Theoretical Foundations Relevant for the Analysis of Hub Airport Competition

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1. Introduction

The discussion about the existence and level of airport competition is ongoing and controversial. A study by the IATA (2013) states that "[c]ompetitive forces alone cannot be relied upon to ensure a fair outcome for consumers and other airport users" and that hence a detailed analysis is required as to the level and effects of competition between airports. Thelle et al. (2012), on the contrary, highlight that "[…] airports of all sizes are often subject to many competitive constraints and that the cumulative impact of these is likely to be significant in many cases". Yet, both studies agree with respect to having a detailed case-by-case analysis for the airports under consideration. In regard to this discussion, the following paper addresses those aspects which play an important role in the analysis of airport competition. The studies discussed here do not cover the entire range of research conducted in the specific fields but outline main approaches and findings relevant for this review.

The review in this paper starts with a short overview of the discussion regarding airport market power and potential competitive constraints (section 2). It highlights factors which are relevant in the passenger and airline decision making process when deciding on the use of an airport (section 3). In addition to that, a particular focus is placed on the characteristics of airline hub-and-spoke networks since network carriers play an essential role in evaluating the level of competition between hub airports (section 4). The vertical relationship between airports and airlines also influences the level of competitive constraint. Section 5 therefore focuses on the synergy potential and incentives for these stakeholders to engage in some form of cooperation. The economic impact of airline networks or airports engaging in some form of competition is outlined in section 6. Section 7 concludes the paper.

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2. Airports: (natural) monopolies versus a competitive industry

"However, infrastructure industries – including airports […] – often contain firms with natural monopoly characteristics where, due to large fixed capital requirements, provision of the service by more than one firm can be less efficient." (IATA, 2007)

Baumol et al. (1982) (p.17) state that "an industry is said to be a natural monopoly if, over the entire range of outputs, the firm's cost function is subadditive". Traditionally, airport infrastructure has been considered as a monopolistic bottleneck since there are economies of scale as well as high sunk cost associated with the provision of runways and terminals. It requires high investment in order to build the infrastructure which cannot be recouped easily once the airport is no longer used for its original purposes. In the single product case, the case of subadditivity may hold in the airport industry. However, an airport is a multi-product firm, which adds a high level of complexity to the determination of the cost function and the examination of subadditivity. Some studies estimate airport cost functions in order to analyze airport efficiency. Martin-Cejas (2002), for example, analyzes the productive efficiency of Spanish airports and estimates a translog joint cost function. The results suggest that airport inefficiencies stem from non-optimal size and that medium-sized airports have a lower level of inefficiency. Oum et al. (2008) apply a stochastic frontier approach to assess the impact of airport ownership on its cost efficiency. Labor, purchased goods, materials and services, number of runways, and the size of passenger terminals are used as input variables. Output measures include number of passengers, freight volume, air traffic movements, and revenues from non-aviation services. The results imply that government-owned airports are the least cost efficient ones.

The existence of a natural monopoly does not necessarily imply that the firm may exploit its market power (Braeutigam, 1989). It is possible that competition for the market may constrain this power. Airport market power may also stem from a locational monopoly, i.e. building a new airport in a nearby geographical location is often constrained by land scarcity or political restrictions (Niemeier, 2009). An ongoing discussion within the airport industry therefore concerns the extent of market power an individual airport may exhibit. In this regard, multiple authors outline a range of factors and developments that can constrain airport market power sufficiently to, for example, abolish or minimize the use of ex-ante economic regulation. A first constraint, as mentioned above, may be the threat of new airport entry which in turn can take a share of the airline-passenger market from existing airports. The threat of substitutes furthermore denotes the case where airports face competition from other transport modes such as high-speed rail, usually constrained to short-haul traffic (Thelle et al., 2012; Graham, 2010; Starkie, 2002; Oum and Fu, 2008).

