Market Structure, Countervailing Power and Price Discrimination: The Case of Airports

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Abstract

A number of interesting policy questions have arisen regarding airport landing fees. For example, what is the impact of joint ownership of airports? Does airline countervailing power stop airports raising fees? Should airports be prohibited, as an EU directive intends, from charging differential input prices to airlines? We set out a model of upstream airports and downstream airlines with varying countervailing power and pricing structures. Our major findings are: (a) an increase in upstream concentration or in the degree of differentiation between airports always increases the landing fee; (b) the effect of countervailing power, via an increase in downstream concentration, lowers landing fees, but typically does not pass through to consumers; (c) with Cournot competition, uniform landing fees are always higher than discriminatory fees.

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1 Introduction

The airline market has provided fertile territory for huge numbers of theoretical and empirical papers in economics. Perhaps one reason is that its institutional features span so many interesting phenomena: competition, regulation, networks, auctions, unionized labour markets, the environment, consumer transport choice, etc. But relative to that considerable weight of work there is relatively little on what would seem a rather important complementary input, namely airports.\footnote{The major exception is the analysis of slot auctions to allocate crowded space at airports. This literature does not deal with modeling of landing fees that we look at here. We neglect slot auctions in the work below, for in practice, many European airports have slot allocation via grandfather rights, that is, slots are allocated according to whether airlines operated that slot last period. Oum and Fu (2008) survey recent literature on airport competition and regulation, touching on a number of issues including single and dual till.}

Perhaps until twenty years ago, it might be argued that the study of airports was not particularly rewarding either by itself or as something that might inform the study of airline competition. Most airports were public sector owned and regulation or specific agreements held landing fees to non-profit levels. The vast majority of airports held plenty of spare capacity and their location was a historical accident; new entry was almost unheard of. Competition between airports was a fanciful notion regarded as impossible.

The position today looks very different. First, market structure. Low cost airlines have brought new, often non-central airports, into effective competition. Even in large cities, competition has emerged between (non-congested) airports: privately-owned rival airports have engaged in documented bidding wars over lower landing fees in cities like Moscow, Belfast, Melbourne, Orlando, Miami and London. Competition has grown even in relatively congested airports where network externalities are important: 33% of London Heathrow passengers only change planes there, leading Heathrow to publicly claim that it competes with hub airports in Paris, Frankfurt and even Dubai. Second, privatization. 55 countries have partially or totally privatized their airports (IATA, 2007). Third, regulation. There are currently a series of major regulatory changes proposed to airports. In the UK, the Competition Commission in 2009 ruled that BAA, the joint owner of most major UK airports (London Heathrow, London Gatwick, London Stansted, Glasgow, Edinburgh, Southampton and Aberdeen), should be broken up. The new EU Airport Charges Directive (2009/12/EC) imposes a host of regulations for large airports, including “non-discrimination”, i.e., an airport must offer the same input charge to all airlines. Other regulatory changes in train include examinations of single and dual till regulation whereby retailing revenue at airports is returned to airlines or airports respectively. Fourth, congestion. Airports have increasingly become more congested, raising additional problems in short-run landing fee pricing but also long-run capacity expansion (Borenstein and Rose, 2007). New runways have been vetoed in London but the new runway at Frankfurt was completed in 2011.

These changes open a number of interesting questions. We cannot study all of them in one paper. This paper sets out a framework that can answer at least some of the following policy-relevant questions: (a) What is the effect on landing fees of ownership structure up and downstream? For example, should the jointly owned UK airports be split up? (b) Would countervailing power from
airlines ever be enough to stop airports charging high landing fees so that even a geographically isolated airport does not need regulation? (c) As airports get more congested, does that alter the nature of the relationship between airports and airlines? (d) Should input price discrimination be allowed by airports?

These questions are recognized to be crucial in policy debates regarding the regulatory choices for airports, yet to the best of our knowledge none of them have been answered using a formal model. As we shall see, some of the answers to these questions are exactly those one would expect, but some are remarkably different, providing a strong motivation to our analysis.

We also think the paper is of broader interest. First, one ingredient of our model is countervailing power, an issue that is common in regulatory cases where more or less concentrated intermediate suppliers and final sellers face each other (e.g., farmers and supermarkets, health insurance companies and hospitals). Second, it turns out that some of the (rather few) existing models in this area have used particular demand functions that do not fully satisfy some requirements such as negative cross-price elasticities of demand. We work with a novel demand system that has not been used before and thus show how we avoid some of the implicit assumptions made in other cases.

We study a vertical industry in which upstream suppliers (airports) provide an essential input (landing rights) to downstream firms (airlines) at a linear price (the per-passenger landing fee). We model various degrees of concentration in the up- and downstream market structure and of substitutability of demand. Upstream, we assume two airports, who have varying derived-demand substitutability between them. The airports may be jointly owned, or be independently owned, to control for upstream concentration. Downstream, we assume up to four products (routes) with varying demand substitutability among them. The flights can be operated by four separate airlines, or by two multiple product airlines that fly from both airports. In this way, we can also investigate the effects of changes in downstream concentration. We also look at different modes of competition downstream. We analyze both cases of airlines competing in quantities and prices, taking these, respectively, as illustrations of more or less congestion of the airport systems. In the last section of the paper, we also consider the effects of a ban on discriminatory landing charges.

Our modeling choices attempt to capture the essential features of the industry under analysis. Some airport systems are under the same ownership (London before the UK CC decision, but also Paris, New York and Rome) while some other face competitors; in some cases locally (Moscow), in some other cases from remote airports (major international hubs). Competition between airports is also related to the offer of overlapping routes by airlines and to the willingness to travel between alternative airports by consumers, both found to be rather high in recent studies (OFT, 2007). As to the landing fee, it is composed of different elements, most of which vary linearly with the number of passengers. The possibility of discrimination between airlines flying from the same airport is explicitly forbidden in Europe by the recent 2011 EU Airport Charges Directive (Competition Commission, 2009, para 6.15) and section 41 of the 1986 Airports Act in the UK (CAA, 2006).

For further details of the institutional background informing our assumptions see Appendix C.
Model findings. We cast our findings in terms of equilibrium landing charges ($\ell$), although we also consider the effects on final prices, consumer surplus and profits.

1. Upstream market power raises $\ell$. Under a wide range of market structures, downstream market games and contract structures, $\ell$ is higher with common ownership of airports or less substitutability between them. We also find an invariance result when the upstream market is under common ownership: the landing fee is always set at the monopoly level, irrespective of the nature of downstream competition. This result no longer holds true once airports are competing against each other, in which case up- and downstream competition reinforce each other.\(^3\)

2. Downstream market power (countervailing market power) generally lowers $\ell$. A concentrated airline can fly its other route from the other airport if the landing fee charged by one airport is too high (fragmented airlines flying one route each have no such option). This tends to lower $\ell$.

3. Downstream market power generally increases final prices. Whilst the effect above sets out what happens to $\ell$, it is of interest to find out what happens to final consumer prices. As seen immediately above, an increase in airline countervailing power generally lowers $\ell$. But one might ask: does that reduction in $\ell$ “pass through” to a reduction in final prices to the passengers? The answer is negative since the negative effect of increases concentration downstream is never fully offset.

4. Bargaining over discriminatory landing fees typically lowers $\ell$ compared to uniform landing fees. This finding, which is true in general for Cournot competition among airlines, is due to the fact that an airline is a tougher negotiator with the airport when any discount obtained does not have to be shared with its rivals.

Related work. As pointed out above, the bulk of the academic literature in this area is not focused on how landing fees emerge from the airport/airline interaction. It is however very rich, looking at airline competition, employee compensation, slot congestion, noise, etc., much of which is summarized in Borenstein and Rose (2007) and Winston (2009) for example.

The literature on congestion pricing and airport capacity financing abounds, especially with atomistic airlines. More relevant for our purposes, some papers consider airlines with some degree of market power, as we do. In the widely cited paper by Brueckner (2002), an airport sets congestion charges with either competitive or monopolistic airlines, but there is no competition with other airports. Zhang and Zhang (2006) study monopolistic airport investment in capacity, under different types of ownership, when oligopolistic airlines have market power. In De Borger and Van Dender (2006), two airports unilaterally set prices and choose capacity in the light of congestion costs that are assumed to reduce demand at each airport; there is no modeling of airlines.\(^4\)

There is no consensus on the best modeling choice for airline competition. Cournot behavior is typically taken as a proxy for competition with limited capacity (a result which goes back to Kreps

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\(^3\)Oum et al. (2008) study the effects of ownership on airports’ cost efficiency. They find that competition typically improves efficiency, but it plays no role when airports in cities with multiple airports are owned and operated by a single airport operator.

\(^4\)Other contributions in this stream of the literature on approaches to internalize congestion include Pels and Verhoef (2004), Zhang and Zhang (2006), Basso and Zhang (2007), Morrison and Winston (2007), Basso (2008), Bruekner (2009), and Verhoef (2010).
and Scheinkman, 1983), and, together with homogeneity, it is assumed by Brueckner (2002), Pels and Verhoef (2004) and Zhang and Zhang (2006). Indeed, evidence consistent with Cournot is found in earlier works, e.g., Brander and Zhang (1990) and Oum et al. (1993). Brander and Zhang (1990) reject Bertrand behavior, however they only consider perfectly homogenous products. More recent work has used Bertrand models of differentiated products to model airline competition to shed light on specific questions such as airline alliances, entry, and hub premiums (e.g., Armantier and Richard, 2008; Goolsbee and Syverson, 2008; Ciliberto and Tamer, 2009; Ciliberto and Williams, 2010).

Other papers that touch on airport competition are Barrett (2000) and Starkie (2001, 2002), the former a rich series of case studies on low cost airlines and the latter papers with some speculation on countervailing power but no formal model. Forsyth (2006) reviews informally several policy questions related to airport competition, while Zhang and Zhang (2003) review airport privatization. Oum and Fu (2008) argue that airports have substantial market power, which may be moderated by competition both in the airport market (as we find) - but not under common ownership (as we also find) - and in the airline market (that we do not necessarily find).

There are two recent studies on landing fees by Van Dender (2007) for 55 large US airports and Bel and Fageda (2010) for 100 large EU airports. Both find lower landing fees when airports face airport competition, an effect anticipated by our model. But in the US it appears that increased airline concentration raises landing fees, whilst lowering it in the EU. Our model can explain these differing results to the extent that US airports are on average less congested than EU airports, which in our model changes the strategic interaction between airlines.5

The application of our modeling approach to airports and airlines is natural, but we point out that these questions are examples of broader issues of countervailing power, whereby, in a vertical chain, upstream suppliers interact with downstream buyers. Such questions have been discussed informally since at least Galbraith’s (1952) book, but have excited theory interest only more recently.6

The plan of the rest of this paper is as follows. In the next section, we set out our model assumptions. Section three presents the results of the main model, while section four considers an extension of our set-up to analyze the issue of discrimination. Section five summarizes and concludes. The Appendices contain some analytical details, all the proofs, and some institutional details underlying our questions and assumptions.

