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COUNTERVAILING POWER AND  
PRICE DISCRIMINATION: THE CASE  
OF AIRPORTS**

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# MARKET STRUCTURE, COUNTERVAILING POWER AND PRICE DISCRIMINATION: THE CASE OF AIRPORTS

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## ABSTRACT

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

We study bargained input prices where up and downstream firms can choose alternative vertical partners. We apply our model to airport landing fees where a number of interesting policy questions have arisen. 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 prices to airlines? Our major findings are: (a) an increase in upstream concentration or in the substitutability between airports always increases the landing fee; (b) the effect of countervailing power, via an increase in downstream concentration, typically lowers landing fees, but depends on the competition regime between airlines and whether airports can price discriminate: airline concentration reduces the landing fee when downstream competition is in quantities, but if downstream competition is in prices landing fees fall only where airports cannot discriminate. Furthermore, only in a specific case (Bertrand competition, uniform landing fees and undifferentiated goods) will lower fees pass through to consumers. (c) With Cournot competition, uniform landing fees are always higher than discriminatory fees, while the reverse is true with Bertrand competition.

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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, unionised labour markets, the environment, consumer transport choice, etc. But relative to that considerable weight of work there is very little on what would seem a rather important complementary input, namely airports.<sup>1</sup>

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. Thus for example the UK 1976 Department of Trade described the common ownership of UK airports as “ensuring the concentration of activity at a small number of airports and no wasteful competition between airports” (quoted in Barrett, 2000). The only benefit of dispersed airport ownership they could find was that local communities would derive “local pride in the ownership and operation of regional airports”.

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 to tempt airlines in cities like Moscow, Belfast, Melbourne, Orlando, Miami and London.<sup>2</sup> 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, *privatisation*. 55 countries have partially or totally privatised 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 have 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, notably “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

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<sup>1</sup>The major exception being 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. Whether this is an optimal mechanism is not the subject of this paper: but we note that while grandfather rights might give (intertemporal) market power and not optimally solve congestion problems, they do have benefit of providing incentives for airlines to sink costs: the baggage system at Heathrow Terminal 1 for example was built by one of the airlines.

<sup>2</sup>We document numerous examples below.

expansion (Borenstein and Rose, 2007). New runways have been vetoed in London but the new runway at Frankfurt is due to be completed in 2011.

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

These questions are recognised to be crucial in any policy debate regarding the regulatory choices for airports, yet to the best of our knowledge none of them have been answered using the logic of 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-elasticities of demand. We work with a demand system that has not been used before and thus show how we avoid some of the implicit assumptions made in other cases.

All formal models will of course focus on some issues and abstract from others. Thus our modeling choice is made in the context of the following considerations. First, in terms of theory, the classic results on vertical relations depend upon up/downstream market structure and contract structure (e.g., linear input tariffs) and so we need to make these as clear as possible in the model. Second, an empirical fact is that many airports are quite congested and so we wish to take account of this.<sup>3</sup> Third, many airport decisions also concern investment. This needs a dynamic model which we leave for another paper, but we use our framework to make at least some educated guesses.

*Model outline.* 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.

Our main endogenous variable of interest is the per passenger landing fee,  $\ell$ , that the airport

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<sup>3</sup>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.

charges to the airline. Empirically, this is the major source of revenues at most airports, above parking and retailing. For traditional airlines, airport charges account for 5% of full service airline costs on average, but this figure goes up to 20% for low cost airlines (for comparison, fuel is 18% and 10% of costs respectively; CAA, 2006). The determination of the landing fee is modeled by assuming that the airport and airline first bargain over  $\ell$  at a particular airport, and then the airlines play a market game. In that initial bargain over  $\ell$ , the airlines can threaten to go to a rival airport. In addition, we model contracts where  $\ell$  is uniform between airlines, as current regulation mandates, or can vary. To solve the model we use the Nash Bargaining solution, whereby, informally, the bargained  $\ell$  reconciles the equilibrium profits of the parties, net of their outside option, and their “concession costs”.

*Bargaining effects in the model.* A number of *ceteris paribus* effects follow immediately. First, an increased outside option for the airport will raise  $\ell$ . So, if only one company owns both airports, its outside option is increased. It turns out then, that increased concentration in airport ownership, or airports that are more dissimilar, raises  $\ell$ . Airports’ outside options are also raised with discriminatory input pricing. Under uniform pricing, disagreement with one airline means disagreement with the other; no airline flies and hence the airport earns no revenue. Under discriminatory pricing, an alternative airline can still fly even with disagreement with one airline, raising the outside option of the airport. Thus, under discriminatory pricing, there is also a tendency toward higher  $\ell$  (in fact the full effect turns out to depend on how discriminatory pricing affects concession costs, see below).

Second, an increased outside option for the airline will tend to lower  $\ell$ . So, if one airline owns a route at an alternative airport, then its outside option is increased, since in the event of disagreement it can still operate the other route. It turns out then, that in most cases, increased concentration in airline ownership, or routes that are more dissimilar, lowers  $\ell$ .

Third, the bargained  $\ell$  also depends on the “concession effect”, that is, the cost to airlines (airports, respectively) of conceding a rise (fall) in the landing fee. These costs depend on the type of downstream competition. One natural assumption is Bertrand price competition between airlines with differentiated products. This assumes that airlines precommit to prices and then accommodate all passengers who want to fly. We face the empirical reality however that crowded airports have a rationed number of slots, fixing thereby the number of planes that can fly per season.<sup>4</sup> The precise modeling of this is a matter for future work, so for the moment, we model this alternative environment as Cournot competition, where quantities are pre-committed.

Regarding the concession effects, an increase in  $\ell$  for an airline always has a direct negative impact on profits, causing the airline to resist such a proposed rise. However, with Bertrand competition, there is also an indirect (strategic) effect that provokes competitors to raise prices too, relaxing price competition. Thus the costs of concession are greater under Cournot than Bertrand, and so a higher  $\ell$  is resisted more strongly by the airlines under Cournot competition than Bertrand. In

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<sup>4</sup>At London Heathrow for example, there are 1,357 slots per day (nighttime flights are banned); currently only 12 pairs are available (Airport Co-ordination Limited, 2010).

particular, the concession cost is greatest under Cournot and discriminatory prices: an input price rise to an airline causes lower output (due to the direct cost effect), but the strategic effect of that lower output under Cournot, makes the rival airline raise output, reducing considerably the profit of the airline and thus making the concession effect particularly large in this case.

*Model findings.* Our findings thus follow from these various effects. Some of them are re-enforcing and we obtain unambiguous comparative statics. Others are countervailing and so the net results depend on functional forms.

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. This follows essentially from the assumption that in the bargaining over  $\ell$  stage, airlines can threaten to go to another airport. Their outside option is much muted with common airport ownership or little airport substitutability.

2. *Downstream market power (countervailing market power) generally lowers  $\ell$ .* Downstream concentration raises the airline outside option, for a concentrated airline can fly its other route from the other airport in the event of disagreement (fragmented airlines flying one route each have no such option). This tends to lower  $\ell$ . However, there are two opposing effects. First, airports raise their outside options when they can discriminate between airlines, tending to raise  $\ell$ . Second, increases in  $\ell$  are less resisted by airlines with discriminatory pricing and Bertrand competition, since concession costs are, as discussed above, the lowest: this is the only case with an opposing effect so strong that  $\ell$  ends up rising.

