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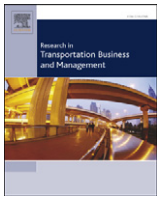

Assessing the importance of hub airports for cargo carriers and its implications for a sustainable airport management

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ABSTRACT

The air cargo sector has developed very rapidly during the last decades from a pure by-product to a self-contained. The strong development changed the airport–airline relationship as cargo became a significant revenue source for airports and airlines. Airport operators invest in new freight terminals, which need to be refinanced efficiently through airport charges. Thus, airport operators favor long-term contracts between airports and airlines. Contrarily, airlines are especially at non-hub airports extremely flexible and change their schedules rapidly if necessary. Therefore, it is financially essential for airports to know about their status within the operating airline's network. The present paper assesses the importance of single airports for cargo airlines from a network perspective and analyzes the implications for airport operators.

1. Airport–airline relationship

Deregulation of the aviation industry enabled new opportunities for airlines as well as greater competition between the airlines. As a result, airlines are independent to allocate their resources. At the same time, airports adopted more businesslike management philosophies (Graham & Dennis, 2007). Some airports have even been privatized (partially or fully) and act more competitively. Therefore, it is financially essential for airports to know about their status within the operating airline's network which will be analyzed for cargo airlines in the present paper.

Experiences with the deregulation of the US aviation market in 1978 reveal three important developments (Burghouwt, 2007):

- dynamics in airport hierarchy,
- flexible airport planning,
- airline network reconfigurations.

Airline networks developed in two different ways: full-service airlines adopted comprehensive hub-and-spoke structures (e.g. American Airlines) whereas low-cost airlines operate point-to-point networks (e.g. Southwest Airlines). In particular the adaptation of hub-and-spoke networks allows airlines to serve many more airports which results in a reduction of airport inequality (Button, 2002). Other studies disagree (e.g. Reynolds-Feighan, 2001; Wojahn, 2001) but all studies have in common that airport traffic has become very volatile and much more uncertain than before deregulation (De Neufville & Barber, 1991). Traffic uncertainties directly impact investment decisions at airports, such as runways, terminals, etc. which need robust traffic forecasts for an efficient dimensioning. A thorough understanding of the market environment and the airport's key players' long-term strategies is needed to be able to refinance the infrastructure investments and to reduce investment risk (Beria & Scholz, 2010). According to Airport Council International (ACI), commercial revenues of airports accounted for 48% in 2006 making traditional airport charges the primary source for airport infrastructure refinancing which is directly influenced by traffic numbers for passenger and freight services (Graham, 2008).

The strong growth of air freight tonnages which even outpaced passenger growth rates changed the airport–airline relationship: cargo has become a significant revenue source for airlines as well as for airports. Literature on the relationship between airports and cargo airlines is scarce and research has so far been focussed on integrated carriers (e.g. Onghena, 2011) even though 25 of the largest 30 air cargo airlines are non-integrated carriers (Heinicke, 2006). Integrated carriers offer door-to-door services whereas airport-to-airport providers concentrate on the airline business by shipping freight from origin to destination airport. Airport-to-airport providers that combine belly capacities of passenger aircraft with freighter capacities of pure freighter aircraft are called combined airlines. In particular former flag carriers, such as Lufthansa, Air France and Korean Air play a significant role in the air freight market as combined carriers. Contrarily, all cargo airport-to-airport carriers focus on cargo services only and operate pure cargo aircraft fleets (e.g. Cargolux). This essential difference between pure cargo and combined carriers needs to be considered when analyzing the airport–airline relationship

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because the course of options between both business models is different.

Comprehensive studies on the location of airports have been carried out by Gardiner et al. (e.g. Gardiner, Ison & Humphreys, 2005; Gardiner, Humphreys, & Ison, 2005; Gardiner & Ison, 2008) who interviewed cargo airline operators to comprehend their airport decisions and their decision framework. Gardiner & Ison (2008) finally detect three major decision classes: geography of the airport location, financial return (including airport charges, etc.) and airport's operations certainty. Once an airport has been identified and has been awarded through its preferred location (geography of location) and no relevant service restrictions exist for the airline (certainty), it is the airport that has the highest financial return potential that will be chosen by the cargo carrier (Gardiner & Ison, 2008). Return is directly determined by the costs of operating the airport (e.g. landing fees, handling fees, fuel prices, etc.) and by the air freight demand from local industry (including the existence of freight forwarders at the airport). In particular the local demand is a key driver why non-integrated cargo airlines congregate at the major airports of the world in contrast to integrated airlines, and why secondary airports usually face comprehensive barriers in attracting non-integrated cargo airlines (Gardiner & Ison, 2008).

