delay against schedule (DAS) that has been taken into account in several earlier studies (see, for example, Morrison and Winston, 1989; Hansen et al., 1998; Mazzeo, 2003; Rupp, 2009). In addition, we 'consider excess travel time' (ETT), an indicator that is robust against schedule padding (Mayer and Sinai, 2003; Martín et al., 2006; Britto et al., 2012). By using DAS and ETT, we pay attention to both observed delays and inefficient schedules.

The remainder of the paper is organized as follows. In Section 2, we present a brief review of the Hubbing Concentration Index and then compute airline-specific hubbing indices for the main US carriers on a quarterly basis between 2000 and 2010. Section 3 describes the data and the methodology used in this study to quantify the impact of hubbing concentration on flight delays. Section 4 presents and discusses the estimation results using different delay measures. Section 5 concludes.

2. Hubbing Concentration Index

A variety of spatial concentration indices characterizing airline networks have been developed and discussed in the literature (see for example, Wojahn, 2001; Reynolds-Feighan, 2001; Burghouwt et al., 2003; Wu, 2010).[5] Martín and Voltes-Dorta (2008) demonstrate that these indicators inadequately describe the specific characteristics of hub and spoke networks, since they do not take into account the proportion of passengers making onward connections. To address this issue, the authors define network concentration using the Hubbing Concentration Index. Martín and Voltes-Dorta (2009) show an application of the HCI that illustrates its descriptive power. We make use of the HCI in order to assess the hubbing activities in airline networks.

The Hubbing Concentration Index was specifically developed for airline networks and focuses on two central aspects. These are the share of passengers making onward connections in the network, and the spatial concentration of the individual hubbing itineraries. In a first step, this is represented as follows:

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[3] For the case that airlines shorten their turnaround times in order to extend their buffer times, schedule padding is not leading to underutilization of aircraft capital and crews. However, such behavior will increase the risk of delays in airline networks already having tightly planned turnaround times.

[4] Both estimates include the costs of schedule padding practices by airlines.

[5] Burghouwt and de Wit (2005) address the issue of temporal configuration of airline networks when they describe the development of European airline networks. This adds a relevant additional viewpoint regarding the description of airline networks and is well suited to complement the spatial analysis of networks.