Airport market power can also be limited by the power airlines exert in terms of potentially switching operations to other airports that offer better conditions. This countervailing power depends on the airline's traffic share and position at the airport (Button, 2010). Starkie (2012) and Thelle et al. (2012) argue that nowadays there are more airlines which can potentially switch operations in case terms and conditions at the respective airport do not match their expectations. Starkie (2012) discusses airlines' increased buyer power which results from the establishment of the European single aviation market and other developments such as the pervasion of the internet. Airlines operating a point-to-point network such as low-cost carriers (LCC) can relocate their relatively mobile aircraft assets across European airports and reduce lock-in effects with airports accordingly (Button, 2010; Graham, 2010; Thelle et al., 2012; Starkie, 2002). Carriers operating hub-and-spoke networks, however, cannot switch their operations easily due to the inherent network structure and the associated investment and costs.

Airports may compete for traffic shares, certain passenger groups or traffic types (Tretheway and Kincaid, 2010; Morrell, 2010). Airports within the same urban region or those with overlapping catchment areas compete for origin-destination traffic. Within these regional markets passengers may be indifferent regarding airport choice. Thelle et al. (2012) highlight the increased amount of airports now available for passengers within certain regions. Furthermore, airports may specialize in attracting particular airline business models or passenger groups such as low cost carrier or business passengers (Tretheway and Kincaid, 2010). Hub airports, for example, may compete for transfer traffic (Morrell, 2010). There is also competition for services within an airport, e.g. between terminals or between airport retail and high street retail shops (Morrell, 2010). In regard to the different business areas at an airport, Starkie (2002) raises the argument whether the complementarity between aviation and non-aviation revenues restricts an airport's incentive to abuse its market power. That would mean that an airport operator would, for example, set lower charges on the aeronautical side since the additional demand attracted by this will generate ancillary revenues on the non-aviation side, e.g. airport parking, shops, restaurants, or real estate (Starkie, 2002; Gillen, 2009). Concerning the competition for passengers and airlines, the following section gives an overview of those factors that influence these stakeholders' airport choice.

3. Airline and passenger choice factors

Airlines and passengers determine an airport's attractiveness by various factors. Hess and Polak (2010) outline three different studies concerned with passengers' airport choice factors. The studies use either revealed or stated preference data and show that originating passengers favor short journey times to their airport of departure. Morrell (2010) states that passengers place high importance on the frequency of transport services as well as the associated cost (see also Matsumoto et al., 2009). However, airport choice factors have to be distinguished by passenger type. A long-haul passenger may accept a much higher travel time to the airport than a passenger traveling short-haul. A way to determine the relevance of different factors is to employ a passenger utility function which includes multiple variables. Harvey (1987) differentiates by business and leisure passengers in the San Francisco Bay Area. Here, the former place high negative utility on airports with no direct flight connections, which is not even offset by superior airport access time. Passengers also do not derive additional benefits from more than nine flights per day to a specific destination.

Matsumoto et al. (2009) cite decision making factors such as comfort aspects or airline loyalty. Malina (2010) and Strobach (2010) also highlight a range of variables which cause passengers to favor a particular airport: the quality of airport access, ticket price, flight availability and frequency, or type of aircraft and aircraft size available. A recent study by Jung and Yoo (2014) investigates passenger choice for air or high-speed rail travel on the short-haul route between Seoul and Gimpo-Busan. The results of the multinomial and nested logit models indicate that ticket price, access as well as overall journey time significantly affect passenger choice and that business passengers are more sensitive to access time changes than leisure travelers.

Pels et al. (2001) and Pels et al. (2003) conduct case studies of airport choice in the San Francisco Bay area with particular regard to passenger preferences. The authors apply (nested) logit models to test for the significance of various passenger decision-making variables. They find that access time to the airport is very important in defining an airport's attractiveness (Pels et al., 2003). Suzuki (2007) extends the model by Pels et al. (2001) by a two-step approach. In the model it is assumed that passengers make their airport and airline choice jointly and then consider a choice set instead of all available alternatives. The airport choice depends on the proximity to a passenger's home and whether the airport has been used before. The airline choice is determined by the level of ticket prices, the frequency of services offered as well as loyalty programs such as frequent flyer programs. Also placing a focus on the metropolitan airport region of San Francisco is Ishii et al. (2009). However, this study specifically focuses on the San Francisco Los Angeles route and finds that both leisure and business passengers' choice is affected by available flight frequency and that business passengers place high importance on punctuality. In addition, the results suggest that the hub premium a network carrier earns at its node airport also results from this carrier offering more frequencies within the region than competing airlines.

