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Measuring connectivity in the air freight industry

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ABSTRACT

In this paper, we present an air transport connectivity model for air freight. For the purposes of this paper, connectivity is defined as all possible direct and indirect connections to or from an airport operated by wide-body aircraft, weighted for the quality of the connection in terms of transhipment and in-flight times. Using this model, we analyse the networks of seven European airports. Europe's largest hub airports carry most air freight thanks to their extensive intercontinental passenger networks, while smaller airports with a strong focus on air freight carry large amounts of cargo on dedicated freighter aircraft. For air freight operations, the catchment area of an airport is much larger than it is for passenger services, as shipments are being trucked to their departure airport throughout all of mainland Europe. Since there are many airports sharing the same catchment area, potential competition for air freight is fierce. We found that well located regions between the four large European airports have access to large air freight networks, whilst regional air freight connectivity in northern and southern parts of Europe is substantially lower.

1. Introduction

The air freight industry is of major importance in the global economy, as it is the main mode of transport for perishable products, luxury goods and other high-value products. Although the air freight industry only covers a limited amount of world trade in terms of tonnage, the share of air freight in terms of value is substantial. Of all trade to and from the European Union in 2014, the share of air freight is 1 percent in terms of tonnage, but 30 percent of total value (Eurostat, 2015). As the economy is recovering from the global financial crisis in 2008 and the European debt crisis, strong growth of international trade and world GDP is expected, leading to an increase in global demand for air freight.

Boeing and Airbus forecast the demand for air freight to grow by 4.7% and 4.5% respectively over the next 20 years (Boeing, 2014; Airbus, 2014). Export rates have grown in both existing producing countries as well as in emerging economies. On the other hand, there has been a strong increase in the availability of wide-body passenger aircraft with a large amount of freight capacity in the belly hold. This competes significantly with the provision of dedicated air freight services, which only sell cargo capacity. The increased demand for passenger air traffic, partly caused by decreasing airfares, has resulted in strong overcapacity in the air freight industry. Because belly-hold space is often considered as a by-product of air service, airline revenue management strategies may primarily focus on passenger revenues and offer cargo capacity at marginal cost level prices. As a consequence, air cargo space is sold at rock bottom prices, and airlines are struggling to keep dedicated freighter operations viable.

Air connectivity is of major importance to a country's economy. Various authors find a relationship between air connectivity and regional economic development (e.g., Ivy et al., 1995; Brueckner, 2003; Button and Yuan, 2013; Allroggen and Malina, 2014; Bilotkach, 2015). Furthermore, there seems to be a positive relationship between freight transport and economic activity (Kupfer et al., 2010; Meersman and van de Voorde, 2013). From a social perspective, there is particular interest in the analysis of connectivity in air transport networks. Appropriate connectivity measures allow policy makers and airports to benchmark the network performance of airports and evaluate policy objectives (Burghouwt and Redondi, 2013). Insights gained from these analyses are also valuable to appraise air transport-related policy measures such as airport infrastructure investments or route subsidies, as well as to identify macro-level trends in airport connectivity in certain regions (Allroggen et al., 2015; Burghouwt and Veldhuis, 2006).

There are numerous models available to measure air passenger connectivity (for an overview, see Burghouwt and Redondi, 2013). In contrast, few studies have addressed connectivity in air freight

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networks. This gap in the available literature most likely has to do with the fact that measuring connectivity in the air freight industry needs to deal with a number of challenges which do not apply to the passenger's side of the market. Among these are:

- Air freight is carried on freighter operations as well as on passenger aircraft. On scheduled passenger aircraft, the available cargo capacity and effectively used capacity is unknown until departure (Popescu et al., 2011);
- Not all passenger operations are used for air freight: some airlines – mainly low cost carriers, typically only operating narrow-body aircraft – do not use their belly capacity at all, whilst others only use their wide-body aircraft for freight. Narrow-body aircraft have limited freight capacity compared to wide-bodies (for example, the Airbus A321 has a total volume capacity of 51.7 m^3, compared to a capacity of 136 m^3 for the smallest version of the A330 (Airbus, 2016));
- Not all air freight is carried on scheduled flights: charters account for some 7–10% of air freight tonnage carried (Heinitz et al., 2013), providing capacity for special consignments or supplementing scheduled air freight traffic volumes;
- Integrator operations (such as FedEx, DHL and UPS) are not published in airline schedule data. The network of integrators, mainly focused on mail and express shipments, also tend to use excess capacity for the general air freight operations by their affiliated forwarding companies, while other forwarders might not have access to this capacity;
- Road Feeder Services (RFS) of airlines might cater to a large part of an airline's short-haul network.
- Air freight may be transported along routes with long detours or transfer times, leading to a larger number of possible routings compared to passenger networks.

