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How do airlines react to airport congestion? The role of networks

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ABSTRACT

In this paper, we investigate the relationship between airline network structure and airport congestion. More specifically, we study the ways in which airlines adjust frequencies to delays (as a measure of airport congestion) depending on the network type they operate. Our results suggest that network structure has a fundamental impact. Thus, while airlines operating fully-connected configurations reduce frequencies in response to more frequent delays, airlines operating hub-and-spoke structures increase frequencies. Therefore, network airlines have incentives to keep frequencies high even if this is at the expense of a greater congestion at their hub airports. This result sheds light on previously unclear results in the literature.

1. Introduction

Network airlines increasingly concentrate their services at a small number of hub airports at which they channel a high proportion of their total flights. At these hubs, dominant network carriers exploit transfer traffic through coordinated banks of arrivals and departures. The operation of such hub-and-spoke (HS) configurations enables airlines to reduce their costs since they can exploit economies of traffic density and offer high flight frequencies, the latter being greatly valued by business and connecting passengers.[3] As Flores-Fillol (2010) points out, network carriers have strong incentives to add new routes to their HS networks because by doing so they gain simultaneous access to one new local market and many connecting markets. By offering a wide diversified range of destinations, hub airports contribute substantially to the competitiveness of firms located in the urban areas under their influence.[4] While low-cost carriers may also concentrate their traffic in just a few airports, they basically operate fully-connected (FC) networks in which most air services are point-to-point.

However, the concentration of traffic favored by HS networks has contributed to an increase in airport congestion. Baumgarten et al. (2014) suggest that HS operations may aggravate congestion problems at peak times because more flights are operated for a given capacity during banks. Furthermore, the larger number of connecting passengers results in an increasing complexity of airport and airline operations. Daniel and Harback (2008) show that dominant airlines at many major US hub airports concentrate their flights at peak times, thereby forcing non-hubbing airlines to cluster their traffic in uncongested periods. The potentially negative effects associated with congestion may be substantial both for passengers and airlines, as reported in several empirical studies. For example, Forbes (2008) uses data from New York-La Guardia airport (one of the four slot constrained airports in the US) to study price responses to flight delays. She finds an average price reduction per additional minute of delay of \$1.42 for direct passengers; this price decrease amounts to \$0.77 for connecting passengers. Britto et al. (2012) examine the impact of delays on consumer and producer welfare for a sample of US routes. They find that delays raise prices and reduce demand. From their results, a 10% decrease in delays implies a benefit of \$1.50-\$2.50 per passenger, while the gains for airlines of reducing delays are about three times higher. Peterson et al. (2013) use a recursive-dynamic model to examine the costs of flight delays both for airlines

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[3] It is generally accepted that the route operations of airlines are subject to density economies (Brueckner and Spiller, 1994), and that airlines can attract more connecting passengers in a HS structure by increasing service frequency than by increasing aircraft size (Wei and Hansen, 2006).
[4] For instance, McDonald and McMillen (2000) discuss the centripetal force of Chicago O'Hare airport for industrial and commercial activities.

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and passengers, finding that a 10% reduction in delayed flights increases net US welfare by $17.6 billion.

HS networks, therefore, are associated with both positive and negative effects. The empirical challenge consists in ascertaining which of these two dominates. This paper aims at understanding the extent to which airlines react to airport congestion. More specifically, we seek to test the impact of airline network type on carriers' reactions to congestion: that is, do airlines operating HS and FC networks behave differently?

A closely related study to the one conducted here is provided by Bilotkach et al. (2013). Drawing on data for the period 2007–2011, they study the impact of the merger between Delta and Northwest on the distribution of traffic between primary and secondary hubs, considering the potential negative effect of increased congestion at the main hub airports. They report a post-merger redistribution of traffic in favor of primary hubs and *no effect of congestion* as a brake on this concentration of traffic. The authors claim that they are surprised by this apparent indifference of the merged entity (Delta-Northwest) to congestion and speculate that it might be due to the economic downturn following the financial crisis in 2008. Our study sheds further light on this puzzling outcome.

Most studies of airport congestion analyze the relationship between delays and airport concentration, focusing on the internalization debate. The internalization hypothesis states that airlines at heavily concentrated airports are likely to internalize the effects of self-imposed congestion.[5]

While several works analyze the determinants of delays, less attention has been devoted to the impact of delays on airline frequencies.[6] The exceptions are the studies published by Pai (2010) and Zou and Hansen (2014), which yield contradictory results. Using data for a sample of US routes, Pai (2010) finds a negative relationship between frequencies and delays. More precisely, he concludes that every extra minute of delay at the airports of origin or destination could result in 2–3 fewer flights per month. By contrast, Zou and Hansen (2014), also using a sample of US routes, find a positive relationship between frequencies and delays.