An overview of different passenger and airline choice factors is given in Table 1.

Table 1: Passenger and airline decision making factors

Passengers	Airlines
Duration and quality of airport access	Customer preferences
Frequency of transport services	Size of relevant market
Ticket price	Nature of local economy
Flight availability	Geographical location
Comfort aspects	Airport infrastructure and facilities
Airline loyalty	Available capacity
Type of aircraft and aircraft size	Airport charging structure

Source: Own depiction

Airlines strongly consider customer preferences when making the decision at which airport to locate their operations (Starkie, 2010). In addition to this, Huston and Butler (1991) highlight the size of the relevant market, the nature of the local economy defined by established industries and business centers, as well as demographic aspects such as population prone to travel, or income of relevant groups. The geographical location also plays an important role in terms of proximity to the markets served by the airline (Martin and Roman, 2004). Since network carriers intend to derive the benefits from hub-and-spoke operations, coordination of schedules is a crucial factor. In order to realize this in an efficient way, runway and terminal structures have to be designed accordingly and offer sufficient capacities (Dennis, 1994). Congestion and delays may cause airline services to be less attractive and hence less competitive. Available spare capacity and the possibility to expand existing infrastructure may therefore exhibit a competitive advantage for an airport (Starkie, 2010).

4. Hub-and-spoke network characteristics

Airlines derive benefits by structuring their operations in a hub-and-spoke (HS) network as opposed to a fully connected or point-to-point network. Carriers operating this type of network have the potential to realize economies of scale. Since traffic from multiple spokes is bundled in the node, airlines are able to obtain higher load factors on their aircraft (Kahn, 1993; Dennis, 1994). Instead of operating a high amount of point-to-point connections as is the case in a fully connected network, traffic concentrates on a small number of spokes and in the node (Hansen and Kanafani, 1989). As a result, average costs per flight are declining (Huston and Butler, 1993). Another positive effect of traffic bundling is the possibility to employ larger aircraft on certain routes (Hansen and Kanafani, 1989; Kahn, 1993; Dennis, 1994). In addition to this, Caves and Christensen (1984) examine the concept of economies of density with regard to specific U.S. airline markets where trunk and local carriers operate. The authors find that the level of traffic density within a given network accounts for differences in airlines' cost. Economies of scale and density differ since the former consider an extension of the network whereas economies of density depict unit costs within a given network (Caves and Christensen, 1984). Furthermore, Brueckner and Spiller (1991) assume that airlines are multi-product firms with cost complementarities which enable them to obtain economies of scope with HS network operations. This is achieved by being able to offer different products, i.e. types of flights, from a single node (Huston and Butler, 1993). Within the HS network the addition of a new destination increases the number of available city-pairs by a multiple factor.

Other benefits gained from HS network operations are an airline's competitive advantage due to being able to offer high service frequencies, lower cost at high quality and multiple destinations for airline passengers (Dennis, 1994). However, this view is opposed by analytical findings that the fares for O&D (origin and destination) passengers in a HS network are higher than those in a fully connected network (Brueckner and Zhang, 2001). The findings suggest that this is due to the fact that the high flight frequency offered by airlines in a HS network induces departure times being closer to passengers' preferred times and hence airlines are able to levy higher prices. Dennis (1994) also supports that network carriers benefit from their position in a HS network by gaining more control over available capacities and prices. These carriers can use internal cross-subsidies to maintain non-profitable routes in order to attract more passengers. Furthermore, network airlines' scale and scope economies outlined above may discourage other carriers to enter the market on certain routes since they will not be able to compete with existing prices and services (Dennis 1994).