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 positive only in particular cases, for, in general, increased concentration downstream means higher retail prices, despite airlines pay lower  $\ell$ . It turns out that final prices only fall with intense Bertrand competition and uniform fees, in which case countervailing power is enough both to lower  $\ell$  and also for that lower  $\ell$  to be passed through to cheaper final prices.

4. *The effect of uniform or discriminatory prices depends on downstream structure: with Bertrand, a discriminatory  $\ell$  is higher; with Cournot, it is lower.* This finding points to the key role played by the competition mode. Discriminatory pricing raises the outside option of the airport and hence tends to raise  $\ell$ . As we saw, however, the overall impact on  $\ell$  depends also on the concession effect. The costs of conceding a higher  $\ell$  to the airline are greater under Cournot than Bertrand and particularly under Cournot and discriminatory prices. It turns out that, under our assumptions, with Bertrand competition, the initial effect, namely that allowing discriminatory prices raises the outside option of the airport so raising  $\ell$ , still holds. However, with Cournot, the resistance to an increase in  $\ell$  rises considerably, such that, overall, allowing discriminatory pricing lowers  $\ell$ .



*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 bargain. 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. 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.<sup>5</sup> 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. 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) reviews airport privatization.

There are two recent studies on landing fees by Van Dender (2007) for the 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 predicted by our model. But in the US it appears that increased airline concentration raises landing fees, whilst lowering it in the EU. As we shall show, the impact of airline concentration on landing fees depends also on whether there is price discrimination and congestion at the airport. Thus we can explain this differing effect to the extent that US airports are on average less congested than EU airports, which in our model changes the strategic interaction between airlines and so the comparative static effect of airline concentration on landing fees.

The application of our modelling 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. The most directly applicable model in this area is Horn and Wolinsky (1988) who model a downstream duopoly who buy inputs on bilateral monopoly relations with suppliers. The price of such inputs is determined by Nash bargaining between each firm and its supplier and they examine what happens to such prices when the upstream suppliers merge. Other work includes Dobson and Waterson (1997, 2007) who study Bertrand competition with differentiated products. Milliou and Petrakis (2007) study the incentives for upstream mergers in a model in which the input price is set via a Nash bargaining. Gal-Or and Dukes (2006) study merger incentives in the media industry, where media stations bargain with producers for advertising rates. Gal-Or (1997) studies the case where health insurance companies and hospitals bargain over the reimbursement rate. All these works generalize along various dimensions the initial contribution of Horn and Wolinsky (1988). But, as emphasized below and in a companion paper by Iozzi and Valletti (2010), they do make particular assumptions, hidden at times, on outside options and use particular demand curves.

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<sup>5</sup>Other contributions in this stream of the literature on approaches to internalize congestion are Pels and Verhoef (2004), Zhang and Zhang (2006), Basso and Zhang (2007), Morrison and Winston (2007), Basso (2008), Brueckner (2009), and Verhoef (2010).

The plan of the rest of this paper is as follows. In the next Section, we set out some salient facts about airports. In Section three, we set out our model assumptions and in Section four the results. Section five summarises and concludes. An Appendix contains the analytical details.

## 2 Institutional background to model and results

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.<sup>6</sup> 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, had their initial planning application successfully blocked by East Midlands so their entry has been drastically slowed.<sup>7</sup> 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.

*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. 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.

*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 privatised in 1996 to be owned by the British Airports Authority (BAA). These BAA airports accounted for 93% of UK air traffic.

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<sup>6</sup>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, left over from WWII where it was used for landings by damaged planes.

<sup>7</sup>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.

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.<sup>8</sup>

*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 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).<sup>9</sup>

*Bargaining and the determination of landing fees.* In the UK, landing fees in the major airports have been regulated since privatisation.<sup>10</sup> At capacity constrained airports, such as Heathrow and

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<sup>8</sup>Although the terminals at JFK are independently owned. For an extensive review of the US, see FAA (1999).

<sup>9</sup>One 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).

<sup>10</sup>Issues 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.

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 commercial UK airports, airlines are offered a preliminary discount to establish new routes, which then expire, typically after three years when the airline reverts back to the published tariff. 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 charge.

*Airline reaction to rivals.* As we shall see, we have to make assumptions later 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, bargaining and settlement takes 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 of course available to all, but 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 aircrafts 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.<sup>11</sup>

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<sup>11</sup>This has come under some strain in Heathrow where British Airways have a brand new terminal and other airlines are in a building site, however, uniform prices have remained due to the impossibility of judging different quality in

By spring 2011, airport charges at 144 European airports (above 1 million passengers per annum, mppa) will also to be subject to the EU Airport Charges Directive.<sup>12</sup> 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 a 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).

### 3 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 an individual flight service on a given route and the quantities sold by airlines correspond to the number of passengers traveling along the different routes.

*Costs.* For an airline, the only input per passenger is a slot at the airport, identical to all airlines and normalized to one. Airports receive a linear input price  $\ell$  per passenger for the intermediate good, which we refer to as the landing charge; under our simplifying assumptions, this is the only cost borne by airlines. All airports’ costs are normalized to zero.

*Consumer preferences.* Demand originates from a representative consumer. As we discuss below, it will be important in what follows to specify demand systems that have certain desirable properties and so we generalise Shubik and Levitan (1980), and assume that the quasi-linear utility function of the representative consumer is given by

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

where  $I$  is the consumption of other goods.

This utility gives rise to a linear demand structure; letting  $\mathbf{q}$  be the vector of flight services for such an interlocked airport.

<sup>12</sup>See also NERA (2009) and Competition Commission (2009), para 6.15.

all routes (i.e.,  $\mathbf{q} \equiv \{q_1, q_2, q_3, q_4\}$ ), inverse demand for good 1 is given by

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

whenever this is positive. Similar expressions hold for the inverse demand of the other goods. The parameters  $b$  and  $m$  describe the nature of the 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 all are completely independent. Parameter  $m$  thus measures 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  $m$ . In words,  $b$  is the substitution parameter between airports.

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

$$q_1(\mathbf{p}) = \frac{1}{2(1+b)} - \frac{2(1+b+m)p_1 + m[1+m(1-b)](p_1 - p_2) - bm(p_3 + p_4)}{4(1+b)[1+m+b(1-m)]} \quad (3)$$

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). In particular, when all goods are sold in the market, the total demand curve reduces to  $\sum_i q_i = \frac{4 - \sum_i p_i}{2(1+b)}$ . 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 perfectly substitute airports ( $b = 1$ ). In other words, 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. For a given total size, routes represent the preferences of consumers on where to fly. This is a desirable property, in that market size does not vary with the number of routes or their substitutability at given prices, which makes comparisons between different bargains with outside options a legitimate exercise.

Another important property of this demand system is that, both for direct and indirect demands, derivatives with respect to the relevant argument have the expected sign, allowing us to analyze both

quantity and price competition. In particular, from (2) and (3), it is easy to check that, when  $b$  and  $m$  are different from 0,  $\frac{\partial p_i}{\partial q_i} < \frac{\partial p_i}{\partial q_j} < 0$ , and that  $\frac{\partial q_i}{\partial p_i} < 0 < \frac{\partial q_i}{\partial p_j}$ , for all  $i, j = 1, \dots, 4$ . We therefore believe that our demand system can be seen as a contribution of the paper, with potential applications to other multiproduct industries.<sup>13</sup>

*Market structure.* We consider, as a base case, a market structure with the two upstream airports owned by separate firms,  $A$  and  $B$ , and the four routes flown by two separate airlines, with airline 13 flying routes 1 and 3, and another airline, named 24, flying routes 2 and 4. In order to study the effects of changes in concentration up- and downstream, we contrast this base case against two possible variations. Our first variation entails a downstream industry as in the base case but a more concentrated upstream market, with the two upstream airports being under joint ownership, and denoted with  $AB$ . The second variation we look at has an upstream market structure identical to our base case but a different downstream ownership structure, whereby the four routes are flown by fully independent airlines, whose payoff will be denoted using subscripts from 1 to 4. This allows to assess the effects of a change in downstream concentration. This framework, albeit not general, is a very parsimonious and, as it will turn out, 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.

