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Airport size and travel time

Tim Hazledine*, Rory Bunker

University of Auckland, Auckland, New Zealand

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A B S T R A C T

Econometric modelling of the scheduled duration of 2010 flights between 57 origin and 375 destination airports in the year 2009 supports hypotheses (a) that airlines will incorporate realistic predictions of aircraft time on the ground into their published schedules, and (b) that this time will depend positively on airport size, as well as other factors. That is, larger airports generate time diseconomies of scale. A corollary is that actual lateness of flights is not related to airport size. The value of additional time is significant compared with airports' operating revenues and costs of slot congestion at large airports.

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1. Introduction

Viewed as a part of the urban landscape, perhaps the most striking feature of airports is just how big they are. London's Heathrow airport, for example, covers twelve square kilometres – more than the city's largest open area, Richmond Park. Whereas wide open spaces in a park are part of their point, for a commercial transport operation such as an airport, space, in itself, is a nuisance – ground to be covered by people or aircraft at a cost in time, fuel and other resources which of itself contributes nothing to the travellers' goal of getting from where they do not want to be to where they do as quickly and conveniently as possible.

It is a largely unavoidable nuisance, of course, since aircraft need flat space to maneuver in, and even airport terminal buildings cannot sensibly be extended in three dimensions to more than about three floor levels. Nevertheless, given (i) that in general the average distance between two randomly selected points on a two-dimensional space increases with the area of the space; (ii) that there has been no empirical investigation of the implications of this for airports, and (iii) airport size is often a private or public investment decision variable (as, for example, when possible expansion is mooted), then it seems reasonable to explore the matter further.

We do this by testing the following hypothesis. Airlines do not like running late (or early), because their customers do not like it, and because it creates further operational problems down the line. Accordingly, airlines will tend to incorporate realistic forecasts of the actual time taken by a particular flight in their published schedule for this. This forecast will be the sum of three elements: expected time on the ground at the origin airport; expected flight time, and expected time on the ground at the destination airport.[1] Then, time on the ground at both ends of the flight will be positively related to the size of the airports, because of longer taxiing distances and possibly other factors such as the need to build in a precautionary margin of time because of a higher probability of "lateness" on the part of passengers and/or ground handling operations.

We test this hypothesis by estimating econometric models of scheduled flight duration on a cross section of data from a sample of flights and airports around the world, incorporating a measure of airport size as well as other controls (such as, obviously, flight distance) as regressors, and breaking down flight duration into ground and air time. These models are the main outputs of the paper. We also test a corollary of the hypothesis: airport size should not explain late departures, because if it systematically did so, then airlines would be failing to use this information to adjust their schedules to compensate.

More informally, we look for evidence that airport size is related to passenger time spent in the terminal; and that size tends to be related to duration and distance of the passenger's trip to the airport.

The normative implications of our results of course depend on the proposition that "time is money", which places our work in the context of the quite large literature on airport productivity or efficiency. We do not attempt a full survey of this literature in the paper, but will note its salient features. Most studies focus on what could be called "hard" measures of productivity, relating measures

* Corresponding author. Tel.: +64 93767141.
E-mail address: T.hazledine@auckland.ac.nz (T. Hazledine).

[1] By time on the ground we mean time from when the aircraft's brakes are released for push-off from the gate to time of lift-off from the runway, and equivalently for the arrival.

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of physical output such as passengers handled or aircraft movements to inputs such as terminal area, number of employees, and number of runways. These studies are of two general types. One type seeks to identify the technological frontier, assumed to represent efficient operations, and then calculates the relative (in) efficiency of actual airports as their distance from the frontier (e.g. Gillen and Lall, 1997). The second type of study focuses on the characteristics of airport technologies by means of econometric estimation of production or cost functions – an approach which naturally lends itself to the identification of scale (dis)economies in the production of airport outputs. A recent example which includes a comprehensive literature survey is Martin et al. (2011). These authors find that returns to scale are increasing throughout the size range of their sample of Spanish airports, a result which they say contradicts the 'standard view' in the literature that returns to scale are exhausted at fairly low airport sizes.[2]

A smaller literature explores the "soft" efficiency dimension of use of time: in particular, delays to flights due to airport congestion or other factors. Here it is usually the behaviour or characteristics of airlines, not airports, that is focused on – for example, a tendency for airlines to create congestion by cramming their flights into particular time slots. Santos and Robin (2010), Rupp (2009) and Mayer and Sinai (2003a) link flight delays to use of hub-and-spoke route structures, and to the interesting issue of whether airlines with significant market shares at an airport have an incentive to partially internalize the congestion they cause. The latter has implications for the effectiveness of congestion pricing of airport slots, explored in a number of papers, including Daniel and Harback (2009). We note here that delay – meaning flights departing and/or arriving later than scheduled – is not necessarily linked to congestion, since the latter can be predicted and allowed for in scheduling. Finally, in an unpublished working paper, Mayer and Sinai (2003b) do empirically model scheduled flight time (i.e., the same variable we will model), and find, with US data, that an airline which has a "hub" at a particular airport is likely to schedule more time for its flights originating at that airport, though the effects are not large (less than a minute, on average).