2 The model

We consider an industry in which two upstream suppliers, A and B, sell an intermediate good to downstream firms. Downstream firms use this input to produce four differentiated goods, 1 to 4, and sell them to final consumers. We take upstream firms A and B to be airports, and downstream
firms to be airlines, which fly passengers along designated routes: routes 1 and 2 can only depart from airport A, while airport B is the origin of routes 3 and 4. Each final product is therefore a flight service on a given route and the quantities sold by airlines are passengers per route.

Costs. For an airline, we assume that the product of the load factor and the seat capacity is constant. Thus when the number of flights is set, this also determines the number of passengers. Each flight needs a slot at the relevant airport. For this, airports receive a linear input price $\ell$ per passenger, which we refer to as the landing fee. We further assume that this is the only cost borne by airlines. All airports’ costs are also normalized to zero.\(^7\)

Consumer preferences. We face a first challenge, as we want to model demand for four goods (flights) with different patterns of substitutability: two differentiated flights originate from airport A, and two further differentiated flights are from airport B. While there is a long tradition in Industrial Organization, at least since Spence (1976) and Dixit and Stiglitz (1977), to model demand among symmetrically differentiated products,\(^8\) these demand functions are of no use here as they would not capture the differences between flights from different airports. For instance, the pattern of substitution between routes 1 and 2 (flying from the same airport) should be different from the pattern of substitution between routes 1 and 3 (flying from different airports).

While a totally flexible demand system would obviously be more general, it immediately loses tractability in a theory paper like ours. We therefore propose a new system of demand functions that is tractable and parsimonious, in that it needs only two parameters to describe the various price elasticities and yet, as we discuss below, it preserves certain desirable properties.

Demand originates from a representative consumer. We generalize Shubik and Levitan (1980), and assume that the quasi-linear utility function of the representative consumer is given by

$$U = I + \sum_{i=1,\ldots,4} q_i - \frac{1}{1+m} \times$$

$$\left\{ (1+b) \sum_{i=1,\ldots,4} q_i^2 + \frac{m}{2} \left[ \left( \sum_{j=1,2} q_j \right)^2 + \left( \sum_{k=3,4} q_k \right)^2 \right] + bm \sum_{j=k=1,2} q_j q_k \right\},$$

where $I$ is consumption of other goods. This utility gives rise to a linear demand structure. Letting $q \equiv \{q_1, q_2, q_3, q_4\}$ be the vector of flight services for all routes, inverse demand for good 1 is

$$p_1(q) = 1 - \frac{2(1+b)}{1+m} q_1 - \frac{m}{1+m} [q_1 + q_2 + b(q_3 + q_4)],$$

whenever this is positive. Similar expressions hold for inverse demand of the other goods.

\(^7\)Because of our fixed-proportion assumption, it is immediate to introduce further positive costs per passenger. Our results can be interpreted as setting the margins over and above these costs.

\(^8\)In their models, there is one single parameter which describes the pattern of substitutability among products. Demand functions originating from a quasi-linear utility with a quadratic subutility, in the same spirit as ours, have also been widely employed in economic geography (e.g., Ottaviano et al., 2002), but again they are assumed to be symmetric in all varieties and employ a single parameter of substitutability, which is not enough in our application.
The parameters $b$ and $m$ describe substitutability between the goods. Substitutability between the pair of routes 1 and 2, and the pair of routes 3 and 4, depends on $m$, where $m \in [0, \infty]$. As $m$ approaches infinity, these goods tend to become pairwise homogeneous, while when $m = 0$ they are completely independent. Parameter $m$ is thus related to the degree of substitutability between the two routes flying from the same airport; it is assumed to be equal in the two airports, thus restricting our analysis to symmetric equilibria. Good 1 (and, symmetrically, good 2) is also substitutable for goods 3 and 4 in an equal manner, determined both by $m$ and by an additional parameter $b$, where $b \in [0, 1]$. When $b = 0$, good 1 is completely independent of the two other goods, while when $b = 1$ they are as substitutable as good 2, depending on the specific value of $m$.

As a possible interpretation, $b$ represents the substitution parameter between airports: if $b = 0$ ($b = 1$) the airports are geographically remote (close).

Inverting the system of four inverse demands as (2), the system of linear direct demand functions can be derived. With all the four goods sold in the final market, and letting $\mathbf{p}$ denote the price vector for all the flight services, the demand for good 1 is given by

$$q_1(\mathbf{p}) = \frac{1}{2(1+b)} - \frac{2[(1+b+m)p_1 + m(1+m(1-b))(|p_1 - p_2|) - bm(p_3 + p_4)]}{4(1+b)[1+m+b(1-m)]}$$

whenever this is positive. Similar expressions also hold for the other goods.

Desirable properties of the demand system. This demand system allows for differences in the nature of the substitutability between different groups of goods, but nevertheless maintains some of the desirable features of the original system proposed by Shubik and Levitan (1980). We therefore believe that it can be seen as a contribution of the paper, with potential applications to other multiproduct industries. When all goods are sold in the market, the total demand curve reduces to

$$\sum_{i=1,\ldots,4} q_i = \frac{4 - \sum_{i=1,\ldots,4} p_i}{2(1+b)}$$

by simply adding up the four demands such as (3). This implies that total demand is fully independent of $m$, the substitution parameter between flights in the same airport. It depends only on $b$, the substitution parameter between airports, which is typically related to the “catchment” area of each airport, i.e., the distance that passengers have to travel to reach the airport. In particular, with two geographically-independent airports ($b = 0$) demand is twice the size than with perfect substitute airports ($b = 1$). This implies that market size does not vary with the number of routes or their substitutability at given prices. With two very distant airports, we have two independent islands, each of maximal size 1 and with two goods each; with identical airports, we have a single island of size 1 and four goods.

Since our demand system is novel, it is of interest to discuss the various elasticities, as they will...
guide the competition results in the following sections. Specifically, when considering a symmetric vector of prices with $p_i = p$ for all $i = 1, \ldots, 4$, it is easily computed that

$$
\begin{align*}
\epsilon_{11} &= \frac{-p}{1-p} \frac{2 + 2b + 3m + m^2(1-b)}{2[1 + b + m(1-b)]}, \\
\epsilon_{12} &= \frac{p}{1-p} \frac{m[1 + m(1-b)]}{2[1 + b + m(1-b)]}, \\
\epsilon_{13} &= \epsilon_{14} = \frac{p}{1-p} \frac{bm}{2[1 + b + m(1-b)]},
\end{align*}
$$

where we have reported for simplicity the elasticities of flight 1 (departing from airport A) with respect to the own price, the price of flight 2 (also departing from the same airport), and the price of flights 3 and 4 (both departing from airport B).

From these expressions it is clear that two parameters, $b$ and $m$, jointly determine three elasticities. We should first note that elasticities all have the expected sign, as $\epsilon_{11} < 0$, $\epsilon_{12} > 0$ and $\epsilon_{13} > 0$. The absolute value of elasticities becomes smaller for lower prices, as it is standard with linear demand models. It is easy to check that $|\epsilon_{11}| > \epsilon_{12} > \epsilon_{13} = \epsilon_{14}$, when calculated at the same prices, which represents a reasonable pattern of substitution in our context.

Limiting cases also pose no particular concern, as, for instance, $\frac{|\epsilon_{11}|}{\epsilon_{12}} = \frac{2 + 2b + 3m + m^2(1-b)}{m + m^2(1-b)}$ tends to 1 when $m \to \infty$ (i.e., goods 1 and 2 are perfect substitutes). Similarly, $\frac{\epsilon_{12}}{\epsilon_{13}} = \frac{1 + m(1-b)}{b}$ tends to 1 when $b \to 1$ (i.e., goods 2 and 3 are equally substitute with respect to goods 1). In fact, more generally, the elasticities are monotonic with respect to the parameters $b$ and $m$

$$
\begin{align*}
\frac{\partial |\epsilon_{11}|}{\partial m} &> 0, & \frac{\partial |\epsilon_{11}|}{\partial b} &> 0, \\
\frac{\partial \epsilon_{12}}{\partial m} &> 0, & \frac{\partial \epsilon_{12}}{\partial b} &< 0, \\
\frac{\partial \epsilon_{13}}{\partial m} &> 0, & \frac{\partial \epsilon_{13}}{\partial b} &> 0.
\end{align*}
$$

As $m$ increases, flights become more substitutable, and all the elasticities increase in their value. The effect of $b$ is also sensible: as $b$ increases, airports gets “closer” and this increases the (absolute value of the) own-price elasticity $\epsilon_{11}$ as passengers find it easier to fly from airport $B$. This explains also the impact on $\epsilon_{13}$, as flight 3 becomes a relatively closer substitute when $b$ increases. The negative effect on $\epsilon_{12}$ means that the positive cross-price elasticity between flights 1 and 2 becomes progressively smaller as $b$ goes up. A way to see this result is to say that the cross-price elasticity $\epsilon_{12}$ reaches its the largest value when $b = 0$, so that flight 2 is the only alternative to flight 1: as airports get closer, and $p_2$ increases, fewer passengers shifts to flight 1 since demand is lost to both flights 3 and 4.

\footnote{Some of the properties of our demand system are also common to the one in use by Dobson and Waterson (1997), which extends to many goods the classical Singh and Vives (1984) set-up and which is also widely used. The Singh and Vives demand system suffers from the fact that the market size is not independent of the differentiation parameter between goods. Its generalization to more than two goods is very delicate and it has the undesirable feature that some of the cross-price derivatives of the direct demand functions do not have the (positive) sign one should expect for substitute goods.}
Notice that the way this demand system is specified imposes that the degree of substitution between flights from the same airport is a lower bound to the degree of substitution between flights from different airports. In other words, inter-airport substitution is always lower than intra-airport substitution.\textsuperscript{11} To be more explicit, this makes our demand system well suited to illustrate consumers’ preferences when both airports offer an identical range of destinations, so that every airline flies to the same end destination, but flights are scheduled at different times (our parameter $m$), on top of airports being more or less close to each other (our parameter $b$).\textsuperscript{12} This would apply both to business and leisure travellers. Similarly, our preferences fit those cases when consumers are not bound to a specific route, like, for instance, in the case of holiday-makers: UK travellers may want to go - say - from London to a Mediterranean country, and they may be variously interested in flights from Heathrow to Spain and Portugal, or from Gatwick to Italy and Greece.