To summarize, we denote with  $\mathcal{U} = (A, B, AB)$  the set of all possible upstream players, and with  $\mathcal{D} = (1, 2, 3, 4; 13, 24)$  the set of all possible downstream players. These hypotheses on the players' ownership give rise to three possible market structures:<sup>14</sup>

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

$1 \times 2$  : Two airports, with common ownership, with profits  $\pi_{AB} = \sum_{i=1, \dots, 4} q_i \ell_i$ , and two airlines flying routes 1 and 3, and 2 and 4, with profits as in case  $2 \times 2$ ;

$2 \times 4$  : Two airports, separately owned, with profits as in case  $2 \times 2$ , and four independent airlines flying one route each and with profits  $\pi_i = (p_i - \ell_i)q_i$  for  $i = 1, \dots, 4$ .

*Input price discrimination.* We will also consider different hypotheses regarding the possibility for an airport of setting discriminatory landing charges to the airlines flying from that airport. In case of discriminatory charges, we allow the negotiation between the different parties at the same airport

<sup>13</sup>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 now widely used. Singh and Vives demand system suffers from the fact that the market size is not independent from the differentiation parameter between goods. Its generalisation 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 sign one should expect for substitute goods. Our demand system does not suffer from these problems.

<sup>14</sup>The demand system also allows to obtain results for the case  $1 \times 4$ . These are not reported for the sake of brevity. Similarly, 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 competition downstream.

to give rise to different landing charges. On the other hand, when charges are uniform, all airlines flying from the same airport face the same input price.<sup>15</sup>

*Market game.* Competition in the industry is described by a two-stage game as follows. At stage 1, each airport negotiates with the airlines flying from that airport the linear input price  $\ell$  (the non-cooperative Nash equilibrium of these bargains is further discussed in the next section). At stage 2, all airlines observe the outcomes of stage 1 and compete against each other, either in prices (Bertrand) or in quantities (Cournot), given the values of the input prices from stage 1. We derive the pure strategy symmetric equilibrium of this game.

### 3.1 Bargaining

The first-stage negotiations are conducted simultaneously so that, during bargaining, the firms' negotiators treat the other landing charges as given.<sup>16</sup> 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. We denote by  $\pi_d(\ell)$  the downstream profit in the last stage of airline  $d$ , with  $d \in \mathcal{D}$ , and by  $\pi_u(\ell)$  the upstream profit in the last stage of airport  $u$ , with  $u \in \mathcal{U}$ . We also let  $\bar{\pi}_d$  and  $\bar{\pi}_u$  be the disagreement payoff for airline  $d$  and airport  $u$  respectively.

*The Nash Bargaining problem.* In the *discriminatory* case, four landing charges,  $\{\ell_1, \ell_2, \ell_3, \ell_4\}$ , 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  $\ell_i$ , with  $i = 1, \dots, 4$ . The bargaining solution is found maximizing the following Nash product

$$\max_{\ell_i} [\pi_u(\ell_i, \ell_{-i}) - \bar{\pi}_u]^\beta \cdot [\pi_d(\ell_i, \ell_{-i}) - \bar{\pi}_d]^{1-\beta} \text{ for } u \in \mathcal{U} \text{ and } d \in \mathcal{D} \quad (4)$$

where  $\beta \in [0, 1]$  denotes the bargaining power of the airport relative to that of the airline.

In the *uniform* case, two landing charges,  $\{\ell_A, \ell_B\}$ , have to be determined. At stage 1, each airport  $u$  forms a separate bargaining unit with both airlines flying from that airport. Each unit bargains over  $\ell_h$ , the common landing charge any airline has to pay for each passenger flying from airport  $h$ , with  $h = A, B$ . The bargaining solution is found maximizing the following Nash product

$$\max_{\ell_h} [\pi_u(\ell_h, \ell_{-h}) - \bar{\pi}_u]^\beta \cdot [\pi_d(\ell_h, \ell_{-h}) - \bar{\pi}_d]^{\frac{1-\beta}{2}} \cdot [\pi_{d'}(\ell_h, \ell_{-h}) - \bar{\pi}_{d'}]^{\frac{1-\beta}{2}} \text{ for } u \in \mathcal{U} \text{ and } d, d' \in \mathcal{D} \quad (5)$$

Notice that, in this uniform case, we have not altered the bargaining power  $\beta$  of the airport compared to the discriminatory case, but divided 50:50 the residual bargaining power of the airlines. In a symmetric equilibrium, the interests of the downstream firms flying from the same airport are

<sup>15</sup>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.

<sup>16</sup>In case of simultaneous negotiation with different counterparts, this means that separate negotiators are sent to conduct independent negotiations with each counterpart.



aligned, and thus (5) simplifies to

$$\max_{\ell_h} [\pi_u(\ell_h, \ell_{-h}) - \bar{\pi}_u]^\beta \cdot [\pi_d(\ell_h, \ell_{-h}) - \bar{\pi}_d]^{1-\beta} \quad \text{for } u \in \mathcal{U} \text{ and } d \in \mathcal{D} \quad (6)$$

This is directly comparable to (4), as the bargaining power of the airport does not change in the two scenarios. Hence, when assessing uniform versus discriminatory landing fees, eventual differences will not arise from having altered the relative bargaining strengths.

The actual form of the players' profit in (4) and (6) depends on the market structure, on the mode of downstream competition, and on the possibility to set discriminatory charges.

To illustrate, take the case with market structure  $2 \times 4$  and with quantity competition downstream.<sup>17</sup> Equilibrium quantities in the second stage, denoted with  $q_i^{2 \times 4}$ , are obtained solving a standard Cournot game for the 4 independent airlines. Plugging these equilibrium quantities in the expression for profits in the first stage, airline  $i$ 's profits are given by  $\pi_i^{2 \times 4}(\boldsymbol{\ell}) \equiv q_i^{2 \times 4}(\boldsymbol{\ell}) \cdot (p_i(q^{2 \times 4}(\boldsymbol{\ell}) - \ell_i))$ . Similarly, airports' profits are given by  $\pi_A^{2 \times 4}(\boldsymbol{\ell}) \equiv \sum_{i=1,2} q_i^{2 \times 4}(\boldsymbol{\ell}) \cdot \ell_i$  for airport  $A$ , and by  $\pi_B^{2 \times 4} \equiv \sum_{i=3,4} q_i^{2 \times 4}(\boldsymbol{\ell}) \cdot \ell_i$  for airport  $B$ .