Table 2: Hub-and-spoke versus point-to-point networks

Network	Passengers	Airlines
Hub-and-spoke	+ Increasing number of available city pairs + High service frequencies – Potentially longer travel times – Potentially higher fares	+ Economies of scale and density + Spatial and temporal concentration of flights + Traffic bundling, higher load factors + Employment of larger aircraft – Potential of negative network effects
Point-to-point	+ Shorter travel times – Low level of interconnected flights	+ Focus on high volume routes + Incentives for new entrants – Unprofitable flights if insufficient demand

Source: Own depiction

Brueckner and Spiller (1991) and Zhang (1996) investigate the so called negative network effect (negative externalities) apparent in HS networks. Basically, competition on a particular route may have positive effects within this city pair but may cause negative effects on other routes within the hub-and-spoke network. Brueckner and Spiller (1991) state that the entry of competitors on a previously monopolistic market results in lower fares for passengers. However, some passengers now switch to the competitor on the affected spokes which leads to reduced traffic volume for the incumbent. Due to economies of density, the incumbent's passengers therefore face higher marginal cost, i.e. higher fares, on these routes which might be offset by the lower fares in the competitive market. The positive effects such as fare reduction do not occur in monopolistic markets within the hub-and-spoke network. These markets do, however, experience the negative effects on the spokes induced by competition in a different market. Zhang (1996) elaborates further that this particular effect occurs when increasing returns to traffic density are strong and that a carrier has to balance its profits, i.e. assess the profits gained from entering a market versus the losses incurred in the network market.

Since in a hub-and-spoke network the network carrier and its respective hub are closely linked and exhibit a high level of dependency, the following section outlines potential synergies and benefits between these stakeholders as well as types of interaction they can engage in.

5. Airport-airline relationship

In regard to vertical or horizontal foreclosure within an industry, Rey and Tirole (2007) define the concept of foreclosure and provide a good review as well as extension to the existing foreclosure literature. They establish a theoretical framework with which to assess the benefits and costs of market foreclosure. This occurs if the owner of a bottleneck, e.g. airport infrastructure, restricts access to its facilities for competitive firms on the downstream market, e.g. airlines, in order to increase its profits. Another option can be to engage in exclusive deals with specific downstream firms. This section starts with an outline of selected studies that investigate the effects of vertical foreclosure or integration between upstream and downstream markets in general and continues with an application to airport-airline relationships.

Comanor and Frech (1985) investigate exclusive dealing and the resulting anticompetitive effects in an industry. In the model, the authors assume that the incumbent on the upstream market may engage in some form of exclusive dealing in order to deter the entry of a new manufacturer. The analysis of low-pricing and high-pricing strategies shows that the incumbent profits regardless of the selected strategy. The decision of the downstream player depends on the consumers’ brand preference for the incumbent's product. If this preference is strong, the downstream producer engages in exclusive dealing only if the incumbent opts for the high-price strategy. However, the low-price strategy is more likely to occur since more consumers will buy the incumbent's product. In this case, no exclusive dealing occurs. Comanor and Frech (1985) highlight that the credible threat of the incumbent to engage in vertical integration may already deter an entrant's strategy.

Salinger (1988) analyzes the effects of a vertical merger in the case of oligopolistic market structures on both the upstream and downstream market. The results imply that vertical mergers have both positive and negative welfare effects by removing the double marginalization effect and increasing the price of the intermediate good, respectively. Diverging from this is the model by Ordover et al. (1990). Here, successive duopolies with two firms in both the upstream and the downstream market are assumed and there are no market imperfections such as double marginalization. The model focuses on whether vertical foreclosure can be applied by a firm in order to increase its market share towards its rival. The authors analyze how measures such as counterstrategies of the non-integrated firms or a bidding process for the merger influence the incentives for vertical foreclosure. In the analytical model, the firms engage in Bertrand competition and they offer homogeneous input on the upstream market, have differentiated products downstream and equal market shares on their respective market. The authors find that for vertical foreclosure to be successful the gain acquired by the unintegrated upstream firm has to be larger than the loss incurred by the unintegrated downstream firm. Furthermore, social welfare decreases since there are no efficiency gains to be accrued by the merger due to the lack of previous double marginalization. A similar analytical approach is taken by Chen (2001). Here, prices are also considered as strategic complements and hence competitors on the downstream market engage in

Bertrand competition. Chen (2001) finds that there is a collusive effect and an efficiency effect going along with vertical integration. The former denotes the case of market foreclosure and the latter the gain in social welfare to be achieved by vertical integration. The analysis shows that the collusive effect prevails if the downstream firms are close substitutes.