*Market structure.* We consider several ownership structures, with more or less concentration both upstream and downstream. Upstream, we look at the cases of the two upstream airports owned by separate firms, $A$ and $B$, or by a single firm, $AB$. Downstream, the four routes may be flown by two separate airlines, with airline 13 flying routes 1 and 3, and another airline, named 24, flying routes 2 and 4; alternatively, the four routes are flown by fully independent airlines, denoted 1 to 4. To summarize, we denote with $U = (A, B; AB)$ the set of all possible upstream players, and with $D = (1, 2, 3, 4; 13, 24)$ the set of all possible downstream players.

\begin{figure}[h]
\centering
\begin{tabular}{cc}
\begin{tikzpicture}[scale=0.5, transform shape]
\node (airportA) at (0,0) {Airport A};
\node (airportB) at (4,0) {Airport B};
\node (route1) at (2,-2) {Route 1};
\node (route2) at (3.5,-2) {Route 2};
\node (route3) at (2,-4) {Route 3};
\node (route4) at (3.5,-4) {Route 4};
\path[->] (airportA) edge (route1)
(airportA) edge (route2)
(airportA) edge (route3)
(airportA) edge (route4);
\path[->] (airportB) edge (route1)
(airportB) edge (route2)
(airportB) edge (route3)
(airportB) edge (route4);
\end{tikzpicture}
&
\begin{tikzpicture}[scale=0.5, transform shape]
\node (airportA) at (0,0) {Airport A};
\node (airportB) at (4,0) {Airport B};
\node (route1) at (2,-2) {Route 1};
\node (route2) at (3.5,-2) {Route 2};
\node (route3) at (2,-4) {Route 3};
\node (route4) at (3.5,-4) {Route 4};
\path[->] (airportA) edge (route1)
(airportA) edge (route2)
(airportA) edge (route3)
(airportA) edge (route4);
\path[->] (airportB) edge (route1)
(airportB) edge (route2)
(airportB) edge (route3)
(airportB) edge (route4);
\end{tikzpicture}
\end{tabular}
\caption{Market structures (same color denotes same ownership)}
\end{figure}

\textsuperscript{11}This feature is often observed in the IO literature on manufacturer/retailer relationships, once one interprets inter- and intra-airport substitution as inter- and intra-brand substitution.

\textsuperscript{12}Pels et al. (2000) use an alternative nested multinomial logit model to describe an aviation market with different departure airports and a single destination.
These hypotheses on the players’ ownership give rise to four possible market structures, also illustrated in Figure 1:\textsuperscript{13}

2 × 2 : Two airports, separately owned, with profits $\pi_A = q_1 \cdot \ell_1 + q_2 \cdot \ell_2$ and $\pi_B = q_3 \cdot \ell_3 + q_4 \cdot \ell_4$, and two independent airlines flying routes 1 and 3, and 2 and 4, with profits $\pi_{13} = (p_1 - \ell_1) \cdot q_1 + (p_3 - \ell_3) \cdot q_3$ and $\pi_{24} = (p_2 - \ell_2) \cdot q_2 + (p_4 - \ell_4) \cdot q_4$ respectively;

1 × 2 : (the most concentrated ownership case) Two airports, with common ownership, with profits $\pi_{AB} = \sum_{i=1}^{4} q_i \cdot \ell_i$, and two independent airlines flying routes 1 and 3, and 2 and 4, with profits as in case 2 × 2;

2 × 4 : (the least concentrated ownership case) Two airports, separately owned, with profits as in case 2 × 2, and four independent airlines flying one route each and with profits $\pi_i = (p_i - \ell_i) \cdot q_i$ for $i = 1, \ldots, 4$;

1 × 4 : Two airports, with common ownership, with profits $\pi_{AB} = \sum_{i=1}^{4} q_i \cdot \ell_i$, and four independent airlines flying one route each, with profits as in case 2 × 4.

This framework, albeit not general, is a very parsimonious and, as it will turn out, an effective way of looking at the effects of changes in down- and upstream market structure on the market equilibrium, while keeping the number of products (and the consumers’ preferences) fixed.

\textit{Market game.} As discussed in the introduction, we consider both the case when airlines compete in a Cournot fashion, by choosing the number of passengers, and the case when the compete à la Bertrand by setting the price of each flight. Competition in the industry is described by a multi-stage game as follows:

1. airports make route-specific offers over landing fees;

2. airlines accept or reject the offers; contract terms are then made public;

3. airlines make their simultaneous and independent choices in the final market (either in prices or quantities); passengers make purchases and payoffs are collected.

In section 4 we extend this set-up to consider a model where airports and airlines bargain over $\ell$, and we modify stage 1 of our game accordingly. This allows us to analyze the effect on landing fees when airports can set discriminatory landing charges. Beside this issue, it turns out that the simplest case described above, where airports have all the bargaining power, allows us to obtain answers to our main questions and to offer quite a rich set of policy guidelines.

\textsuperscript{13} Other market structures could be easily addressed, such as the same airline flying both routes from the same airport, which we do not consider as we want to have some intra-airport competition downstream.
2.1 Discussion of the players’ decisions

In the set-up at the core of the paper, landing fees are set simultaneously in the first stage by the airports, which make take-it-or-leave-it (TIOLI) offers to the airlines. Airlines can only accept or reject them. When all offers are accepted, then the game proceeds to the next stage of downstream market competition.

In stage 1, when both airports are under the same ownership, they set their landing fees by solving the problem

\[
\begin{align*}
\max_{\ell_1, \ell_2, \ell_3, \ell_4} & \sum_{i=1}^{4} \ell_i \cdot q_i \\
\text{s.t.} & \pi_d \geq \bar{\pi}_d \text{ for } d \in D
\end{align*}
\]

where \(\pi_d\) is calculated at the last stage equilibrium, either in prices or in quantities, in the downstream market. The term \(\bar{\pi}_d\) indicates the disagreement payoff for airline \(d\); this denotes the profits the airline would make when rejecting the offer made by the airport.

If airports operate under separate ownership, each airport determines its own landing fees: the problem of airport \(A\) can be written as

\[
\begin{align*}
\max_{\ell_1, \ell_2} & \sum_{i=1,2} \ell_i \cdot q_i \\
\text{s.t.} & \pi_1 \geq \bar{\pi}_1, \pi_2 \geq \bar{\pi}_2
\end{align*}
\]

while a similar problem is faced by airport \(B\) who sets \(\ell_3\) and \(\ell_4\). The solution to each airport’s problem gives best-reply landing fees relative to the rival’s choice; the equilibrium landing fees are the Nash equilibrium landing fees.

In stage 2, airlines choose whether to accept or reject the offer comparing the anticipated equilibrium profits \(\pi_d\) with those they would get by rejecting the offer. In this event, the corresponding route cannot be operated, as disagreements are permanent. Hence, if the airline flies a single route, its profits \(\bar{\pi}_d\) are simply zero. If, on the other hand, the airline is multi-route, it has to evaluate profits on the other route. We assume “passive beliefs”, whereby each player, in evaluating an offer, holds beliefs at the anticipated equilibrium levels when evaluating off-equilibrium play. In terms of our model, this implies that an airline evaluates the profits from rejecting the offer assuming that, in case it rejects the offer, other airlines believe that all offers are accepted at the equilibrium level (as it happens along the equilibrium path). This holds true for all outsiders, while the disagreeing airline is allowed to re-optimize over its remaining route.\(^{14}\)

To say things differently, imagine British Airways (BA) faces an offer by Heathrow. If the offer is not accepted, this is not observed by any rival - say, Virgin. Hence Virgin would still follow its

\(^{14}\)Appendix C sets out institutional details to justify this assumption. Passive beliefs are attractive due to their simplicity to implement. Segal and Whinston (2003) and Rey and Vergé (2004) discuss other belief systems, such as “wary” beliefs.
strategy as if the BA route was in place. BA’s people at Heathrow, however, will contact Gatwick,
in the case BA flies from there too: hence BA’s outside option will be calculated by allowing BA to
know that it only has a route from Gatwick, and not from Heathrow. It is from these choices that
disagreement payoffs can be calculated.

It turns out that no outside option is ever binding at equilibrium in any of the problems above:
the constraints are always slack. Hence, the solution in the first stage is simply derived from the
unconstrained problems (4) or (5) of the upstream firms.

3 Results

All the technical details, as well as the proofs, are relegated to the Appendices A and B. Here we
discuss directly our findings. We summarize first the equilibrium levels of the landing charges.

Lemma 1 Let $\ell^t_{ms}$ be the landing fee, where the type of downstream competition is $t = \{B =
Bertrand, C = Cournot\}$, and where the market structure is $ms = \{1 \times 2, 1 \times 4, 2 \times 2, 2 \times 4\}$. Then,
under upstream monopoly:

$$\ell^1_{C} = \ell^1_{B} = \ell^1_{\times 2} = \ell^1_{\times 4} = \frac{1}{2}.$$  \hspace{1em} (6)

Under upstream duopoly:

$$\ell^2_{C} = \frac{1}{2} + \frac{1}{1 + K^2_{C} \times 4 \times 2} \ell^2_{\times 4} = \frac{1}{2} + \frac{1}{1 + K^2_{C} \times 2 \times 2},$$  \hspace{1em} (7)

$$\ell^2_{B} = \frac{1}{2} + \frac{1}{1 + K^2_{B} \times 4 \times 2} \ell^2_{\times 4} = \frac{1}{2} + \frac{1}{1 + K^2_{B} \times 2 \times 2},$$  \hspace{1em} (8)

with $K^t_{ms} > 0$ for all $b \in (0, 1]$ and $m \in (0, \infty]$.

The actual values of $K$’s are given in Appendix B. The Lemma illustrates that a landing fee
equal to the monopoly level, i.e., $\ell = \frac{1}{2}$, is the equilibrium result when the upstream industry is
monopolistic, irrespective of the nature of the downstream market, since it holds both for Cournot
and Bertrand, as well as for all the downstream ownership structures we consider. This invariance
result of the common input price sold by a monopolist to a downstream industry is already known
in the literature with a single upstream manufacturer supplying a single input (see, e.g., Greenhut
and Ohta, 1976). This finding is generalized here to a single upstream manufacturer selling two
inputs. However, the invariance result no longer holds true when there is some degree of upstream
competition. These more interesting features of the results given in the Lemma are discussed in the
following sections.

3.1 Upstream concentration and competition

One first set of results concerns the effects of a change in upstream concentration and the intensity of
upstream competition, the parameter $b$. Thus we first analyze the case of separate vs. joint airport
ownership, which played a central role in the UK Competition Commission case.
Proposition 1  Competition between separate airports reduces the landing fee. More specifically: i) the landing fee is always lower with separate rather than with joint airport ownership; ii) an increase in \( b \) (airport substitutability) further reduces the landing fee: this effect is larger the larger is \( m \) (route substitutability); iii) \( b = 1 \) is a necessary but not sufficient condition for landing charges to go down to marginal cost.

Proposition 1 states that a decrease in upstream concentration unambiguously leads to a reduction in the landing fee; in other words, a more competitive airport industry leads to lower landing charges. Also, the reduction in the landing fee due to an increase in the substitutability between airports is larger the closer substitutes are the airlines’ products. In other words, a more competitive downstream market magnifies the effect on the landing fee of any increase in competition upstream. Conversely, if \( b \) is very small, landing fees are near-monopolized, irrespective of downstream competition. Notice that landing fees do not decrease down to cost (i.e., zero in our normalization) even for very intense airport competition. This is because, as \( b \) tends to 1, goods do not become perfectly substitutable, as each route can fly only from one specific airport. As we show in the proof, it is only when downstream routes and airports are perfectly substitutable that landing charges may equal marginal cost.