In case of uniform charges, the bargaining problem between airport  $A$  and airlines 1 and 2, formulated in general terms in (5), can now be restated as

$$\max_{\ell_A} [\pi_A^{2 \times 4}(\ell_A, \ell_B)]^\beta \times [\pi_1^{2 \times 4}(\ell_A, \ell_B)]^{\frac{1-\beta}{2}} \times [\pi_2^{2 \times 4}(\ell_A, \ell_B)]^{\frac{1-\beta}{2}} \quad (7)$$

or, making use of (6),

$$\max_{\ell_A} [\pi_A^{2 \times 4}(\ell_A, \ell_B)]^\beta \cdot [\pi_1^{2 \times 4}(\ell_A, \ell_B)]^{1-\beta}; \quad (8)$$

a similar problem between airport  $B$  and airlines 3 and 4, solves for  $\ell_B$ . Notice that the outside option is now equal to zero for both parties: as to the airport, because of the non discrimination requirement, a failure to negotiate with one airline implies that no other airline can fly from the same airport. As to the airlines, a zero outside option follows from the dispersed ownership, under which each airline can fly along one route only.

In case of discriminatory charges, the bargaining problem between airport  $A$  and airline  $i$ , formulated in general terms in (4), can now be restated as

$$\max_{\ell_i} [\pi_A^{2 \times 4}(\ell_i, \ell_{-i}) - \bar{\pi}_A^{2 \times 4}]^\beta \cdot [\pi_i^{2 \times 4}(\ell_i, \ell_{-i})]^{1-\beta} \quad \text{for } i = 1, 2. \quad (9)$$

Likewise, airport  $B$  forms two distinct bilateral bargaining units with airlines 3 and 4 for the definition of  $\ell_3$  and  $\ell_4$  respectively. Notice the now positive outside option for the airport: since landing fees are discriminatory, the failure of the negotiation still leaves open the possibility of selling to the other airline.

*Disagreement payoff.* We now turn to discuss the disagreement payoffs of the above bargaining

<sup>17</sup>All cases are illustrated in the Appendix.

problems. In the event of an unsuccessful negotiation between an airport and the airline(s) over a landing charge, the corresponding route(s) cannot be operated and market players can only derive alternative profits from operating other routes.

The impossibility of operating one or more routes has two immediate consequences on demand and the strategic behaviour of other parties where bargaining has not broken down. 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. Similarly, the system of *direct* demands (3) has to be re-obtained by removing these routes from the consumer's choice when inverting the system of inverse demand functions.

The second important consequence depends on the way the downstream rivals react to the disagreement, which in turn hinges on their possibility of observing the negotiation breakdown. We will assume that players not directly involved in a negotiation cannot observe the breakdown of that negotiation.<sup>18</sup> Therefore, in case of a breakdown, airlines not involved in the negotiation are not able to adjust their behavior to the absence of some route(s) in the downstream market; in other words, they adopt their optimal strategic behavior (in prices or quantities) as if all routes were in operation. When airlines are multiproduct though (i.e., they offers routes from both airports), those involved in a failed negotiation with one airport can observe this breakdown and, on the route they operate from the other airport, react and adopt an optimal choice (in prices or quantities) which takes into account that some routes are not in operation.<sup>19</sup> From these (price or quantity) choices of the airlines in case of disagreement, we can then compute the outside options for both up- and downstream firms.

To illustrate, take the case  $1 \times 2$  with downstream quantity competition; this is the most illustrative since it is one in which the disagreement payoff is different from zero both upstream and downstream.<sup>20</sup> With uniform landing charges, the bargaining problem to set  $\ell_A$

$$\max_{\ell_A} [\pi_{AB}^{1 \times 2}(\ell_A, \ell_B) - \bar{\pi}_{AB}^{1 \times 2}]^\beta \cdot [\pi_{13}^{1 \times 2}(\ell_A, \ell_B) - \bar{\pi}_{13}^{1 \times 2}]^{1-\beta}.$$

In case of disagreement, uniform charges common to the airlines mean *both* airlines know that no routes from airport  $A$  can be operated and then, in the competition stage of the game, adjust their optimal choices from the other airport by solving the following problems

$$\max_{q_i} [p_i(0, 0, q_3, q_4) - l_B] \cdot q_i \quad \text{for } i = 3, 4. \quad (10)$$

In (10), notice that the demand function already anticipates the readjustment in the behavior of consumers, who do not find routes 1 and 2 on offer when making their purchase decisions. Letting

<sup>18</sup>See Horn and Wolinsky (1988) and most of the literature using their approach.

<sup>19</sup>In this, we follow Dukes et al. (2006). For further discussion of the effects of the different options in modeling the outside option in a Nash Bargaining over input prices in a vertical industry, see Iozzi and Valletti (2010).

<sup>20</sup>Details for all different cases are in the Appendix.

$q'_3$  and  $q'_4$  be the solution to these problems, we can use them to compute the disagreement payoffs of the players. As for the airlines, the solution in this case is obtained by plugging back into (10) these solutions (i.e.,  $\bar{\pi}_{13}^{1 \times 2} = [p_3(0, 0, q'_3, q'_4) - l_B] \cdot q'_3$ ). Similarly, the disagreement payoff for the airport is given by  $\bar{\pi}_{AB}^{1 \times 2} = (q'_3 + q'_4) \cdot \ell_B$ .

More subtle is the computation of the disagreement payoffs in case of discriminatory charges. Take the case of the bargaining over  $\ell_1$  which can now be stated as

$$\max_{\ell_1} [\pi_{AB}^{1 \times 2}(\ell_1, \boldsymbol{\ell}_{-1}) - \bar{\pi}_{AB}^{1 \times 2}]^\beta \cdot [\pi_{13}^{1 \times 2}(\ell_1, \boldsymbol{\ell}_{-1}) - \bar{\pi}_{13}^{1 \times 2}]^{1-\beta}.$$

In case of disagreement, airline 24 does *not* know about the breaking down of the negotiation and therefore chooses quantities as if all the routes were served; in other words, it chooses still  $q_2$  and  $q_4$  as along the equilibrium path where it maximizes  $[p_2(\mathbf{q}) - l_2] \cdot q_2 + [p_4(\mathbf{q}) - l_4] \cdot q_4$ . 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  $\bar{\pi}_{13}^{1 \times 2} = [p_3(0, q_2, q'_3, q_4) - l_3]q'_3$ , while, for airport  $AB$ , we have  $\bar{\pi}_{AB}^{1 \times 2} = q_2\ell_2 + q'_3\ell_3 + q_4\ell_4$ .

*First order conditions.* Solving problems (4) (or (6)) and rearranging, one gets

$$\frac{\beta}{1 - \beta} \frac{\pi_d(\ell_i, \boldsymbol{\ell}_{-i}) - \bar{\pi}_d}{\pi_u(\ell_i, \boldsymbol{\ell}_{-i}) - \bar{\pi}_u} = - \frac{\partial \pi_d(\ell_i, \boldsymbol{\ell}_{-i}) - \bar{\pi}_d / \partial \ell_i}{\partial \pi_u(\ell_i, \boldsymbol{\ell}_{-i}) - \bar{\pi}_u / \partial \ell_i} \text{ for } u \in \mathcal{U} \text{ and } d \in \mathcal{D}, \quad (11)$$

which we will use to illustrate the different forces affecting the level of the landing charge.

The LHS of (11) is a product of two terms. The first term is simply the relative bargaining power of the parties. This ratio is increasing in  $\beta$  (the bargaining power of the airport). The second term is the ratio between the profit *levels* of the two bargaining parties, net of the value of their outside options. This ratio is decreasing in the equilibrium landing charge when the downstream (respectively, upstream) net agreement profits are decreasing (respectively, increasing) in  $\ell_i$ . Both outside options depend on the nature of the market interaction but are independent of the negotiated landing charge; their role is simply to provide a shift to the LHS, for each given value of  $\ell_i$ . This reflects the fact that a party becomes relatively stronger the higher is the value of its outside option. The role of the outside options is therefore somewhat similar to that played by the players' bargaining power; while the bargaining power is exogenously given, the outside option depends instead on market characteristics.