In this paper, we present an air freight connectivity model that allows for measuring the connectivity performance at the level of airports, regions and countries, but also at the level of individual origin-destination markets. Our methodology takes into account the connectivity of wide-body aircraft, which leads to an exclusion of short-haul and most low-cost carrier (LCC) operations. Connectivity is expressed in terms of frequency rather than capacity, presenting route alternatives for the individual customer. Except for very large shipments, freight itinerary choice is not driven by available capacity. Given the unreliability of capacity data and its relative unimportance in the customer's choice process, we refrain from including capacity in the model.

In our paper, we first discuss the existing literature in the field of air freight connectivity. Section 3 describes the model and the way the model is able to deal with the complexities of the air cargo industry. In Section 4, the model is used to benchmark the air freight connectivity performance for seven European airports. Section 5 elaborates on airport competition for dedicated freighter operations. In Section 6, we apply the model to determine the regional connectivity for a large set European region. Section 7 concludes and presents suggestions for further research.

2. Literature review

2.1. The air freight industry

The air freight supply chain consists of three major players: shippers, forwarders and carriers (Popescu et al., 2011). The shipper is the party that wants to have a good shipped from one place to another. The forwarder arranges the door-to-door transport of the shipment and takes care of all necessary documentation. Some large organisations have in-house freight forwarding services, predominantly where economies of scale merit this approach. The carrier is responsible for the airport-to-airport shipment. There are three types of cargo carriers: integrators, combination carriers, and full-cargo airlines (Dewulf, 2014). Integrators or express carriers are companies providing overnight door-to-door services for time-sensitive small parcels (Onghena, 2013). These carriers have experienced strong growth over the last decade and have to some extent replaced traditional air freight carriers, particularly in the domestic US market. Combination carriers are passenger airlines carrying cargo in the belly hold of their passenger aircraft and in dedicated freighter aircraft. Full-cargo carriers are companies solely operating dedicated freighter aircraft and are not involved in the passenger business.

Both carriers and forwarders need to choose an airport from which they operate. Combination carriers are mostly hub carriers, operating mainly from their hubs. All cargo carriers base their choice on several factors such as the presence of freight forwarders, airport experience with air cargo, level of airport and ground handling charges (Kupfer et al., 2011), local demand, customs efficiency (Zhang and Zhang, 2002), and the availability of night capacity (Gardiner et al., 2005b; EUROCONTROL, 2009). Push factors include bilateral restrictions, noise regulation and airport congestion (Gardiner and Ison, 2008). For the location of an integrator hub, night curfews, noise and environmental restrictions are particularly important, as the lion's share of integrator operations take place at night (Gardiner et al., 2005a; Onghena, 2013).

The choice of an airport for freight forwarders depends on the type of airfreight. Zhang distinguishes between local cargo, gateway cargo, and hub cargo (Zhang, 2003). Local cargo contains shipments to or from the local market, whereas gateway cargo is shipments transported to the respective airport from another area through other modes of transport. Hub cargo is transhipped air-to-air cargo. For local cargo, the market is largely captive, there are relatively high costs involved in choosing another airport. For gateway cargo, the set of substitutable airports is larger and competition between airlines/airports is more intense. The airport choice for freight forwarders is to a large extent dependent on the choice of the carrier. Most network carriers operate out of their respective hubs, and operate road feeder networks for continental transport. The forwarder's choice of a carrier may also be influenced by existing contracts or a 'preferred supplier status'.

Chu (2014) discusses the carrier and route preferences of freight forwarders in Taiwan. The author distinguishes between the forwarder's choice for a carrier and for a freight routing. The most important attributes for selecting cargo carriers are reliable and on-time services, possibility for express shipments and a good reputation of the carrier. The highest-rated attributes related to route choice are: less intermediate stops, efficient handling, and customs clearance service at the destination airport.

The literature provides little evidence on the role of connectivity offered by carriers in the forwarders' choice of an airport. For sea freight, the shipping frequency is the second most important factor determining the port choice of freight forwarders, after port efficiency. A higher frequency of ship visits translates into more route choice options and more competitive prices for forwarders (Tongzon, 2009). In a survey of air cargo shippers, connectivity was rated as the most important factor for airport choice (Seabury, 2015).

2.2. Airport catchment area size

It is important to acknowledge that the catchment area for air freight is much larger than for passengers. Research commissioned by the European Commission based on a questionnaire under cargo customers (European Commission, 2008) indicates that freight