3.2 Downstream concentration, competition and countervailing power

We now turn to assess the effects of a change in downstream concentration and competition. This analysis captures changes in market structure of airlines, and their product differentiation. It is sometimes argued that consolidation among airlines make them tougher counterparts, which should reduce landing fees and possibly end users’ prices. The main policy question relates here to the existence and effects of airlines’ countervailing power.

We have already given a partial answer to this question, showing that, whenever the airport industry is monopolized, the landing fee is always at the highest level, irrespective of countervailing power. However, the presence of upstream competition allows the nature of the downstream market to affect the landing fees. These effects are described in the following results.

Proposition 2  When airports are under separate ownership: i) (countervailing power) a more concentrated airline industry always reduces the landing fee; ii) an increase in \( m \) (more substitutable routes) always reduces the landing fee: this effect is larger the larger is \( b \).

Proposition 2 addresses the issue of countervailing buyer power in our setting. Indeed, it shows that, as the downstream market becomes more concentrated, airlines are able to obtain lower landing fees, but only when the upstream ownership is sufficiently dispersed. This is basically due to the fact that a multi-airport airline which faces an increase in the landing fee in one airport, can benefit from the increase in traffic on the route flying from the other airport. In turn, this reduces the incentive to the airport to charge a high landing fee. Clearly, this effect disappears if the airports are under the same ownership as they coordinate the level of their landing fees.
3.3 Welfare results

The results that we have obtained above have an immediate counterpart in terms of prices and, in turn, consumer surplus and total welfare, that we now discuss. We first concentrate on some results on prices that immediately derive from the previous analysis, and then focus on some more structured analysis of the effects of the different market structures on consumer surplus and welfare.

The increase in the landing fee due to a common upstream ownership, illustrated in Proposition 1, has also an identical adverse effect on consumers’ final prices, and consumers unambiguously lose from an upstream merger. This happens for all values of $m$ and independently of the competition mode.

On the other hand, Proposition 2 points towards a possible beneficial effect of an increase in downstream concentration, via a reduction in costs to the airlines which could be passed on to consumers. However, this has to be contrasted with the tendency to increase prices due to more concentration downstream. The overall effect on prices is described in the following Proposition.

**Proposition 3** An increase in downstream concentration always increases final consumer prices.

The Proposition illustrates that consumers always lose from an increase in downstream concentration since the countervailing buyer power is never passed onto them in a measure to offset the negative effect of the increased airline market power. With a monopolized upstream industry, it is the natural result of landing fees being set always at monopoly level; only market concentration plays a role in shaping the final prices and clearly more concentration implies higher prices. With upstream competition, effects are richer. Under Bertrand competition, the lower landing fee obtained by more concentrated airlines tends to marginal cost in the limiting case of $b = 1$ and $m \to \infty$, when landing fees go down to zero both in the $2 \times 2$ and in the $2 \times 4$ case; only the larger market power of a more concentrated airline industry determines the final result. Under Cournot competition instead, even with perfectly homogenous up- and downstream markets, the landing fee is always lower in a more concentrated downstream industry. The final result on prices is then determined by a pass-through not pronounced enough to offset the upward pressure on prices due to the increased concentration.

We now assess more precisely the effects of changes in upstream and downstream changes in concentration on consumer surplus and welfare. In a symmetric equilibrium, when $p^*$ is the equilibrium price of each good and $q(p^*)$ is equilibrium quantity sold over each route, using (1) and (3) we can simplify consumer surplus and total welfare as

\[ CS(p^*) = U(q(p^*)) - 4p^* q(p^*) = \frac{(1 - p^*)^2}{1 + b}, \]
\[ W(p^*) = U(q(p^*)) - 4p^* q(p^*) + 4\ell q(p^*) + 4(p^* - \ell)q(p^*) = \frac{1 - p^*}{1 + b}. \]

Both expressions are decreasing in $p^*$. We therefore immediately get that any change that would make final prices increase, would also reduce both consumer surplus and total welfare.

An important policy intervention that we are interested in this paper concerns the ownership
structure of airports, as motivated, for instance, by UK Competition Commission decision to break up common ownership of Heathrow, Gatwick and Stansted. While we can predict that, unambiguously, consumer surplus and welfare go up with separate ownership of airports, the magnitude of the changes depends on $p^*$ under each ownership structure, which in turn depends on the type of downstream competition, and on the parameters $m$ and $b$ in the utility function. The CC did no welfare calculations of their decision. We therefore make a new contribution to the debate by doing so. We have, of course, no direct information on $m$ and $b$, but the elasticity expressions can be written in ratio terms as $\frac{\epsilon_{11}}{\epsilon_{12}} = \frac{2+2b+3m+m^2(1-b)}{m+m^2(1-b)}$ and $\frac{\epsilon_{12}}{\epsilon_{13}} = \frac{1+m(1-b)}{b}$. Using estimates of the elasticities, we may solve this system of two equations for the two unknowns, $m$ and $b$, and hence obtain $p^*$, and so $W$.

Information about $|\epsilon_{11}|$, i.e., own-price elasticity of an airline, is available from several sources which report values in the range $-1.5$ to $-2.5$ (EasyJet, 2007; InterVISTAS, 2007). Most studies are in the more elastic range, so we use a value $|\epsilon_{11}| = 2.2$. The elasticity $\epsilon_{12}$ represents the sensitivity of travelers on a certain route from a certain airport, with respect to price of another route at the same airport. There is no central estimate of this in the literature, mostly because very few studies have actual airline-by-airline price data (in turn because, with price discrimination, the price of a specific flight/route is a very hard thing to measure). Our sense, from the little empirical work there, is that this elasticity is quite high, although not as high as own-price elasticity, because of route differentiation. We will use a value $\epsilon_{12} = 1$. Finally, $\epsilon_{13}$ represents the percentage change in flights at some airport, when the price of a flight at another airport changes. If all airports offer the same routes, which is certainly true in the case of London Heathrow/Gatwick, this is the effect of passengers switching airports to fly the same route but from a different airport. Easyjet’s public analysis shows this is quite small, but not zero. We will use a value $\epsilon_{13} = 0.4$. With these three values at hand, $\epsilon_{11} = -2.2$, $\epsilon_{12} = 1$ and $\epsilon_{13} = 0.4$, we can retrieve that $b = \frac{16}{19}$ and $m = 7$.

We are now in a position to compute the changes induced by the separation of Heathrow and Gatwick, using our model as a benchmark. Since these airports are quite congested, it is likely that airlines compete in a Cournot fashion, although, for completeness, we also state the results the case of Bertrand competition. The table below reports the percentage changes of going from joint airport ownership to separate airport ownership, under different scenarios related to airline concentration downstream, as well as competition mode.

<table>
<thead>
<tr>
<th></th>
<th>Cournot $\times 2$</th>
<th>Cournot $\times 4$</th>
<th>Bertrand $\times 2$</th>
<th>Bertrand $\times 4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta \ell$</td>
<td>-45%</td>
<td>-26%</td>
<td>-38%</td>
<td>-34%</td>
</tr>
<tr>
<td>$\Delta p$</td>
<td>-21%</td>
<td>-15%</td>
<td>-26%</td>
<td>-20%</td>
</tr>
<tr>
<td>$\Delta \Pi_d$</td>
<td>+111%</td>
<td>+59%</td>
<td>+91%</td>
<td>+81%</td>
</tr>
<tr>
<td>$\Delta \Pi_u$</td>
<td>-21%</td>
<td>-7%</td>
<td>-14%</td>
<td>-12%</td>
</tr>
<tr>
<td>$\Delta CS$</td>
<td>+111%</td>
<td>+59%</td>
<td>+91%</td>
<td>+81%</td>
</tr>
<tr>
<td>$\Delta W$</td>
<td>+33%</td>
<td>+19%</td>
<td>+25%</td>
<td>+22%</td>
</tr>
</tbody>
</table>

Table 1 - Effect on equilibrium values of changes in upstream concentration.
Although we of course fall short of any generalization, this calibration exercise shows that changes in ownership structure at airports can have very large effects on landing fees. These feed into passenger prices and also produce large welfare changes, in particular to the ultimate benefit of passengers when airports split up. The size of our welfare results is however heavily dependent on the fact that, in our model, landing fees are the only marginal cost, since we normalized to zero all other costs, precisely to focus more clearly on landing fees. Landing fees therefore play a disproportionate role compared to a situation where they would be diluted by other marginal costs. However, since in the real life they typically range approximately from 5% to 30% of airline costs, it is clear that their impact would be relevant also in a model that accounted fully for all types of costs. Also, and more importantly, all the directions of our welfare changes would be preserved in a more realistic model which included non-zero marginal cost for both airlines and airports.

The table indeed does show some interesting relative effects: with downstream Bertrand competition, $W$ rises almost regardless of airline concentration. However, with Cournot, $W$ rises by more in the $\times 2$ case, i.e., where there is some countervailing power. This suggests that the marginal effect on $W$ of breaking a concentrated upstream industry is increased, in the presence of congested airports, by concentrated downstream market structure. We tried other values of elasticities and found very similar qualitative results. As well as making the general point that effects depend on downstream concentration, our findings also casts doubt on an argument made by the airport owners, namely that there would be no benefit to passengers in changing airport ownership if airports faced concentrated airlines downstream (e.g., BA being a dominant airline at Heathrow). Interestingly, our results show that airports would lose relatively more profits the more concentrated the airline industry.

3.4 Modes of competition and incentives to invest in capacity

Now we conduct a different exercise. We fix market structure, but vary modes of competition. This is a customary comparison in the literature on airline competition, as both modes of competition may be relevant to the airline market, depending on the level of airport congestion, slot and aircraft availability.

**Proposition 4** When airports are under separate ownership, landing fees are higher under Bertrand competition than under Cournot competition when the downstream market is concentrated. The opposite holds with a more dispersed downstream market.

All else constant, each input faces a larger level of demand under downstream price competition, making it optimal to charge a higher $\ell$. However, derived demand for the input is also more sensitive to price increases, leading to a lower $\ell$. When $b = 0$ (or when airports are jointly owned), these effects exactly cancel out, getting the irrelevance result (see Lemma 1).

The irrelevance result no longer holds when airports are separately owned. When downstream airlines fly multiple routes, airports stand to lose revenue if they raise $\ell$ since airlines can switch to
rival airports. Now, when there is a fragmented airline market structure (case × 4), price competition makes derived demand much more elastic than does quantity competition. So, with fragmented airline Bertrand competition, an airport that increases ℓ loses much demand to the other airport. Thus ℓ is lower under Bertrand compared to Cournot. But, when the airlines are more concentrated downstream (case × 2), the differences in derived demand between Cournot and Bertrand is much less. Hence ℓ is higher under Bertrand, since the level of demand is higher than under Cournot.