The RHS of (11) is the ratio of the *marginal effects* on the firms' profits of a change in the landing charge. It can also be seen as the ratio of *concession costs*, defined as follows. First, for the airline, a concession is an agreement to pay a higher landing charge; it increases its cost and weakens its competitive position in the downstream market relative to rivals. Second, for the airport,

a concession is an agreement to accept a lower landing charge. Thus, the RHS illustrates how the bargaining solution has the property that a party becomes relatively stronger the more costly are its concessions, since it will more reluctant to concede. Contrary to the case of the LHS, this ratio is typically increasing in  $\ell$ ; this behavior with respect to  $\ell$  is perhaps less intuitive, though it reflects the rather general property that the concession cost for a downstream firm relative to that of the upstream firm, is higher the higher is the general level of the input price (and, thus, the smaller is the equilibrium quantity produced by the downstream firm).

## 4 Results

We start by focusing first on the simple benchmark cases where at least one of the two substitution parameters is equal to 0, which reduces to a minimum the strategic effects between airports and/or airlines. Then we consider the case of full strategic interaction between airports and airlines.

### 4.1 Cases without full vertical strategic interaction

When  $m = 0$ , routes are independent and the landing charge is always equal to

$$\ell_i = \frac{\beta}{2} \tag{12}$$

under any circumstances: each airline has an independent product and must negotiate the landing fee with the airport it is flying from. This implies that the landing charge varies from the monopoly price ( $\frac{1}{2}$ ) to the competitive price (0) only depending to the bargaining power of the parties.

When  $b = 0$ , airports are independent. A landing charge equal to  $\frac{\beta}{2}$  is also the equilibrium result when charges are uniform, irrespective to the mode of competition and the value of  $m$ . This invariance result of the common input price sold by a monopolist to a downstream industry is already known in the literature when the input price is set directly by the input provider (see, e.g., Greenhut and Ohta, 1976), and it is here immediately generalized to a simple Nash framework.

When  $b = 0$  and charges are discriminatory instead, the landing charge is

$$\ell_i = \frac{1}{2} \frac{\beta}{1 + \frac{(1-\beta)m}{m+4}} \tag{13}$$

under Cournot competition for any market structure, and

$$\ell_i = \frac{1}{2} \frac{\beta}{1 - \frac{2(1-\beta)m(1+m)}{(2+m)(4+3m)}} \tag{14}$$

with Bertrand competition, which is clearly higher than the landing fee under Cournot competition. Recall that, when  $b = 0$ , the two airports are fully independent and each route is a substitute only to the other route from the airport (according to the value of  $m$ ). The setting is therefore of one upstream supplier and two symmetric competing downstream firms, similar to one analyzed in Iozzi

and Valletti (2010).<sup>21</sup> They illustrate that a higher input price with Bertrand competition arises due to the lower airline’s concession cost: an increase in the input price is “resisted less” under price competition compared to Cournot competition because, *ceteris paribus*, it softens competition .

These results on market structure and differentiation parameters are knife-edge cases, due to the lack of full strategic interactions in the vertical chains. In what follows, we focus our attention on the more challenging cases of strictly positive values of parameter  $b \in (0, 1]$  and  $m \in (0, \infty)$ . All the analytical expressions are relegated to the Appendix. In all cases we obtain closed-form solutions, but in some cases, expressions are rather cumbersome. Thus we have relied on simulations for all ranges of parameters to prove the results that follow.

## 4.2 Upstream concentration and competition

Our 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** *An increase in upstream concentration always increases the landing charge. Similarly, a decrease in  $b$  (that is, substitution between airports) weakly increases the landing charge.*

Proposition 1 states that, going from two independent airports to jointly-owned airports, leads unambiguously to an increase in the landing charge. The increase in the landing fee due to a common ownership 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.

This result is intuitive but it is instructive, for the understanding of the other more complex situations we consider in the rest of the paper, to show more precisely the channels through which it arises. A change in upstream ownership has no effect on the airlines’ outside options, nor does it affect their concession cost. Instead, the outside option of the airport is strictly higher with joint ownership: for instance, in case of a disagreement in airport  $A$ , routes 3 and 4 are still operated from the other airport  $B$  which is owned by the same company. Hence, this level effect tends to push the landing fees up. On the other hand, the airport’s concession cost is affected by a change in the upstream market structure. In particular, a landing fee discount is resisted more under joint ownership as the cost of conceding, say, a unilateral discount to airline 1 in airport  $A$ , is coupled not only with a reduction in quantity along route 2 but also with an additional reduction along routes 3 and 4. Thus both the outside option and the concession cost for the airport(s) push up landing fees more the more concentrated in the upstream market.

In a similar fashion, a decrease in the parameter  $b$  of differentiation between airports weakly increases the landing fees. This is strictly true when there is airport competition (cases  $2 \times 2$  and

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<sup>21</sup>Given the hypothesis used here for the definition of the outside options, the results of this paper are analogous to the case referred to as *No Reaction* in Iozzi and Valletti (2010).

$2 \times 4$ ). It is worth noting, however, that, as  $b$  tends to 1, goods do *not* become perfectly substitutable, as each route can fly only from one specific airport. Therefore it is not necessarily the case that landing fees decrease down to cost (i.e., zero in our normalization) even for very intense airport competition. In fact, this happens only in case  $2 \times 2$ , both under Cournot and Bertrand, when also  $m$  tends to infinity: this implies that identical airlines can fly identical routes from identical airports. This limiting result also holds in the  $2 \times 4$  case, but only under Bertrand competition. Only in these cases, a *fully deregulated* airport industry could lead to efficient levels of the landing fees. On the contrary, efficiency is never achieved when airports are jointly owned, for any combination of  $b$  and  $m$ .<sup>22</sup>

### 4.3 Downstream concentration and competition

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. The main policy question relates here to the existence and effects of airlines' countervailing power.

**Proposition 2** *An increase in downstream concentration always reduces the landing charge when downstream competition is in quantities. This also applies when downstream competition is in prices but only with uniform landing charges.*

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 bargain lower landing fees, but only under some conditions. The main mechanism at work in Proposition 2 comes from the role of the outside options. More downstream concentration (i.e., going from  $2 \times 4$  to  $2 \times 2$ ), means that an airline always has the ability to fly from an alternative route in disagreement: a multi-route airline (say, airline 13), if in disagreement with airport  $A$  over route 1, can always fly route 3 from airport  $B$ . The precise value of this outside option will differ according to the mode of downstream competition and between the discriminatory and the uniform case.

Take first the case of Cournot competition. Under discriminatory landing fees, only airline 13 knows about the disagreement and readjusts its choice (i.e., it increases its quantity) in the other airport; while in the uniform case, also its rival will do the same and hence the effect of the readjustment of airline 13 is diluted. As far as the airport outside option is concerned, this is always zero under the uniform fee. Under discrimination, airport  $A$  can still sell through route 2 but the value of this outside option is invariant with respect to the downstream concentration (i.e., going from  $2 \times 4$  to  $2 \times 2$ ), since  $q_2$  is always set at the anticipated Cournot equilibrium. Thus, the outside option effect when going towards more concentrated airlines is always in favour of the airlines, resulting in lower landing charges.