Section 2 describes the data and sources, Section 3 presents the econometric and other empirical results, and Section 4 discusses normative implications of our findings that airport size matters for all three components of a trip: journeys to/from airports; moving through airport terminals, and time in the aircraft on the ground.

2. Database

A key source of data was the website www.flightstats.com, on which is recorded information on just about every commercial flight taking off and landing at just about every commercial airport in the world every day of the year. The information includes: operating airline; flight number; equipment type; scheduled and actual departure time; scheduled and (in most but not all cases) actual arrival time at destination. Only direct (non-stop) flights are recorded, and there are no data on numbers of passengers, so the basic unit is the aircraft movement, not the passenger's journey, which of course may involve stop-overs and changes of plane.

The flightstats data are – at least in their public record – ephemeral, being on display for just five dates: two days before; flight date and two days after (at which times any divergences between scheduled and actual arrival times can be observed). We and our research assistants observed the flight data manually, printing out pages from the website and then recording these on a spreadsheet. This is a quite time-consuming process which eventually yielded data on 2010 actual flights, over various dates in 2009 and 2011. The flight data were supplemented with data culled from search engines, websites and other sources on airport[3] and aircraft characteristics.

Although we did not undertake any formal randomization of the observation process, we did work with the research assistants to get a good spread of flights: across days of the week; time of day; length of flight; type of aircraft, and size of origin and destination airports. There is some regional bias in the choice of the 57 origin or departure airports: 51% of these are in the United States; 23% in Europe; 16% in Canada, and 10% in Australia or New Zealand. This means that nearly all flights to small airports are also within these regions, which in turn means that English-language information from websites and Wikipedia would likely be available for the small airports, few of which have basic data such as annual numbers of passengers recorded on standard databases. There are 366 different destination airports in the sample, including all of the origin airports.

A key concept to quantify is the size or scale of an airport. We are interested in economic size, and will measure this in terms of physical output – the quantities of goods and services handled. A quite standard measure of output in the airport productivity literature is the number of "Workload Units" (WLUs), where one WLU is either one passenger[4] handled (either departing or arriving) or 100 kg of freight loaded on or off aircraft. For smaller airports, information on freight handled is often not available from websites or annual reports, and so we will simply use total numbers of passengers as our measure of the functional size of each airport. For the 27 largest US airports, freight handled, in hundreds of kilogrammes, is on average 16% of the number of passengers handled.

We do check the correlation between total passengers and two other size-related variables: total commercial aircraft movements,[5] and size of the airport terminal in square metres. Ordinary Least Squares results using the EViews 7.2 regression package are shown in Tables 1 and 2.

The Table 1 regression has the log of total annual passengers handled by an airport (PAX) explained by the log of total commercial aircraft movements and a dummy variable equal to one if the airport is in North America. The correlation between passengers and movements is very strong and the coefficient (greater than one) implies that, overall, larger airports tend to have larger aircraft (more seats) using them,[6] which is unsurprising. The large negative coefficient on the dummy variable tells us, at least in our sample of airports, average aircraft size is smaller in North America, which in turn may reflect a greater tendency there to use air travel, with relatively small aircraft, for shorter trips that in Europe might be carried out by rail. In any case, the regression suggests that passenger numbers are a more generally comparable indicator of the output of an airport than in aircraft movements.

The Table 2 model explores the link between output and one of the major airport inputs: terminal size in square metres. Larger flows of passengers do seem to require a larger terminal, though

[2] Chang et al. (2013) use a combination of frontier and econometric analysis of the productivity of 41 Chinese airports, and find that airports serving larger cities (populations greater than 2 million) tend to be relatively more efficient.

[3] For larger airports, data on passenger numbers are available from the Airports Council International (ACI) *World Airport Traffic Report*.

[4] These are passengers on scheduled or commercial charter flights. This excludes travellers on private aircraft and corporate jets. A "passenger" is someone either taking off or landing at an airport.

[5] That is, excluding general aviation movements (e.g. corporate aircraft). A "movement" is an aircraft either taking off or landing at an airport (i.e., a round trip counts as two movements).

[6] Dividing number of passengers by number of movements gives the average number of seats utilized per aircraft.

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