These results on the effect of the mode of competition on landing charges inform the discussion about the reduction in congestion at airports via investments in new runways, terminals and/or improvements in air traffic management. Although we do not have a model of investment and congestion, we note that a reduction in congestion has the potential to change the nature of competition among airlines. While investments will of course also enhance demand, via introducing the possibility of having more routes, etc., we ask if, over and above these effects, it is airports or airlines which have an interest in promoting the reduction of congestion, i.e., via sinking costs in a previous, unspecified phase, that might also alter the model of competition, turning a Cournot market into a Bertrand one. Hence, via comparing the parties’ profits under Cournot and Bertrand in the different regimes, we can provide a partial answer to this.

In a symmetric equilibrium, the profits per route of each downstream airline and each upstream airport are respectively

\[
\pi_d = \frac{(p^* - \ell)(1 - p^*)}{2(1 + b)},
\]

\[
\pi_u = \frac{\ell(1 - p^*)}{2(1 + b)}.
\]

These expressions take different values according to the type of competition, and to the ownership structure, but are already informative as to the main trade-offs involved. It turns out that airlines always prefer competition to be in quantities. This is trivially true with a concentrated market upstream, when the landing fees are always at monopoly level and the only effect of the mode of competition is through the more competitive environment under Bertrand competition. The same result is true also in the case of 2 × 2, when in addition, there is the effect of the higher landing fees under Bertrand competition. In case of 2 × 4, the competition effect still dominates over the one resulting from the lower landing fees with price competition.

As far as airports are concerned, there is a similar fundamental trade-off. On the one hand, airports clearly prefer the mode of competition that results in higher landing fees (as characterized by Proposition 4). On the other hand, these landing fees are earned over passengers, and in this respect Bertrand competition has an expansion output effect that is preferred by airports, ceteris paribus. This output effect is the only one present in the case of a concentrated upstream industry and, in the case of two separate airports, is also the dominant one in most cases. However, in case 2 × 4, when the landing fees tend to marginal cost for sufficiently large values of b and m only under price competition (see Proposition 1), for sufficiently large values of the market parameters, it is
the landing fee level effect that ends up being dominant and airports obtain higher profits under quantity competition downstream.

4 Uniform vs discriminatory landing fees

The previous results already offer quite a rich set of policy guidelines. As we mentioned in the description of the model (end of Section 2.1), it turns out that the outside option constraints in the problems (4) and (5) are always slack. This, together with our focus on symmetric equilibria, make our setting unsuitable to analyze the specific issue of discriminatory landing fees. If an airport was required to not discriminate between the two symmetric airlines flying from its premises, it would offer the same (identical) landing fee obtained under a regime which allows discrimination. Thus a ban on price discrimination would have no effect on the landing fees and on the equilibrium.

In this section, we therefore amend the model with the purpose of obtaining meaningful results on the issue of discriminatory landing fees. We now assume that landing charges, rather than being unilaterally set by the airports, are negotiated by airports and airlines. In case of discriminatory charges, we allow the negotiation between the different parties at the same airport to give rise to different landing charges. On the other hand, when charges are uniform, all airlines flying from the same airport must face the same input price.\(^\text{15}\)

The structure of the game is identical to the one previously discussed except the way landing fees are set. Now, in the first stage, each airport negotiates with the airlines flying from that airport the linear input price \(\ell\). These first-stage negotiations are conducted simultaneously so that, during bargaining, the firms’ negotiators treat the other landing charges as given.\(^\text{16}\) Each bargain is obtained using the \(n\)-person Nash solution. The outcome is then a set of input prices which represents a Nash equilibrium in the Nash bargains.

In the discriminatory case, four landing charges \(\ell_i\), with \(i = 1, \ldots, 4\), have to be determined. At stage 1, each airport \(u\) forms a separate bargaining unit with each airline \(d\) flying from that airport. Each unit bargains over \(\ell_i\). The bargaining solution is found maximizing the Nash product

\[
\max_{\ell_i} \left[ \pi_u(\ell_i, \ell_{-i}) - \bar{\pi}_u \right]^{\beta} \cdot \left[ \pi_d(\ell_i, \ell_{-i}) - \bar{\pi}_d \right]^{1-\beta} \text{ for } u \in \mathcal{U} \text{ and } d \in \mathcal{D}
\]  

(9)

where \(\bar{\pi}_u\) denotes the disagreement payoff for airport \(u\), and \(\beta \in [0, 1]\) denotes the bargaining power of the airport relative to that of the airline.

In the uniform case, two landing charges, \(\ell_h\), with \(h = A, B\), have to be determined. We assume that each airport \(u\) forms a separate bargaining unit with one of the airlines flying from that airport; the choice of the airline is made randomly, but, because of the symmetry of the model, this does not affect our results. Each unit bargains over \(\ell_h\). If the bargain is successful, uniformity requires that

\(^{15}\)Uniformity eventually applies to landing charges at one specific airport, thus a uniform price constraint applies separately to different airports, even under the same ownership.

\(^{16}\)In case of simultaneous negotiation with different counterparts, this means that separate negotiators are sent to conduct independent negotiations with each counterpart.
the same landing fee is applied also to all other airlines flying from that airport. Instead, in case of failure of the negotiation, the other airline can still operate from the airport at the anticipated landing fee.¹⁷ The bargaining solution is then found maximizing the following Nash product

\[
\max_{\ell} \left[ \pi_u(\ell_h, \ell_{-h}) - \bar{\pi}_u \right]^\beta \cdot \left[ \pi_d(\ell_h, \ell_{-h}) - \bar{\pi}_d \right]^{1-\beta} \text{ for } u \in \mathcal{U} \text{ and } d, d' \in \mathcal{D}
\]

(10)

The actual form of the players’ profits in (9) and (10) depends on market structure and on the mode of downstream competition. This is also true for the players’s disagreement payoffs, which also depend on the specific hypotheses made on the structure of the bargains and the information available to the players. We discuss these issues here, referring for the sake of brevity only to the case of quantity competition downstream.

To illustrate, take the case with market structure $2 \times 2$ and with quantity competition downstream. In case of uniform charges, the bargaining problem between airport $A$ and the designated airline, say, 13, formulated in general terms in (10), can now be restated as

\[
\max_{\ell_A} \left[ \pi^{2 \times 2}_A(\ell_A, \ell_B) - \bar{\pi}^{2 \times 2}_A \right]^\beta \cdot \left[ \pi^{2 \times 2}_{13}(\ell_A, \ell_B) - \bar{\pi}^{2 \times 2}_{13} \right]^{1-\beta}
\]

(11)

A similar negotiation takes place between airport $B$ and one of the airlines operating at that airport for the definition of $\ell_B$.

In case of discriminatory charges, the bargaining problem between airport $A$ and airline 13 for the determination of $\ell_1$, formulated in general terms in (9), can now be restated as

\[
\max_{\ell_1} \left[ \pi^{2 \times 2}_{24}(\ell_1, \ell_{-1}) - \bar{\pi}^{2 \times 2}_{24} \right]^\beta \cdot \left[ \pi^{2 \times 2}_{13}(\ell_1, \ell_{-1}) - \bar{\pi}^{2 \times 2}_{13} \right]^{1-\beta}
\]

(12)

Likewise, airport $A$ with airline 24 and airport $B$ with airlines 13 and 24 form three distinct bilateral bargaining units for the definition of $\ell_2$, $\ell_3$ and $\ell_4$, respectively.

Along the equilibrium path, equilibrium quantities and the corresponding profits for all players in the second stage are obtained in the customary way. These determine $\pi^{2 \times 2}_u$ and $\pi^{2 \times 2}_d$ in (11) and (12), according to whether landing fees are uniform or discriminatory.

We now turn to discuss the disagreement payoffs $\bar{\pi}^{2 \times 2}_u$ and $\bar{\pi}^{2 \times 2}_d$. In the event of an unsuccessful negotiation between an airport and the airline over a landing fee, the corresponding route cannot be operated and market players can only derive alternative profits from operating other routes.

The impossibility of operating one route has two immediate consequences on demand and on the strategic behavior of airlines. First, consumers are unable to buy flight services on these routes and the system of demand functions has to, therefore, be re-adjusted. In the system of inverse demand functions (2), the quantity of demanded services on the routes affected by the breakdown is simply set equal to zero.

¹⁷This bargaining structure is usually referred to as “pattern bargain” and has been used extensively in the literature on wage bargaining between firms and unions (Matthew and Merlo, 2004, and Dobson, 1994). In our context, this structure ensures that, even in the case of disagreement between the airport and one of the airlines, the airport remains in operation.
The second important consequence depends on the way the downstream firms react to the disagreement, which in turn hinges on their possibility of observing the negotiation breakdown. As in Section 2.1 with TIOLI offers, we assume “passive beliefs” for all the players that are not involved in a certain negotiation: in other words, they adopt their optimal quantities as if all routes were in operation. For those players which instead are aware of a negotiation breakdown, we allow a strategic response taking into account that route is not in operation.\(^{18}\)

We illustrate this by going back to our illustrative case 2 \( \times \) 2. With uniform landing charges as in (11), in case of disagreement, both airlines are aware of the breakdown of the negotiation: airline 13 because it has failed the negotiation with airport A, and airline 24 because it is assigned the residual right to operate from airport A. Both airlines, in case of disagreement, then redetermine their quantities to take into account route 1 is no longer available by solving, respectively, the following problems

\[
\max_{q_3} [p_3(0, q_2, q_3, q_4) - l_B] \cdot q_3 \tag{13}
\]

\[
\max_{q_2, q_4} [p_2(0, q_2, q_3, q_4) - l_A] \cdot q_2 + [p_4(0, q_2, q_3, q_4) - l_B] \cdot q_4. \tag{14}
\]

Letting \( q'_2, q'_3 \) and \( q'_4 \) be the solutions to these problems, we can then obtain the airlines' disagreement payoffs by plugging back these solutions into the objective functions in (13) and (14); that is, \( \pi^{2 \times 2}_{13} = [p_3(0, q'_2, q'_3, q'_4) - l_B] \cdot q'_3 \) and \( \pi^{2 \times 2}_{24} = [p_2(0, q'_2, q'_3, q'_4) - l_A] \cdot q'_2 + [p_4(0, q'_2, q'_3, q'_4) - l_B] \cdot q'_4 \). Similarly, the disagreement payoff for the airport is given by \( \pi^{2 \times 2}_A = q'_2 \cdot \ell_A \).

The computation of the disagreement payoffs in case of discriminatory charges is different. Taking (12), in case of disagreement, airline 24 does not know about the breaking down of the negotiation and therefore has passive beliefs; in other words, it chooses still \( q_2 \) and \( q_4 \) as along the equilibrium path where it maximizes \( [p_2(q) - l_2] \cdot q_2 + [p_4(q) - l_4] \cdot q_4 \). On the other hand, airline 13 is an active part of the failed negotiation and thus knows that route 1 will not be operated. Therefore, it readjusts its quantity choice over the other route, taking into account the unchanged rivals’ choices. In other words, it chooses \( q_3 \) to maximize \( [p_3(0, q_2, q_3, q_4) - \ell_3] \cdot q_3 \); let this quantity be denoted by \( q''_3 \). We can now compute the disagreement payoffs of the players. The outside option of airline 13 is given by \( \pi^{1 \times 2}_{13} = [p_3(0, q_2, q'_3, q_4) - l_3] \cdot q'_3 \), while, for airport A, we have \( \pi^{2 \times 2}_A = q'_2 \cdot \ell_2 \).