A similar story applies to the case of Bertrand competition with uniformity. In fact, the airport still has a zero outside option under any market structure, while the airlines have a positive outside

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<sup>22</sup>When market structure is  $1 \times 2$ , uniform landing fees still decrease in  $b$  but never converge to cost; otherwise, discriminatory landing fees are invariant to  $b$ .

option. The increase in the value of an airline outside option with more downstream concentration is actually higher under uniformity (than under discrimination), contrary to the Cournot case. This is because, in disagreement, under uniformity both airlines flying from the other airport  $B$  readjust their prices upwards, which considerably relaxes competition, while under discrimination only airline 13 does so, while its rival (who is not aware of the breakdown), still sets its anticipated equilibrium price under unrestricted competition. Under discrimination, this outside option in favour of the airlines not only is smaller than under uniformity, but there is now also an opposing and prevailing force via the outside option of the airport. To see this, recall that under discriminatory pricing and  $2 \times 4$ , the outside option to airport  $A$  when disagreeing with airline 1 is equal to  $q_2(0, p_2, p_3, p_4) \cdot \ell_2$ , while, as the downstream market becomes more concentrated (i.e., the  $2 \times 2$  case), the outside option when disagreeing with airline 13 increases to  $q_2(0, p_2, p'_3, p_4) \cdot \ell_2$ , because of the upward readjustment in the price set by airline 13 on route 3,  $p'_3$ , which is strictly greater than  $p_3$ .

What is the effect on final prices to consumers? 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.

**Proposition 3** *An increase in downstream concentration always increases final consumer prices unless, when in the discriminatory regime, downstream competition is in prices and  $m$  is sufficiently large.*

Intuitively, from Proposition 2, it is already clear that an increase in downstream concentration makes consumers worse off when competition is in prices and under discrimination, since there is no countervailing power and the landing fee already goes up. In the other cases, consumers might benefit to the extent that the countervailing buyer power is passed onto them; however, the pass-through is not full under Cournot competition and the reduction in quantities following concentration ultimately pushes final prices up. It is only under Bertrand competition and uniform fees instead, that there is countervailing power (from Proposition 2) and the pass-through effect will prevail to the extent that competition is high.

#### 4.4 Uniform vs discriminatory landing charges

In this section we consider the regulatory question whether or not to allow airports to bargain discriminatory fees with each airline independently. This is at the core of recent changes in the EU regulation. It turns out that the mode of competition plays a crucial role.

**Proposition 4** *With Cournot competition, uniform charges are always higher than discriminatory charges. With Bertrand competition, the opposite is true.*

The Proposition makes it clear that the mode of competition changes considerably the bargaining behavior of the parties. One effect, common both to Cournot and Bertrand, comes from the outside

option of the airport: with discriminatory fees, the airport, when in disagreement with one airline, can always sell to the other airline. Thus discrimination would tend to push up the fees because of this level effect. Indeed, this is our finding with Bertrand competition, where this outside option effects dominates. For instance, take airport  $A$  that negotiates over its profits  $\ell_1 q_1 + \ell_2 q_2$ : In disagreement, it can still sell  $\ell_2 q'_2$ . Notice that  $q'_2 > q_2$ , as airline 2 still plays the precommitted Bertrand price, but consumers, having observed the missing route 1, will partially readjust their schedules through route 2.

Under Cournot competition instead, airline 2 precommits to its quantity and still sells exactly  $q_2$ . Thus the outside option effect is diluted under Cournot. In addition to this, under Cournot competition, the concession costs for the airlines and for the airport push in the opposite direction and result, in the end, in higher uniform than discriminatory fees. We now detail this reasoning. As far as the airlines are concerned, concession costs are lower when the rival from the same airport has also to face the same increase in the landing fee, i.e., under uniformity. As to the airport, the demand for its aggregate input is more responsive to changes of the uniform landing fee. This is because, under discrimination, the change in the quantity along one route caused by a change of its landing fee is always partially compensated by an opposite change along the other route. Therefore, the opportunity cost of offering a uniform discount is much higher.

We also notice that the effect on the landing fees from Proposition 4 has a similar impact on profits. Thus, airlines prefer discriminatory charges only when competition is in quantities while airports have the opposite interest. Under Bertrand competition, it is airports who would prefer to bargain over discriminatory fees, though this would penalize airlines.

#### 4.5 Modes of competition and incentives to invest in capacity

In the previous section we showed that the mode of competition affects the comparison between uniform and discriminatory fees. Now we conduct a different exercise. We fix the regime of fee charging and ask what are the effects of the different 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 5** *With uniform landing charges, Cournot competition always leads to charges higher than Bertrand. With discriminatory landing charges, Bertrand competition leads to charges higher than Cournot, except in case  $2 \times 4$  when  $b$  and  $m$  are sufficiently large, when the opposite holds.*

The result with uniform charges is mostly driven by the level of firms' profits under the two different competition modes, as described by the LHS of eq. (10). Take for simplicity the case  $2 \times 4$ , so that outside options under uniform landing fees are zero for all the parties involved in a bargain. For a given uniform landing fee, the profits of the downstream airlines are higher under Cournot than under Bertrand, while the opposite is true for the profit of the airport, since output is higher under Bertrand. Therefore, the ratio captured by the LHS of eq. (10) is unambiguously



“shifted up” under Cournot than under Bertrand competition. This generates the result stated in the Proposition, over and above any other effect arising from concession costs.

Things are more involved with discriminatory fees. First of all, the airport always has an outside option. This is particularly profitable under Bertrand, since the other airline flies more passengers in disagreement than under Cournot, at the anticipated respective equilibrium. This tends to push landing fees up under Bertrand compared to Cournot. Second, concession costs become now pivotal: a unilateral increase in the landing fees relaxes competition with strategic complements, and therefore airlines are more likely to concede such an increase under Bertrand than under Cournot competition. Again, this tends to increase landing charges in equilibrium under Bertrand compared to Cournot. The net result of these two effects and of the effect described for the uniform charges, still at work here, is as described by the proposition, which makes clear that functional forms matter for the net effect.

These results on the effect of the mode of competition on landing charges can also help us inform the discussion about the reduction in congestion at airports via investments in new runways, terminals and/or improvements in the air traffic management. While we do not have a model about investment and congestion, we limit ourselves to note that 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 could provide a partial answer to this.

It turns out that, as far as airports are concerned, there is always a fundamental trade off. On the one hand, airports prefer the mode of competition that results in higher landing fees (as characterized by Proposition 5). 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*. Hence the comparison of profits for airports typically depends on the parameters of differentiation.<sup>23</sup>

On the airlines’ side, it is clear that, any time Bertrand competition increases landing fees, this negative effect is further magnified by the more intense competition. In fact, it turns out that the increase in competition under Bertrand compared to Cournot typically prevails over the effect from landing fees, even in those cases with uniform charges when Bertrand would allow to secure cheaper fees (see Proposition 5). However this result is not robust to all market structures, and therefore we just report this general tendency instead of formalising it into a proposition.

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<sup>23</sup>In line with Proposition 5, airports have higher profits, in most cases, when landing fees are discriminatory. When they are uniform, Bertrand yields higher profits when the degree of up- or downstream differentiation is not too high.

## 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 model consists of upstream airports, who compete with each other to varying extents, bargaining landing fees with downstream competing airlines. It isolates a number of effects on landing fees, the net effect of which determines the answer to the questions above.

Thus our results can be summarized as follows. First, should jointly owned airports be broken up? A break up turns out to reduce  $\ell$  in all cases as airlines have an increased outside opportunity to switch airports.

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 airlines might potentially fly the same route from a nearby airport, this raises the airline outside option and the bargained  $\ell$  falls, just as the airports argue.