There are different forms of vertical relations between an airport and an airline (Oum and Fu, 2008). First, airlines may obtain a so called signatory status. Basically, the airline commits to using the airport to a certain degree and to provide part of the financing of operations. In return, it obtains a share of control over certain areas at the airport such as relevant infrastructure projects, slot allocation, or facility usage. Long-term usage contracts depict another option which can often be found between airports and their respective low cost carrier. Furthermore, in some cases airlines acquire direct control over certain airport facilities or services by investing financially and earning respective revenues from airport functions. Resulting from this type of cooperation, both the airline and the airport derive benefits such as risk sharing, ensuring investments and generating (additional) revenues. The positive demand externalities of the airline-airport relationship are hence intended to be internalized (Oum and Fu, 2008).

Fu and Zhang (2010) examine the effects on consumer surplus as well as social welfare if the airport and one or multiple airlines engage in concession revenue sharing. The model considers three different airline market structures, namely a monopoly airline as well as a symmetric and an asymmetric airline oligopoly. The airport is non-congested and acts as an input monopoly. Within this setting, the airport operator offers the involved airlines to participate in the sharing of concession revenues which the airlines can accept or reject (stage one of the game). In the second step, airlines engage in Cournot competition and the subgame perfect Nash equilibrium is determined. The findings of the model show that there may be an increase in social welfare due to the internalization of demand complementarities on the concession revenue side and the elimination of double marginalization. In the monopoly case, both airline and airport profits increase as do consumer surplus and social welfare. If the airport engages in revenue sharing with symmetric airlines in an oligopoly, the airport's profit as well as social welfare increase. On the contrary, if the airport has an exclusive deal with only one airline, the latter increases its output at the extent of its competitors (Fu and Zhang, 2010). The analysis also reveals that the airport operator has an incentive to exert influence on the downstream airline market, i.e. it can thus attain additional surplus apart from aviation service charges in the form of fixed payments by the airline. An asymmetric airline duopoly sets incentives for the dominant carrier and the airport to commit to revenue sharing. In this particular case, the position of the dominant airline is further strengthened which has negative effects on competition. Overall, positive effects of revenue sharing include an increase in consumer surplus and social welfare whereas on the negative side increased airline market power and an airport's incentive to raise aeronautical charges have to be noted (as opposed to Starkie, 2002). The authors outline potential future extensions of their model by integrating airport competition, airport congestion, capacity investment, and the cost of regulation.

Barbot (2009) analyzes the incentives for vertical collusion between an airline and an airport by considering a three-stage game. The airlines engage in Bertrand competition in a spatial setting which leads to the airport's derived demand function. According to that, the airports set the level of aeronautical fares and in turn both parties decide whether they engage in collusion. If there are market and quality asymmetries the applied model shows that there will not be any collusion. However, in the case of market asymmetry and airline vertical differentiation, the conditions are suitable for collusion between the airport and the airline. Integration of a parameter accounting for the airport's concession revenue does not yield any significant changes to the findings. Barbot (2009) therefore concludes that this aspect does not make a difference with respect to the collusion decision.