Before proceeding to present our result, it is useful to present the first order conditions of problems (9) (or (10)). Solving these problems and rearranging, one gets

\[
\frac{\beta}{1 - \beta} \frac{\pi_d(\ell, \ell - i) - \pi_d}{\pi_u(\ell, \ell - i) - \pi_u} = -\frac{\partial \pi_d(\ell, \ell - i) - \pi_d}{\partial \ell_i}/\frac{\partial \ell_i}{\partial \ell_i} \quad \text{for } u \in \mathcal{U} \text{ and } d \in \mathcal{D}, \tag{15}
\]

which we use to illustrate the different forces affecting the level of the landing fee. Moving term by term, a first determinant is the relative bargaining power of the parties (\( \beta \)). The second determinant is a level effect: the higher is the airport’s (airline’s, respectively) outside option, the higher (lower) will be the landing fee. The third determinant are the concession costs, given by the ratio of marginal

\(^{18}\)See Horn and Wolinsky (1988) and most of the literature using their approach.
profits, which we will further discuss below.

We now turn to illustrating the result of this section. We summarize first the equilibrium levels of the landing charges.

**Lemma 2** Let $\ell_{ms}^r$ be the landing fee, where the market structure is $ms = \{1 \times 2, 1 \times 4, 2 \times 2, 2 \times 4\}$ and the pricing regime is $r = \{D = \text{Discriminatory}, U = \text{Uniform}\}$. Then, $\ell_{ms}^r = \frac{1}{2} \frac{1}{1 + K_{ms}^r}$ with $K_{ms}^r > 0$ for all $b \in (0, 1]$ and $m \in (0, \infty]$.

The actual values of the $K$’s are omitted. The first immediate result derived from Lemma 2 is that the irrelevance of the downstream market to the landing fees which we found in the case of TIOLI offers (Lemma 1) does not hold with bargained landing fees. As expected, the higher the degree of bargaining power of the airlines, the lower the landing fees.

As to the main interest of this section, i.e., the comparison of the landing fees under the uniform and discriminatory regime, our results are presented in the following Proposition. We concentrate on the case of quantity competition downstream. Our focus on the Cournot case is legitimate given the intent to provide a theoretical analysis of the requirement of uniform landing fees contained in the EU Directive 2009/12/EC; this Directive indeed applies only to airports above 1 million passengers per year, that is, to airports likely to experience the capacity constraints we want to capture with quantity competition.

We find the following result.

**Proposition 5** With Cournot competition, uniform charges are always higher than discriminatory charges.

The main force behind this result is the change in concession costs that airlines face under the two regimes. When landing fees are discriminatory, an airline is made a “tougher” negotiator since any decrease in its own landing fee would both decrease its cost and strengthen its competitive position in the downstream market relative to rivals. On the contrary, an airline is much less inclined to negotiate discounts in the uniform regime, as it anticipates that this will benefit also its rival. This effect is at work in all the market structures analyzed. For some market structures (as, for instance, in the case $2 \times 2$ illustrated above), it is further reinforced by the better outside option that airports have under the uniform regime. This is due to the fact that, in all $\times 2$ structures, the disagreement is observed by the other airline operating in the airport only in the case of uniform charges. This other airline will react by offering a higher quantity from that airport, which improves the airport’s outside option.

The result of Proposition 5 is illustrated in Figure 2, which depicts the equilibrium landing fee for different market structure and for $m = 7$, i.e., the same value of $m$ we used in the calibration exercise in Section 3.3. Panel (a) illustrates the landing charges when the upstream industry is monopolistic, while Panel (b) refers to the case of two competing airports. In both panels, the red lines depict

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19 The values of the $K$’s are contained in a separate Appendix, available from the authors upon request. The Appendix also contains the proof of Proposition 5 and a brief treatment of the case of downstream Bertrand competition.
the landing fees when two multiproduct airlines operate downstream (the ×2 cases), while the black lines are the landing fees in the case of a dispersed airline industry (the ×4 cases). The solid lines are the landing fees in the uniform regime, while the dotted lines are those under discrimination. Consistent with the result of Proposition 5, all dotted lines (the discriminatory landing charges) lie below the corresponding solid line (the uniform landing fee). [ADD LABELS TO THE CURVES]

![Graph](image)

**Fig. 2** - Uniform (solid lines) vs Discriminatory (dotted lines) landing fees for industry structures ×2 (red lines) and ×4 (black lines), when $\beta = \frac{1}{2}$.

Our analysis of negotiated landing fees confirms most of the results we obtain when fees are determined by TIOLI offers by the airports, and adds a few new ones. The discussion we provide here is in terms of Figure 2, drawn for a specific value of $m$, but our results hold more in general for any value of this parameter.

First of all, we fully confirm, and for any type of landing fee regime, the results in Proposition 1: less concentration upstream reduces the landing fees, and the difference between the landing fees with more or less upstream concentration is also larger the greater is $b$. This can be observed by simply comparing any landing fee in panel (a) (upstream monopoly) with the corresponding landing fee in panel (b) (airport competition): the latter always lies below the former. Also, panel (b) illustrates that, when the airport industry is competitive, the downward pressure on the landing fee deriving from a more concentrated airline industry (Proposition 2) is confirmed both in the case of discriminatory and uniform landing fees: these are lower the more concentrated is the downstream industry as it is shown by the fact that the red lines (the landing fee in the case 2 × 2) are always lower then the corresponding black line (the landing fee in the case 2 × 4).

The new results come essentially from panel (a), which shows that the irrelevance result obtained under TIOLI with a concentrated upstream industry (Lemma 1) is a limiting case that cannot be generalized to a broader general bargaining framework. We now find that, when the airport industry is concentrated, there is no evidence in favor of countervailing power, and in fact the result is reversed: a more concentrated downstream industry negotiates a higher landing fee than a more competitive one, independently from the landing fee regime. Therefore, once a bargaining protocol is introduced,
possible support for the countervailing power hypothesis depends on the interaction between both the upstream and the downstream degrees of concentration.\textsuperscript{20}

### 5 Conclusions

In this paper we have set out a model of up- and downstream bargaining and competition and applied it to airports. Our model sheds light on some key policy questions such as: what are the consequences of joint ownership of airports and airlines? Do remote airports need price regulation? Should airports be permitted to price discriminate between airlines?

Our results can be summarized as follows. First, should jointly owned airports be broken up? A break up turns out to reduce landing fees $\ell$ in all cases, as airports compete against each other. In fact, up- and downstream competition reinforce each other, with lower landing fees as both airports and airlines become more substitutable.

Second, what about the countervailing power of airlines? Airports frequently argue that they are stopped from raising $\ell$ if they are dealing with a dominant airline. Indeed, our model shows that, when a concentrated airline might potentially switch to fly the same route from a nearby airport, the landing fee falls, just as the airports argue. But there are other effects. Airlines succeed in lowering $\ell$ but keep most of that surplus. So relying on countervailing power is not likely to be welfare-enhancing via reducing prices to consumers.

Third, do airlines prefer the new EU rules that appear to make discriminatory pricing harder? Broadly speaking, airlines resist discriminatory pricing more when they are Cournot competitors, so, overall, $\ell$ is lower in this case compared to uniform landing fees. Thus, if there was Cournot competition at a crowded airport, and the airport moved from a uniform to a discriminatory regime, $\ell$ would fall. Therefore the model would predict that airports should welcome the proposed EU rule at congested airports, in contrast with airlines.\textsuperscript{21}

The final question we touched on indirectly is how an airport expansion would affect profits of the various parties. There are two broad effects. First, for a given $\ell$, an expansion raises airport profits, since quantity rises. But second, an expansion might change the nature of competition and so change $\ell$. It is likely that an expansion of a crowded airport changes competition from Cournot to Bertrand. The expansion effect always increases airports’ profits under common ownership, though results are more nuanced under separate ownership. As for airlines, they too have more volume, but if competition changes from Cournot to Bertrand their final prices fall as well as their profits.

Our approach to the analysis of the vertical structure of oligopolistic up- and downstream industries is amenable to other applications. As mentioned in the Introduction, retailing shows many analogies and similar modelling features. Of course, the model leaves a number of avenues for future

\textsuperscript{20}Under Bertrand competition, our main finding that airlines negotiate lower landing fees under a discriminatory regime, still emerges, though it is not general anymore. While the insight that an airline is a tougher negotiator under a discriminatory regime is still at work, the outside option effect may push in the opposite direction.

\textsuperscript{21}In our model, all airlines have the same bargaining power. The model could be extended to account for an airline who is “better” at bargaining (Ryanair perhaps?).
work. One is investment incentives in airports. This requires a dynamic investment model and the resulting impact of a change in capacity on competition. Second, there are a number of potentially interesting issues in slot trading. One feature often not realized is that airlines incur substantial sunk costs at airports; thus the grandfather rights to slots may provide appropriate incentives to incur such costs. But this process interacts with competition and so its effects await further analysis. A related issue on slots is that airlines in full airports, with \( \ell \) regulated for example, can switch airports by buying slots from each other: an effect we have not modeled but would require an additional price in the model and bargaining between airlines.

References


Appendix A: Equilibrium in the last stage

We present here the equilibrium choices of the downstream firms in the last stage of the game, as a function of the landing fees. We only present the case when all routes are in operation, as it will turn out to be in the equilibrium of the game. Further details are in Haskel et al. (2011).