But there are other effects. First, if the airport can charge different prices to airlines (i.e., a discriminatory input price), then the airport's bargaining position is stronger (it has an outside option in event of disagreement with one airline), and so  $\ell$  rises. Second, the bargaining response of airlines to proposed changes in  $\ell$  depends on the mode of competition with other airlines. With Bertrand competition, falls in  $\ell$  that result in airlines reducing their prices provoke a tough competitive response from other airlines. So airlines push less hard for falls in  $\ell$  at the margin, with Bertrand competition than with Cournot. So, as regards countervailing power, increasing airline power reduces  $\ell$  depending on airline product market competition and airport ability to charge discriminatory prices:  $\ell$  turns out to fall with Cournot competition and with Bertrand competition but non-discriminatory prices.

Third, and related, would countervailing airline power lead to lower prices for consumers? We find that the lower  $\ell$  in Cournot is not passed on to consumers, since airlines succeed in lowering  $\ell$  but keep some of that surplus. The only case where there is countervailing airline power turns out to be with strong Bertrand competition, i.e., with highly substitutable routes in which case consumers gain from the reduced  $\ell$  in the bargain. So relying on countervailing power is likely to be welfare enhancing only in very special circumstances.

Fourth, do airlines prefer the new EU rules that appear to make discriminatory pricing harder? Broadly speaking, discriminatory pricing tends to raise  $\ell$  for it raises airports outside option. But airlines resist discriminatory pricing more when they are Cournot competitors, so, overall,  $\ell$  is lower in this case. Thus, if there was Bertrand competition at airports and the airport moved from discriminatory to uniform,  $\ell$  would fall. Therefore the model would predict that airlines would welcome the proposed EU rule at non-crowded airports.<sup>24</sup>

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<sup>24</sup>In our model all airlines have the same bargaining power. An airline who is "better" at bargaining (Ryanair

The final question we touched 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. If there is discriminatory pricing, then this raises  $\ell$ , if uniform this lowers  $\ell$ . So the effect on airports depends on the type of pricing. As for airlines, they too have more volume, but if competition changes from Cournot to Bertrand their output prices fall and profits might fall. In most of our cases, airlines profits tend to fall due to the change in competition mode, but we do not have any general results here.

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 work. One is investment incentives in airports. This requires a dynamic investment choice 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 realised 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 still await for 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. Last, we have not considered the hub nature of airports such as Heathrow, which is somewhat a special case, but raises a number of other issues related to platforms and demand externalities.

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perhaps?) would oppose the non-discrimination rule.

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## Appendix

In this Appendix, we present the analysis of the different market structures when downstream competition is in quantities. The analysis of the Bertrand case is relegated to a separate Appendix, available at <http://www.economia.uniroma2.it/iozzi/>.

*Demand system.* In case of breakdown of the negotiations, some routes are not operated and consumers readjust their behaviour on the basis of the goods on offer. Therefore, the system of inverse demands used for the evaluation of the outside option need to be redetermined, setting equal to zero all quantities not sold.

When  $q_1$  is not sold, inverse demand comes from the maximisation of (1), setting  $q_1 = 0$ . For good 2 (similar expression are for the other goods), this is given by

$$p_2(0, q_2, q_3, q_4) = 1 - \frac{m + 2(1 + b)}{1 + m}q_2 - \frac{bm}{1 + m}(q_3 + q_4) \quad (\text{A-1})$$

When  $q_1$  and  $q_2$  are not sold, inverse demand comes from the maximisation of (1), setting  $q_1 = q_2 = 0$ . This is given by

$$p_i(0, 0, q_i, q_j) = 1 - \frac{m + 2(1 + b)}{1 + m}q_i - \frac{m}{1 + m}q_j \quad \text{for } i = 3, 4; i \neq j. \quad (\text{A-2})$$

*Second stage.* We present here the equilibrium quantities chosen by the downstream firms in the second stage of the game, as a function of the negotiated landing fee. We first solve the case in which the downstream market is operated by four independent airlines. Each airline  $i$  (with  $i = 1, \dots, 4$ ) maximises  $[p_i(\mathbf{q}) - \ell_i]q_i$ . Equilibrium quantities, obtained by solving the system of four FOCs of the above four problems, are denoted by  $q_i^{\times 4}(\ell)$ . For good 1 (similar expressions holds for the other goods), we have

$$q_1^{\times 4}(\ell) = \frac{1 + m}{m(3 + 2b) + 4(1 + b)} \left\{ 1 + \frac{bm(\ell_3 + \ell_4)}{m(3 - 2b) + 4(1 + b)} + \frac{m[m(3 - 2b^2) + 4b + 4]\ell_2 - [2m^2(3 - b^2) + 20m(1 + b) + 16(1 + b(2 + b))]\ell_1}{(4 + 4b + m)(m(3 - 2b) + 4(1 + b))} \right\} \quad (\text{A-3})$$

These quantities, when plugged into the relevant demand functions (2), result in the following equilibrium price for good 1 (similar expression hold for the other goods)

$$p_1^{\times 4}(\ell) = \frac{1}{m(3 + 2b) + 4(1 + b)} \cdot \left\{ \frac{[(3 - 2b^2)m^3 + (28 - 12b^2)(1 + b)m^2 + 56m(1 + 2b + b^2) + 32(1 + 3b^2 + b^3 + 3b)]\ell_1}{(m(3 - 2b) + 4(1 + b))(4b + 4 + m)} + (2 + m + 2b) \left( 1 + \frac{bm(\ell_3 + \ell_4)}{m(3 - 2b) + 4(1 + b)} + \frac{m[m(3 - 2b^2) + 4(1 + b)]\ell_2}{(m(3 - 2b) + 4(1 + b))(4b + 4 + m)} \right) \right\} \quad (\text{A-5})$$

The resulting second stage equilibrium profits are denoted as  $\pi_i^{\times 4}(\ell) = \pi_i(\mathbf{q}_i^{\times 4}(\ell))$ .

Take now the case when the downstream market is operated by two independent airlines; airline 13 solves the problem  $\max_{q_1, q_3} [p_1(\mathbf{q}) - \ell_1]q_1 + [p_3(\mathbf{q}) - \ell_3]q_3$ , while a similar problem is faced by airline 24. Equilibrium quantities, obtained by solving the system of four FOCs of the above two problems, are denoted

by  $q_i^{\times 2}(\ell)$ . For good 1 (similar expressions hold for the other goods), we have

$$q_1^{\times 2}(\ell) = \frac{1+m}{(3m+4)(b+1)} \left\{ 1 - \frac{2[3m^3(1-b) + 2m^2(11-5b^2) + 48m(1+b) + 32(1+2b+b^2)]\ell_1}{(m+4)(3m(1-b) + 4(1+b))(m(1-b) + 4(1+b))} \right. \\ + \frac{m[3m^2(1-b) + 16(m(1-b^2) + 1+b)]\ell_2}{(m+4)(3m(1-b) + 4(1+b))(m(1-b) + 4(1+b))} \\ \left. + \frac{bm[(16(1+b) - 3m^2(1-b))\ell_4 + 2bm[3m^2(1-b) + 12m + 16(1+b)]\ell_3}{(m+4)(3m(1-b) + 4(1+b))(m(1-b) + 4(1+b))} \right\}. \quad (\text{A-6})$$

These quantities, when plugged into the relevant demand functions (2), result in the following equilibrium price for good 1 (similar expressions hold for the other goods)

$$p_1^{\times 2}(\ell) = \frac{m+2}{3m+4} + \frac{1}{(m+4)(3m+4)(3m-3bm+4b+4)(m-bm+4b+4)} \\ \left\{ [3m^4(1-2b+b^2) + 40m^3(1-b) + 256m(1+b) + (168-88b^2)m^2 + 128(1+2b+b^2)]\ell_1 \right. \\ - 8bm^2[2+m(1-b)]\ell_3 + m(2+m(1-b))[3m^2(1-b) + 16(1+m+b)]\ell_2 \\ \left. + 2bm[5m^2(1-b) + 16(1+b+m)]\ell_4 \right\}. \quad (\text{A-7})$$

The resulting second stage equilibrium profits are denoted as  $\pi_i^{\times 2}(\ell) = \pi_i(q_i^{\times 2}(\ell))$ .