Barbot (2011) extends the analysis of Barbot (2009) by investigating the effects of various types of possible vertical relations. Within the analysis, Barbot (2011) models different types of vertical integration between an airport and an airline assuming that there is a monopolist on the upstream market and imperfect competition on the downstream market. The three types of arrangements include joint profit maximization, airline's operative participation in the upstream market (e.g. terminal provision), and price discrimination in favor of the dominant airline. In the first two cases the author finds anti-competitive behavior with regard to the downstream market whereas price discrimination does not lead to market foreclosure. If the airport and airline jointly maximize profits or if there is price discrimination, consumer surplus as well as welfare will increase due to the prevention of double marginalization. The underlying assumption for this is linearity of demand in the downstream market. In case the dominant airline engages in the upstream market, Barbot (2011) finds that there will be a decrease in both consumer surplus and welfare which can only be avoided if this interaction leads to an increase in efficiency of the operated facilities. The same findings result if Cournot competition in the downstream market is assumed. The author also outlines regulatory implications resulting from the findings of the analysis.

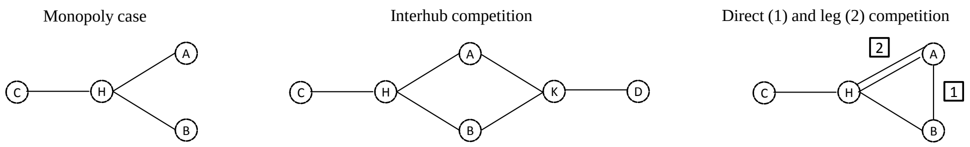
D'Alfonso and Nastasi (2012) take up the three arrangements discussed in Barbot (2011) and add competition in both the upstream and downstream market. The authors analyze the incentives for airlines and airports, and the incentives for social welfare, consumer surplus as well as pro-competitiveness. Assumptions of the model are that airports do not compete for airlines but for passengers via airlines. In terms of airline market structure in the model, D'Alfonso and Nastasi (2012) assume that there is a leader at each facility which engages in Stackelberg competition with its followers. Among themselves, both the leaders and the followers engage in Cournot competition. Further assumptions include a spatial competition model of an infinite linear city with each airport having spare capacity available and no congestion. The findings suggest that vertical collusion and an airline's participation in the upstream market are anti-competitive. However, the incentives for the players to engage in price discrimination are rather small compared to the incentives for collusion. This finding is slightly different to Barbot (2009) since D'Alfonso and Nastasi (2012) assume that the market is not fully covered. They outline that regulatory considerations may address the arising tradeoff between airline competitiveness and welfare as well as the fact how incentives have to be designed for the implementation of agreements that maximize social welfare.

The outline of the research within the field of vertical interaction between airlines and airports is complemented in the following section by an outline of the effects of competition between airline networks and/or the respective (hub) airports.

6. Effects of airline network and airline competition

The welfare and distributional effects which might arise due to competition in airline hub-and-spoke networks are analyzed by, inter alia, Brueckner and Spiller (1991). In the study, the authors use the monopoly setting as basis against which to compare the outcome of competition between different hubs offering the same transfer connection (interhub competition), competition between a transfer and a direct connection as well as the competition that might occur on one of the legs of the transfer connection (see Figure 1).

Figure 1: Different types of airline network and airport competition



Source: Brueckner and Spiller, 1991

The authors find that a hub-and-spoke network structure is optimal for an airline due to economies of density. Assuming symmetric demand across routes, Brueckner and Spiller (1991) derive the outcome for the monopolist profit maximization problem. In order to compare this outcome to cases involving different forms of competition, marginal revenue and marginal cost functions are assumed to be linear as well as of increasing returns. The monopoly airline operates via a hub and offers no direct connections between the points connected by this node. In the case of interhub competition, another airline serves the same points (cities) via a different hub. The passenger hence has the choice between two different routes connecting the same city pair. The rivaling airlines engage in Cournot competition on the routes connecting the city pair AB and set monopoly prices on the other routes. Compared to that, direct competition means that an airline offers a direct connection between points A and B and leg competition denotes competition on the route between the hub and one of the nodes. With direct competition the welfare effects strongly depend on the level of increasing returns as well as demand whereas leg competition leads to higher traffic volume and lower fares on the affected leg and the reverse effect on the monopoly routes. The overall analysis shows that competition may have negative effects outside of the market where it takes place and that it is important to consider the level of increasing returns (Brueckner and Spiller, 1991). Brueckner et al. (1992) and Brueckner et al. (1994) apply the developed model and results in order to test different empirical hypotheses. They find that network characteristics influence respective fares (Brueckner et al., 1992) and that consolidation in operations produces welfare effects which are able to offset negative effects from decreased competition (Brueckner et al., 1994).