**Cournot competition.** We first solve the case when downstream competition is in quantities. When four independent airlines operate, each airline \( i \) (with \( i = 1, \ldots, 4 \)) chooses \( q_i \) to maximize \([p_i(q) - \ell_i] \cdot q_i \). Equilibrium quantities, obtained by solving the system of four FOCs of the above four problems, are denoted by \( q_i^{*4}(\ell) \). For good 1 (similar expressions hold for the other goods), we have

\[
q_1^{*4}(\ell) = \frac{1 + m}{m(3 + 2b) + 4(1 + b)} \left\{ 1 + \frac{bm(\ell_3 + \ell_4)}{m(3 - 2b) + 4(1 + b)} + m[2m^2(1 - b) + 3m(1 - b^2) + 16(1 + b)](m(1 - b) + 4(1 + b)) \right\}. \tag{A-1}
\]

Take now the case when only two independent airlines operate in the downstream market; airline 13 solves the problem \( \max_{q_1, q_3} \) \([p_1(q) - \ell_1] \cdot q_1 + [p_3(q) - \ell_3] \cdot q_3 \), while a similar problem is faced by airline 24. Equilibrium quantities, obtained by solving the system of four FOCs, are denoted by \( q_i^{*2}(\ell) \). For good 1 (similar expressions hold for the other goods), we have

\[
q_1^{*2}(\ell) = \frac{1 + m}{(3m + 4)(b + 1)} \left\{ 1 - \frac{2[3m^3(1 - b) + 2m^2(11 - 5b^2) + 48m(1 + b) + 32(1 + 2b + b^2)]\ell_1}{(m + 4)(3m(1 - b) + 4(1 + b))(m(1 - b) + 4(1 + b))} \right. \right.
\left. + \frac{m[3m^2(1 - b) + 16m(1 - b^2) + 1 + b)]\ell_2}{(m + 4)(3m(1 - b) + 4(1 + b))(m(1 - b) + 4(1 + b))} \right.
\left. + \frac{bm[16(1 + b) - 3m^2(1 - b)]\ell_4 + 2bm[3m^2(1 - b) + 12m + 16(1 + b)]\ell_3}{(m + 4)(3m(1 - b) + 4(1 + b))(m(1 - b) + 4(1 + b))}, \right. \tag{A-2}
\]

**Bertrand competition.** Take now the case of downstream price competition. When four independent airlines operate in the downstream market, each airline \( i \) (with \( i = 1, \ldots, 4 \)) chooses \( p_i \) to maximize \([p_i - \ell_i] \cdot q_i(p) \). Equilibrium prices, obtained by solving the system of 4 FOCs, are denoted by \( p_i^{*4}(\ell) \). For good 1 (similar expressions hold for the other goods), we have

\[
p_1^{*4}(\ell) = \frac{2(1 + b + m - bm)}{(1 - b)m^2 + (5 - 2b)m + 4(1 + b)} + \frac{bmz_1(\ell_2 + \ell_4)}{z_2} \tag{A-3}
\]

\[
+ \frac{2z_1[(1 - 2b + b^2)m^3 + 8(1 - b)m^3 + 7(3 - b^2)m^2 + 22(1 + b)m + 8(1 + 2b + b^2)]\ell_1}{[3m^2(1 - b) + 7m + 4(1 + b)]z_2}
\]

\[
+ \frac{mz_1[(1 - 2b + b^2)m^3 + 6(1 - b)m^2 + (9 - 2b^2)m + 4(1 + b)]\ell_3}{[3m^2(1 - b) + 7m + 4(1 + b)]z_2},
\]

where \( z_1 \equiv (1 - b)m^2 + 3m + 2(1 + b) \) and \( z_2 \equiv [(1 - b)m^2 + (5 - 2b)m + 4(1 + b)][(1 - b)m^2 + (5 + 2b)m + 4(1 + b)]. \)

Take now the case when only two independent airlines operate downstream; airline 13 chooses
Appendix B: Proofs

Proof of Lemma 1. In all our cases, the constraints faced by the airports regarding the disagreement payoffs of the airlines are always slack. This implies that offers are always accepted, and the airports are always able to make their unconstrained offers to airlines. We solve the unconstrained problems (4) and (5), where quantities are obtained from the various last stage equilibria (A-1)-(A-4), according to the type of competition and market structure. Concentrating on symmetric equilibria, simple but tedious computations give the landing fees reported in the Lemma, where

\[ K_{C}^{2 \times 4} = \frac{bm}{4(1 + b) + m(3 - 2b)}, \]
\[ K_{C}^{2 \times 2} = \frac{3bm}{8(1 + b) + 6m(1 - b)}, \]
\[ K_{B}^{2 \times 4} = \frac{bm[m^2(1 - b) + 3m + 2(1 + b)]}{2[1 + b + m(1 - b)][m^2(1 - b) + m(5 + 2b) + 4(1 + b)]}, \]
\[ K_{B}^{2 \times 2} = \frac{bm[m^2(1 - b) + 4m + 6(1 + b)]}{2(m + 2)[1 + b + m(1 - b)][4(1 + b) + m(1 - b)]}. \]

From inspection, it is always $K_{t}^{ms} > 0$ for all values of $b$ and $m$, with $K_{t}^{ms} = 0$ only when $b$ and/or $m$ are equal to zero. Q.E.D.

Proof of Proposition 2. Part i) follows from the fact that each $K_{t}^{2 \times x} > 0$, hence the corresponding landing fee $\ell_{t}^{2 \times x}$ is lower than $\ell_{t}^{1 \times x}$. Part ii) comes from noting that $\frac{\partial \ell_{t}^{ms}}{\partial b} < 0$ and $\frac{\partial^2 \ell_{t}^{ms}}{\partial b \partial m} > 0$ for all $t$ and $ms$. Part iii) comes from noting that, for $b = 1$ and finite values of $m$, landing charges are always greater than 0. Instead, when $b = 1$ and $m \to \infty$, then all landing charges are equal to zero, except in the case $2 \times 4$ and Cournot competition, when they equal $\frac{1}{4}$. Q.E.D.

Proof of Proposition 3. Part i) follows from the fact that each $K_{t}^{2 \times 2} > K_{t}^{2 \times 4}$. Part ii) comes from $\frac{\partial \ell_{t}^{ms}}{\partial m} < 0$, while the cross derivative is as shown in the proof of Proposition 2. Q.E.D.

Proof of Proposition 4. At a symmetric equilibrium, the price of each good is obtained from (2), and it is simply $p_{i} = 1 - 2(1 + b)q_{i}$, which are increasing in $\ell$. Hence the comparisons among landing
fees immediately generate implications in terms of prices.

Under Cournot, the equilibrium quantities at a symmetric equilibrium, derived from (A-1) and (A-2), simplify respectively to

\[
q_C^{x2}(\ell) = \frac{(1 + m)(1 - \ell)}{(3m + 4)(1 + b)},
\]

\[
q_C^{x4}(\ell) = \frac{(1 + m)(1 - \ell)}{(3m + 4)(1 + b) - bm},
\]

which are decreasing in \(\ell\) and such that \(q_C^{x2}(\ell) < q_C^{x4}(\ell)\) for any \(\ell \in [0, 1)\). Since \(\ell_C^{1x4} = \ell_C^{2x4}\), then \(q_C^{1x4} > q_C^{2x4}\) and therefore \(p_C^{1x4} < p_C^{2x2}\). Also, since \(\ell_C^{2x4} < \ell_C^{2x2}\), then \(q_C^{2x4} > q_C^{2x2}\) and therefore \(p_C^{2x4} < p_C^{2x2}\).

Under Bertrand, the equilibrium quantities at a symmetric equilibrium, derived from (A-3) and (A-4), simplify respectively to

\[
q_B^{x2}(\ell) = \frac{(1 - \ell)(2 + m)}{2(1 + b)(m + 4)},
\]

\[
q_B^{x4}(\ell) = \frac{(1 - \ell)(m^2 - bm^2 + 2b + 3m + 2)}{2(1 + b)(m^2 - bm^2 + 5m - 2bm + 4 + 4b)},
\]

which have the same features as in the case of Cournot competition; the rest of the proof is identical to the one used there and is therefore omitted. Q.E.D.

Proof of Proposition 5. Follows from noting that \(K_C^{2x2} > K_B^{2x2}\) and \(K_C^{2x4} < K_B^{2x4}\). Q.E.D.

Appendix C: Some institutional details underlying our questions and assumptions

We now turn to some of the details of the airport market, that inform our questions and modeling. Most relate to the UK, but much of that experience is common to other countries.

Location and new building. Airport location in the UK is a historical accident, dictated largely by extensive building in WWII. On the extensive margin, local planning restrictions makes building of new airports more or less impossible. Thus the only opportunity for entry is the opening of a past military airport for civil use. There are only two examples of note in the UK, Doncaster and Manston (both ex RAF). Manston, a remote airport on the Kent coast, went bankrupt after one year of scheduled flights. Doncaster, situated in South Yorkshire near Sheffield and Leeds, opened in 2005, but had their initial planning application successfully blocked by East Midlands airport so

\[\text{Footnote 30}\]

Heathrow for example was started in 1930 as a test aerodrome for early aircraft factories and then requisitioned in WWII. Stansted was chosen to be London’s third airport because it possessed an unusually long runway, leftover from WWH where it was used for landings by damaged planes.
their entry has been drastically slowed.\textsuperscript{23} The intensive margin is to build a new runway. No new runway has been built in the South-East of the UK for 60 years and the new Government has blocked new runways at London Heathrow, Stansted and Gatwick: Luton cannot build a new runway due to local topography. Manchester succeeded in building a new runway which opened 5 years ago. Overall then, entry into the airport business is very hard.

\textit{Passenger travelling between airports and overlapping routes.} An important element of potential competition between airports is the extent to which passengers are willing to travel between alternative airports offering overlapping routes. Passenger choice of airports has been studied quite extensively. \textit{OFT} (2007) finds considerable readiness of passengers to travel between airports and considerable route overlap in the UK. In 2005 for example, Heathrow ran daily flights to 180 destinations, Gatwick to 210. Of these, 86 destinations were served from both airports. Of these 180 destinations served daily by Heathrow, over 40 were also served daily from Stansted, and Stansted and Gatwick had flights to around 80 common destinations on a daily basis.

\textit{Airport ownership.} Ownership of UK airports was by local municipalities, except for the largest, London Heathrow, London Stansted, London Gatwick, Glasgow and Edinburgh, and Aberdeen all of which were owned by the central government, until they were privatized in 1996 to be owned by the British Airports Authority (BAA). These BAA airports accounted for 93\% of UK air traffic. After a two-year investigation the UK Competition Commission (CC, 2009) ruled that BAA should be broken up to improve competition. During the case, BAA argued that competition between airports was infeasible due to their geographical remoteness and/or their being full, and any local monopoly power was offset by the countervailing power of dominant airlines. The low cost airlines argued strongly that competition was feasible and would bring benefits. Manchester and Luton are both owned by the local municipality, but managed privately and compete under commercial terms. The other UK airports all compete freely with each other. Similar examples of joint ownership are in other countries. For example, in Rome Ciampino and Fiumicino are jointly owned, as are the major Paris and New York airports.\textsuperscript{24}

\textit{Charging.} Most airports make their money by charging airlines who use the airport. This fee is made up of three main components, of which Heathrow is illustrative. First, 70\% of it is per passenger. For example, an airline leaving Heathrow has to pay 22.97 GBP per passenger to international destinations (and 13.43 GBP to domestic, see Heathrow Airport, 2010, table 5.2). Second, 19\% is a fee for each aircraft landing movement. This charge differs by weight. Third, the remaining 11\% is for parking, which depends on length of time, time of day and weight. There is a rebate for the non-use of stands, currently 3.79 GBP per passenger at Heathrow (which is why low cost airlines

\textsuperscript{23}Rival airports in Nottingham objected to Doncaster renaming themselves “Doncaster Robin Hood” airport. Doncaster is in fact in the county of Nottinghamshire by virtue of the 1957 runway extension that extended the runway 200 feet into this county’s territory.