Our analysis seeks to reconcile the results in this scarce and incipient literature by undertaking a more general analysis in which we introduce a new relevant element: network structure. In particular, we undertake an empirical analysis of the US market during the period 2005–2013 to examine the relationship between airline frequencies and delays (as a measure of airport congestion) under different route structures. We study the different ways in which airlines adjust their frequencies to airport congestion depending on the network type they operate.

The results of the empirical analysis suggest that the effect of the network structure is fundamental. We provide some evidence about the different reaction to congestion of carriers operating HS networks (i.e., network carriers) as compared with carriers operating FC networks (i.e., mainly low-cost carriers). We find that while airlines operating FC configurations reduce frequencies in response to more frequent delays, airlines operating HS structures increase frequencies. Therefore, network airlines have incentives to keep frequencies high even if this is at the expense of greater congestion at their hub airports. The rationale behind this result would seem to lie in the higher yield associated with flight banks; the cost savings from an intense exploitation of economies of traffic density; and the strategic behavior of airlines that may adopt a preemptive strategy so as to avoid losing market power, which involves releasing slots that might be taken over by other competing airlines.[7]

Our results confirm the theoretical findings in Fageda and Flores-Fillol (2015), which suggest that congestion typically increases the profitability of HS networks (since frequencies are higher than those in FC networks). Our findings are also in line with the empirical results in Brueckner (2002), which show that delays are higher in hub airports after controlling for airport size and other airport attributes. Finally, our paper goes some way to accounting for the non-existent reaction to congestion by the merged Delta-Northwest airline reported in Bilotkach et al. (2013). This is unlikely to have been caused by the economic downturn in 2008, but rather represents an active decision on the part of the consolidated airline.

The rest of this paper is organized as follows. In the next section, we explain the data used in the empirical analysis. In Section 3, we specify the empirical model and state our expectations for the explanatory variables. Section 4 deals with various econometric issues and then we report the regression results and Section 5 provides some robustness checks. The last section contains our concluding remarks.

2. Data

We have data for 50 large US continental airports, including all hubs and the country's most congested airports, during the period 2005–2013. Data on airline frequencies and flight shares at the airport level have been obtained from RDC Aviation (Capstats Statistics), representing an aggregation of the T-100 dataset collected by the US Department of Transportation. Since we focus on US domestic traffic, intercontinental flights are excluded from the analysis. Moreover, we only include airlines that provide at least one flight per week from the airport under consideration. The unit of observation of our regressions is the airline–airport pair, so that our final sample comprises 4259 observations.

We also consider the variables that might affect flight demand at the airports in our sample. Specifically, we use data on population and GDP per capita obtained from the US census, which refer to the Metropolitan Statistical Area (MSA) in which the airport is located.

An essential feature of our analysis is the distinction drawn between network airlines that operate HS networks and other airlines (usually low-cost airlines) that operate FC configurations. Alaska Airlines, American Airlines, Continental, Delta, Northwest, United, and US Airways are identified as network airlines; and AirTran, Allegiant Air, Cape Air, Frontier, Great Lakes, Jet Blue, Pacific Wings, Republic, Southwest, Spirit, Sun Country, USA3000, and Virgin America are identified as low-cost carriers. All network airlines are integrated in an international alliance (i.e., Oneworld, Star Alliance, and SkyTeam) in the period under study, with the only exception of Alaska Airlines that has codeshare agreements with several airlines integrated in airline alliances. Note also that all network airlines rely extensively on regional carriers to feed their flights. These regional carriers may be either subsidiaries of a network carrier or independent airlines that have signed contracts with a network carrier.[8]

By definition, hub airports are those airports in which a dominant network carrier exploits the transfer traffic through coordinated banks

[5] Daniel (1995) is the first that recognizes the potential for internalization. However, he supports the idea that carriers behave atomistically due to the competitive pressure exerted by fringe carriers (a result that is confirmed in Daniel and Harback, 2008). Differently, Brueckner (2002) proposes a model that relates internalization of congestion with market power. Mayer and Sinai (2003) demonstrate that, even though delays at hub airports can be longer than those at non-hub gateways, increasing airport concentration does reduce these delays. Rupp (2009), however, reverses Mayer and Sinai's findings, using a different measure of delays. Brueckner and Van Dender (2008) seek a consensus in the internalization debate by showing that some competitive scenarios do lead to self-internalization, while others do not.

[6] Several empirical studies have examined the determinants of airline frequencies at the route level. These studies have generally focused on the effects of either route or airport competition (see, for example, Bilotkach et al., 2010 and 2013, and Fageda, 2014).

[7] It is true that low-cost carriers' passengers may have a lower cost of time (as compared to network carriers' passengers) and that this could be reason for these carriers to incur longer delays. However, our results suggest that there are other factors that overcome this effect and explain the incentives for network carriers to incur longer delays (i.e., the higher yield associated with flight banks; the cost savings from an intense exploitation of economies of traffic density; and the strategic behavior of airlines).

[8] Our data set assigns the flight to the major carrier in those cases where it is operated by a regional carrier on behalf of the major carrier.