Finding the optimal hub-and-spoke network from an airline point of view is the research focus in the paper by Adler and Berechman (2001). The authors' approach includes the generation of a network and consecutively connecting the different hubs via either minimization of distance or of total legs traveled. For the model development it is assumed that the relevant network configuration for an airline is determined by the profit maximizing objective. This model is applied to data of the Western European air transport system. In their findings, Adler and Berechman (2001) show that the preferable network for an airline consists of an international hub and an intra-European, secondary hub. Furthermore, they highlight that the airports in question are impacted by the airlines' decisions in regard to their pricing policies or strategic capacity planning. Adler (2005) extends the analysis of Adler and Berechmann (2001) by considering competition between hub-and-spoke networks and how this influences an airline's optimal network choice. A multinomial logit model is applied to determine airlines' market shares, an operations research based program is used to solve the airlines' objective function of profit maximization, and a game theoretic approach enables to depict the competitive situation with multiple airlines. These choose their network first and consecutively maximize profits given the other airlines' decisions. In the application of this model to the Western European aviation market, the author finds that a single, monopolistic subgame perfect equilibrium exists with British Airways as the monopolist running a hub-and-spoke network with London Heathrow (LHR) and Zurich Airport (ZRH) as their primary and secondary hubs. Conducting a so called doubled-demand sensitivity analysis shows that there is sufficient demand to support two profitable airline networks.

Adler and Smilowitz (2007) also apply a game theoretic approach, this time to analyze airlines' choice of networks considering the potential of mergers and alliances and the effects of a competitive operating environment. Within the model, different network configurations under various merger or alliance scenarios are considered and each tested for the respective profitability. The framework developed in this paper yields insight into the effects of airlines' mergers and alliances on social welfare and the aviation system in total.

Flores-Fillol (2009) investigates the airline network structure under competition in an unregulated environment. Welfare implications are assessed by analyzing different scenarios in an equilibrium analysis. The author applies a duopoly model of schedule competition and looks at fully connected (FC) and hub-and-spoke (HS) networks and which conditions have to be fulfilled in order for symmetric or asymmetric equilibria to arise. The findings reveal that in the presence of low transport cost airlines opt for a HS network structure and with high transport cost for a FC network. HS networks are characterized by different effects which entail opposing impacts: the demand effect, i.e. higher flight frequencies than in a FC network, the cost-saving effect resulting from economies of density, and the cost-per-passenger effect. The latter effect depicts the situation in which the airline has to pay the cost per passenger twice since it does not serve particular markets directly but via its hub. Therefore, in case the transport costs are very high, the airline will incur high costs which can eventually not be offset by the former two effects and hence aim for a FC network. Furthermore, the author states that asymmetries may arise, i.e. there might be airlines establishing FC networks and others relying on HS networks, without previously having introduced asymmetry in the model. Interesting aspects for future research in this regard hence include the explicit introduction of asymmetries in the model, the consideration of congested hub airports as well the introduction of oligopolistic structures in the airline market (Flores-Fillol, 2009).

Basso (2007) and Basso and Zhang (2007) develop a model illustrating the vertical structure and competition of congestible facilities and the resulting effects on prices and capacities. Within Basso (2007) it is assumed that airports are input providers whose demand is a function of airport charges, capacities, and airline market structure. To determine optimal prices and capacity decisions it is therefore not only necessary to have information on the airport's cost and demand function but also on the respective airline market. Considering different airport objective functions, i.e. welfare and profit maximization, shows that prices are higher and traffic levels are lower in a profit-maximizing setting which leads to an oversupply of capacity Basso (2007). Other cases considered in this paper are the joint profit maximization of an airport and an airline as well as the case of two independent profit-maximizing airports. The first case may help to avoid so called vertical double marginalization whereas the second one addresses horizontal double marginalization which occurs when airports' outputs are considered complements.