The elaborations of Gardiner, Ison (2005), Gardiner, Humphreys (2005) and Gardiner & Ison (2008) examine non-integrated cargo airlines as one homogeneous group of actors and draw general conclusions for this group. Kleiser (2010) found significant differences within the airline group that necessitate a further differentiation of the sector into six homogeneous groups, namely mass providers (e.g. Cargolux), premium providers (e.g. Lufthansa), market specialists (e.g. Air India), product specialists (e.g. Volga-Dnepr), by-product provider with direct selling (e.g. Thai Airways) and by-product provider without direct selling (e.g. AirBerlin). Of these six classes, mass providers and premium providers are by far the most important business models based on freight transported which are further analyzed in the following. In contrast to Gardiner, Ison (2005), Gardiner, Humphreys (2005), and Gardiner & Ison (2008) the objective of the present paper is to evaluate the network configuration of cargo airlines and to quantify the importance of single airports for the airline (airport hierarchy). The under-researched nature of cargo airlines, the (expected) long-term growth rates and the future challenges for airlines and airports (e.g. over-capacities of cargo volumes, upcoming investments at airports) motivated the paper to focus the analysis on pure cargo airlines. Therefore, the literature on the assessment of airline networks is reviewed in the following section.

2. Airport hierarchy assessment for cargo airlines

The importance of single airports in a network is usually assessed by location based measures (e.g. passenger, cargo or operation numbers). Such an approach neglects the airport's importance for the entire network configuration (structure). In academic literature two philosophies exist that aim to describe airline networks: the spatial and the temporal network approach. Together both approaches guarantee to represent the two main features of the hub-and-spoke network properly (Reynolds-Feighan, 2001). The spatial configuration can be defined as the level of concentration of an airline network around one or a few central hub airports (concentration in space). The temporal concentration analyzes how departure and arrival flights are coordinated at the main airport of the airline (usually the hub airport of full-service carriers). Airlines operate synchronized waves of flights from their main airports with the aim to optimize the quantity and quality of connections offered (Graham, 1995; Reynolds-Feighan, 2001). The higher the importance of a single airport for the airline, the higher is the potential of a long-term collaboration between airport and airline.

The spatial approach was developed since the 1960s to study the spatial characteristics of networks (Burghouwt, 2007). Literature categorized real world airline networks by considering theoretical graph structures, such as line networks (Hanlon, 1996), fully connected versus hub-and-spoke networks (e.g. Shy, 1997) and linear versus hub-and-spoke networks (e.g. Oum, Zhang, & Zhang, 1995). Burghouwt (2007) applies the spatial network approach to differentiate between network structures of former flag carriers, such as Lufthansa, and Low Cost Carriers (LCC) and found out that flag carriers operate more concentrated network than LCCs. Alderighi, Cento, Nijkamp, and Rietveld (2007) applied a famous concept of social network analysis to airline network structures, the concept of centrality. (Spatially) Central vertices are defined as more important than less central vertices. Freeman has developed three main concepts of centrality in the late 1970s, and the concept of betweenness centrality that assesses the degree to which a vertex lies on the shortest path between two other vertices is applied here. Vertices with a high betweenness value are able to control the flows within the network (Opsahla, Agneessensb, & Skvoretz, 2010). In contrast to concentration measures which focus on the spatial concentration within the network, centrality measures assess the network's structural configuration.

The concept of temporal concentration is based on observations that show that airlines operate synchronized, daily waves of flights through their hub airports (Graham, 1995; Reynolds-Feighan, 2001). The aim of such structures is to optimize the number and quality of connections offered. Veldhuis (1997) introduced the concept of indirect connections at the major airports of an airline. This concept allows airlines and airports to identify their strategic position in the network (Veldhuis, 1997). Burghouwt and Wit (2005) further developed the idea of temporal configuration and compared the performance of different carriers. Differences between large and small carriers were observed as well as an increase in wave-system structures at major airports that has stimulated the number of connecting opportunities at hub airports. The efficient coordination of arrival and departure flights leads to a wave-system structure where departure flights (departure wave) follow a wave of arrival flights to achieve a maximum number of transfer flights for the customers. Airports with wave-system structures generally offer more indirect connections than airports without a wave-system structure, given a certain number of direct flights (Burghouwt & Wit, 2005). The existence of a wave-system structure constitutes very high implementation and coordination efforts for airlines that operate comprehensive wave-systems at airports are expected to remain at the airport for strategic reasons. Such airlines can be determined only by a two step approach which first analyzes the spatial concentration of the airline's network to ascertain the spatially important airports of the network and secondly analyzes the temporal importance of these major airports.

All mentioned studies focus on the classification of air passenger networks whereas cargo traffic was neglected completely. The present work tries to fill this gap by analyzing cargo carriers' network configurations based on spatial and temporal network configurations and draws conclusions on the implications of the network structures for the airport management. Therefore, the selection of airlines as well as the underlying data set is introduced next before the analysis is carried out.

3. Data and selection of airlines

Data of the Official Airline Guide (OAG) for the year 2007 have been chosen for the analysis. This base year has been chosen with caution as 2007 was an average year for the air cargo business without major external effects such as the economic crises which hit the entire supply-chain but especially the air freight sector between 2008 and 2010. Such an ordinary year guarantees that differences between the planned OAG schedules and the airlines' realized flights are minimized. The total tonnages of the whole year 2007 are considered for the spatial analysis (to avoid seasonal supply fluctuations) whereas the temporal in depth analysis uses data of one representative week. The temporal concentration analysis reverts to the coordination of flights at a single airport. Therefore,