\textsuperscript{24}Although the terminals at JFK are independently owned. For an extensive review of the US, see FAA (1999).
do not use stands). The vast bulk of fees vary by passenger, and since more passengers increase weight, the movement and parking charges effectively vary by passenger as well. Thus the observed charges have only a very minor nonlinear part tariff element and hence we model charges as linear in passengers.

Landing fees differ substantially between airports and, sometimes, between airlines at an airport. In their sample of 100 major European airports for example, Bel and Fageda (2010) find a coefficient of variation of 0.37. The exact landing fees depend on the circumstances at the airport. Regarding congested regulated airports, fees do not tend to differ between airlines, but do between airports in line with, e.g., local capital costs, operating expenses and investment plans. In uncongested airports, the typical variation in prices is temporal. Airlines who start a route are offered an initial discount which expires after a few years. At the end of that time, they renegotiate the price, which tend to then depend on how full the airport is. So for example, no airlines at Heathrow or Gatwick have discounts. At Stansted introductory discounts expired in March 2007 and were not continued when the airport was more or less full (see OFT, 2007, para 5.64).

Bargaining and the determination of landing fees. In the UK, landing fees in the major airports have been regulated since privatization. At capacity constrained airports, such as Heathrow and the summer in Gatwick, and early morning slots at Luton and Stansted, the landing fees charged are those at the price cap with no discounts. At other airports, a bargaining process occurs, that was well documented by the Competition Commission report, for both UK and foreign cases (see Competition Commission, 2009, Appendix 3.3).

As an example, take Cardiff and Bristol which are about 50 miles apart. Both have plenty of spare capacity. In all non-congested commercial UK airports, airlines are offered a preliminary discount to establish new routes In 2006, the discounts offered to Ryanair at Cardiff expired, and were not renewed. Ryanair immediately switched its daily Dublin service to Bristol. In 2007, Flybe were operating twice weekly services from Bristol to Paris. They switched that route to Cardiff following the refusal of Bristol to lower its charges. Thomas Cook, by contrast, stayed at Bristol following an offer of a lower landing fee.

Airline reaction to rivals. We make assumptions in the paper on just what reactions airlines can make in the event of bargaining breaking down between other airlines and their chosen airport. Now the empirical evidence on this is hard to garner; in our model, deals and settlements take place instantly as we do not have a fully articulated extensive form dynamic game describing all stages. Nonetheless there are some institutional points. First, regulated “list” tariffs are available to all,

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25One might imagine that airports would try to vary charges by time of day. Airports in the UK do not do this following a case brought by the US government in the early 1980s when Heathrow attempted to introduce peak load pricing by raising landing fees for early morning arrivals. This was held to be discriminatory against US carriers who land early morning by reason of global time differences and Heathrow was obliged to pay substantial damages (Starkie, 2002).

26Issues around the appropriate price cap level and incentives to invest are beyond the scope of the current paper, but we do ask if regulation is needed at all by asking when landing fees tend to marginal cost (see Proposition 3).
though the details of negotiations are regarded as commercially confidential. Second, the evidence suggests limited scope for airlines to react to competitors in some dimensions. Airlines can change pricing very rapidly and they do so via the software that controls their yield management. However, their ability to change the number of flights is limited in the short run. It is zero in heavily used airports, since there are no slots available. Even at relatively empty airports, slots are preallocated months before the summer and winter season (on the grandfather rights basis). It is true that vacant slots can then be allocated at short notice, but in fact low cost airlines rely heavily on early morning slots and these might be unavailable. Reactions by varying the aircraft size is limited by economies of scope: low cost airlines never vary fleet size to keep economies of scope by having the same planes in operation. Launching a whole new route is costly, since it needs marketing spending; in contrast, airlines can easily react within their route system: airlines can and do switch aircraft between pre-existing slots at different airports.

Price discrimination. At “designated” airports, price discrimination, often called “differential pricing“, is covered by section 41 of the Airports Act, 1986 (see CAA, 2007). The essential point is that airports are not allowed to price discriminate between airlines who are offered the same service from the airport. The precise interpretation of this is complicated of course, and in practice airlines at Heathrow and Gatwick pay the same price to the airport (with the exception of whether they use a stand or not) whereas airlines elsewhere pay different prices.

From spring 2011, airport charges at 144 European airports (above 1 million passengers per annum, mppa) are also subject to the EU Airport Charges Directive. It generally outlaws “differential pricing” unless on the basis of clear differences in service levels offered. Airports are required to publish their revenues, costs and methodology for price calculation. Discrimination in pricing on the basis of airline country of origin is outlawed. Once again, the practical interpretation of this is open to question. As we saw above, landing charges vary by service level, e.g., low cost airlines do not tend to use passenger steps. But they also vary by time, i.e., airlines get a discount for the launch of a new service; it is not clear whether this will be outlawed by the directive. The Directive is opposed by Ryanair (Ryanair, 2008).

Congestion and investments. Some airports, e.g., New York and Heathrow, are congested all day, that is, no slots are available to land. Others are congested in the mornings and evenings, but have available slots in the middle of the day. Cost efficiency in the low-cost airline model, however, requires low-cost airlines to fly multiple legs per day meaning that an early morning departure is essential. Thus early-morning congestion is binding for them.

The Competition Commission (2009) report on BAA, the joint owner of the London airports, documented BAA’s comparative inaction in lobbying for new runways despite the airports being full (Heathrow and Gatwick all the time, Stansted in the early mornings when low cost airlines must fly). Stansted proposed building a second terminal (not runway), though it did not get permission.

\textsuperscript{27}See also NERA (2009) and Competition Commission (2009), para 6.15.
The only major airport in the UK to build a new runway in the last 60 years was Manchester; a new runway was opened in 2000. According to the Competition Commission report (2002), no airlines have more than 10% market share, and the airport had some local monopoly power. This might then be regarded, in the terms of our model, as a relatively concentrated upstream airport facing unconcentrated downstream airlines.
Appendix to Section 4: Uniform vs discriminatory landing fees (for the use of referees only)

Simple but tedious computations give the landing fees reported in the Lemma (2), where

\[
K_2^{2 \times 2} = \frac{(y_5 b^5 + y_4 b^4 + y_3 b^3 + y_2 b^2 + y_1 b + y_0) + (z_5 b^5 + z_4 b^4 + z_3 b^3 + z_2 b^2 + z_1 b + z_0)}{(-3 m + 3 bm - 4 b - 4)(x_4 b^4 + x_3 b^3 + x_2 b^2 + x_1 b + x_0)4 \beta}
\]

\[
K_2^{2 \times 4} = \frac{(3 - \beta (3 - 4 b)) m^2 + 8 (1 + b)(2 - \beta (2 - b)) m + 16 (1 + b) (1 - \beta)}{4(2 + m + 2 b)(4(1 + b) + m(3 - 2 b)) \beta}
\]

\[
K_1^{1 \times 2} = \frac{1 - \beta}{\beta} \times \left[ (10 m^2 - 32 b^2 + (3 m^3 - 48 m - 64) b - 48 m - 32 - 22 m^2 - 3 m^3) / (x_4 b^4 + x_3 b^3 + x_2 b^2 + x_1 b + x_0) \right]
\]

\[
K_1^{1 \times 4} = \frac{1 - \beta}{\beta} \times \left[ (3 m + 4 b + 4)(m + 4b + 4) / (4(2 + m + 2 b)(4(1 + b) + m(3 - 2 b)) \right]
\]

\[
K_2^{2 \times 2} = \frac{x}{(m + 4)[m(1 - b) + 4(1 + b)][(m(1-b) + 2(1+b))] \beta}
\]

\[
K_2^{2 \times 4} = \frac{x}{(m + 4)[m(1 - b) + 4(1 + b)][(m(1-b) + 2(1+b))] \beta}
\]

\[
K_1^{1 \times 2} = \frac{1 - \beta}{\beta} \times (2 + m) / (m + 4)
\]

\[
K_1^{1 \times 4} = \frac{1 - \beta}{\beta} \times \left[ (m^2 - 8)b^2 + (10m + 16)b + 3m^2 + 10m + 8) / (m + 4(1 + b)][m(3 - 2 b) + 4(1 + b)] \right]
\]
\[ y_5 = -108m^7 + 600m^6 + 2432m^5 - 4160m^4 - 12288m^3 + 12288m^2 + 16384m - 16384 \]
\[ y_4 = -54m^8 + 486m^7 + 2244m^6 - 7840m^5 - 30528m^4 + 13312m^3 + 91136m^2 - 81920 \]
\[ y_3 = 189m^8 + 270m^7 - 6936m^6 - 22336m^5 + 19328m^4 + 138752m^3 + 88064m^2 - 163840m - 163840 \]
\[ y_2 = -243m^8 - 2160m^7 - 2424m^6 + 27488m^5 + 102400m^4 + 82944m^3 - 159744m^2 - 327680m - 163840 \]
\[ y_1 = 135m^8 + 1998m^7 + 11088m^6 + 25088m^5 - 3648m^4 - 135680m^3 - 280576m^2 - 245760m - 81920 \]
\[ y_0 = -27m^8 - 540m^7 - 4572m^6 - 21376m^5 - 60352m^4 - 105472m^3 - 111616m^2 - 65536m - 16384 \]
\[ z_5 = -120m^6 - 80m^5 + 2624m^4 + 1536m^3 - 12288m^2 - 4096m + 16384 \]
\[ z_4 = -126m^7 + 36m^6 + 4576m^5 + 5184m^4 - 31744m^3 - 48128m^2 + 49152m + 81920 \]
\[ z_3 = -27m^8 + 234m^7 + 2832m^6 + 1504m^5 - 36992m^4 - 80384m^3 + 40960m^2 + 237568m + 163840 \]
\[ z_2 = 81m^8 + 450m^7 - 2448m^6 - 23072m^5 + 46336m^4 + 46080m^3 + 288768m^2 + 376832m + 163840 \]
\[ z_1 = -81m^8 - 1098m^7 - 4872m^6 - 2000m^5 + 53568m^4 + 198656m^3 + 323584m^2 + 258048m + 81920 \]
\[ z_0 = 27m^8 + 540m^7 + 4572m^6 + 21376m^5 + 60352m^4 + 105472m^3 + 111616m^2 + 65536m + 16384 \]
\[ x_4 = 18m^6 - 80m^5 - 392m^4 + 1792m^2 + 256m^3 - 2048 \]
\[ x_3 = 9m^7 - 60m^6 - 380m^5 + 544m^4 + 4224m^3 + 3072m^2 - 7168m - 8192 \]
\[ x_2 = -27m^7 - 84m^6 + 684m^5 + 3472m^4 + 2944m^3 - 9728m^2 - 21504m - 12288 \]
\[ x_1 = 27m^7 + 276m^6 + 812m^5 - 736m^4 - 9344m^3 - 21504m^2 - 21504m - 8192 \]
\[ x_0 = -9m^7 - 150m^6 - 1036m^5 - 3848m^4 - 8320m^3 - 10496m^2 - 7168m - 2048 \]