Basso and Zhang (2007) also employ a model which incorporates two rival congestible facilities (airports in a multi-airport region) which are input providers for the downstream market (airline operators) and hence the final consumers (passengers). The competing airports choose prices and capacities for the input they provide for the downstream market. Subsequently, the airports' respective carriers compete and the final consumers select one of the facilities. The results from competition in terms of welfare are compared with the single airport case. The facilities' decisions and the resulting service levels for users depend on the nature of the game. In a closed loop game (decisions on prices and capacities are made sequentially) as in DeBorger and Van Dender (2006) the duopolists offer a lower service quality than the monopolist. In a situation where capacity and pricing decisions are made at the same time, the service level under a duopolist regime is the same as in a monopolist setting (Basso and Zhang, 2007).

The analysis by Allroggen and Malina (2010) also looks at the existence and extent of market power with regard to hub airports. The cases of joint and independent profit maximization of an airport and an airline are considered. Assumptions of the analytical model are duopolistic Bertrand competition for transfer passengers on the downstream market and a monopolistic upstream market. Both airlines and airports are considered to be profit maximizers and both exhibit symmetric cost structures. An airport's non-aeronautical revenues are not considered in the model. Due to the competition on the airline market, the authors find that the market power of hub airports is limited and that there are incentives for joint profit maximization of the different players. In this particular case, individual profits for both the airport operator and the respective airline are maximized. The theoretical model suggests that independent profit maximization causes a negative impact on social welfare. Considering the benefits of the strategic vertical relationship, the paper proposes to consider asymmetric regulation for hub airports, i.e. restrain regulatory measures restrains to areas other than the transfer passenger market.

The strategic interaction between airports on different continents and the resulting effects on prices and capacities are examined in Benoot et al. (2012). The analysis considers the role of airport regulation and its impact on airline markets. The authors assume in their analytical model that there are two airports on different continents with each having a regulator determining the charging structure. The airlines are non-atomistic consumers of the congestible facilities as in DeBorger et al. (2007). The airports act as Stackelberg leaders regarding the airline market by determining capacities in a Cournot game and subsequently setting airport charges. Due to the complementary nature of these airports, i.e. considering them as successive monopolies (Benoot et al., 2012), the problem of horizontal double marginalization occurs which leads to welfare losses (see also Basso and Zhang, 2007). Important findings of this analysis state that strategic airport pricing and capacity choices by the regulators on the different continents lead to these welfare losses. Furthermore, the losses exceed the negative impacts resulting from imperfect competition on the international airport market. The paper therefore suggests that a reduction in the number of monopolist regulators can induce an increase in overall welfare (Benoot et al., 2012).

7. Conclusion

The paper reviewed the literature, including different theoretical models, that is relevant for the analysis of airport competition. There is a variety of factors that potentially impose competitive constraints on an airport's market power. One of these is the passengers' or the airlines' decision to select a particular airport. Their reasons are manifold and the importance placed on the individual aspects differs by customer groups. A detailed analysis of an airport's specific target group helps to adjust supplied products and services accordingly. A specific focus within the review is placed on hub-and-spoke networks since network carriers and their respective hub airport(s) face a high level of dependency. The network carrier has to invest a lot of effort to switch operations to another airport since it requires sufficient capacities as well as slots within a certain time period to optimize its (transfer) schedules. A high share of aircraft movements and passengers frequenting the airport stem from the operations of the network carrier. The airport operator therefore relies on the continuation of network carrier operations. The review of models in regard to vertical cooperation between airports and airlines shows the potential for synergies between these two stakeholders. Cooperation may hence be beneficial for both by strengthening the competitive position in the market. In order to analyze the welfare and distributional effects of competition several models are outlined. These approaches can be used both by regulators and airport operators to assess the level and impact of competition and they also offer a valuable application for further research.

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