*First stage.* We now present the subgame perfect equilibrium landing charges negotiated by up- and downstream firms in the first stage of the game. For each market structure, we derive the equilibrium first in the uniform and then in the discriminatory case.

$2 \times 4$ : The bargaining problem between airport  $A$  and airlines 1 and 2 to set the *uniform* charge  $\ell_A$  has been described in the main text in (8). Likewise, airport  $B$  and airlines 3 and 4 form a distinct bilateral bargaining unit for the definition of  $\ell_B$ . All parties' outside option are equal to zero. From the FOCs of the two bargaining problems, we get

$$\ell_h = \frac{1}{2} \frac{\beta}{1 + \frac{bm(2-\beta)}{m(3-2b)+4(1+b)}} \quad \text{for } h = A, B. \quad (\text{A-8})$$

The bargaining problem between airport  $A$  and airline  $i$  (with  $i = 1, 2$ ) to set the *discriminatory* charge  $\ell_i$  has been described in the main text in (9). Likewise, airport  $B$  and airline  $j$  (with  $j = 3, 4$ ) form two distinct bilateral bargaining units for the definition of  $\ell_j$ . The airport's outside option is now positive: in case of airport  $A$  when negotiating with, say, airline 1, it is given by the profits obtained by selling the input to airline 2. Since airline 2 is not aware of the breakdown of the negotiation, the quantity offered in the market is equal to  $q_2^{\times 4}(\ell)$ , as in (A-3); the airport's outside option is then  $\bar{\pi}_A^{2 \times 4} = \ell_2 q_2^{\times 4}(\ell)$ . Similarly for all the other negotiations; from the FOCs of the four bargaining problems, we get

$$\ell_i^{2 \times 4} = \frac{1}{2} \frac{\beta}{1 + \frac{m[(1-\beta)(3-2b^2)+b(2-\beta)]m+4b(3-2\beta)+4(1-\beta)+4b^2(2-\beta)}{(m(3-2b)+4(1+b))(4+4b+m)}} \quad \text{for } i = 1, \dots, 4. \quad (\text{A-9})$$

$2 \times 2$ : The bargaining problem between airport  $A$  and airlines 13 and 24 to set the *uniform* charge  $\ell_A$  is as follows

$$\max_{\ell_A} [\pi_A^{2 \times 2}(\ell_A, \ell_B)]^\beta \cdot [\pi_{13}^{2 \times 2}(\ell_A, \ell_B) - \bar{\pi}_{13}^{2 \times 2}]^{1-\beta}. \quad (\text{A-10})$$

The airport's outside options is zero. Instead, the airline's outside option is positive: it is given by the profits obtained by serving route 3 from airport  $B$ . Given the consumers' readjustment, in case of disagreement on

$\ell_A$ , in the second stage of the game, airlines 13 and 24 would be aware of the absence of operating routes from airport  $A$  and solve the problem

$$\max_{q_i} [p_i(0, 0, q_i, q_j) - \ell_i]q_i \text{ for } i, j = 3, 4; i \neq j. \quad (\text{A-11})$$

We denote with  $q_i^{\prime \times 2}(\ell)$  the equilibrium quantities, obtained by solving the system of two FOCs of the above two problems. For good 3, we have (similar expressions hold for the other good):

$$q_3^{\prime \times 2} = \frac{(1+m)(m\ell_3 - 2(2(1+b) + m)\ell_4 + 4(1+b) + m)}{(4b + 4 + 3m)(4 + 4b + m)} \quad (\text{A-12})$$

The airline's outside option is then  $\bar{\pi}_{13}^{2 \times 2} = [p_3(0, 0, q_3^{\prime \times 2}, q_4^{\prime \times 2}) - \ell_3]q_3^{\prime \times 2}$ . Similarly for the other negotiations; from the FOCs of the two bargaining problems, we get

$$\ell_h^{2 \times 2} = \frac{1}{2} \frac{\beta}{1 + \frac{bm(16(1+b^2+2b)(16-10\beta) - 48m(6(1+b)\beta - 10-9b+b^2) - 18m^2(3(3-b^2)\beta - 2(8-b-3b^2)) + 27m^3(1-b)(2-\beta)}{2(16m(4+b(3-b)) + 9m^3(1-b) + 6m^2(7-b(2+3b)) + 32(1+b(2+b))(3m(1-b) + 4(1+b))}} \quad (\text{A-13})$$

for  $h = A, B$ .

The bargaining problem between airport  $A$  and airline 13 to set the *discriminatory* charge  $\ell_1$  is

$$\max_{\ell_1} [\pi_A^{2 \times 2}(\ell_1, \ell_{-1}) - \bar{\pi}_A^{2 \times 2}]^\beta \cdot [\pi_{13}^{2 \times 2}(\ell_1, \ell_{-1}) - \bar{\pi}_{13}^{2 \times 2}]^{1-\beta} \quad (\text{A-14})$$

Likewise, the same airport  $A$  and airline 24 form a distinct bilateral bargaining unit for the definition of  $\ell_2$ ; also, airport  $B$  and airlines 13 and 24 form two distinct bilateral bargaining units for the definition of  $\ell_3$  and  $\ell_4$  respectively.

The airport's outside option is positive: in case of airport  $A$  (when negotiating with airline 13), it is given by the profits obtained by selling the input to airline 24. Since airline 24 is not aware of the breakdown of the negotiation, the quantity offered in the market is equal to  $q_2^{\times 2}(\ell)$ , as in (A-6); the airport's outside option is then  $\bar{\pi}_A^{2 \times 2} = \ell_2 q_2^{\times 2}(\ell)$ . The airline's outside option is also positive and it is given by the profits obtained by offering the good on route 3. Airline 13 is clearly aware of the breakdown of the negotiation on  $\ell_1$ . Therefore, it adjusts its quantity on route 3 taking into account that its rival will keep offering the quantity as if all products were sold in the market. Thus, it solves the problem

$$\max_{q_3} [p_i(0, q_2^{\times 2}, q_3, q_4^{\times 2}) - \ell_3]q_3. \quad (\text{A-15})$$

Let this quantity be denoted by  $q_3^{\prime \prime \times 2}(\ell)$  and be given by

$$q_3^{\prime \prime \times 2}(\ell) = \frac{(1+m)}{(2+m+2b)(3m+4)} \left\{ (m+2) - \frac{8bm^2[2+m(1-b)]\ell_1}{(m+4)(3m(1-b) + 4(1+b))(m(1-b) + 4(1+b))} \right. \\ \left. + \frac{2bm[5m^2(1-b) + 16(1+b+m)]\ell_2 + m[(2+m(1-b))(3m^2(1-b) + 16(1+b+m))]\ell_4}{(m+4)(3m(1-b) + 4(1+b))(m(1-b) + 4(1+b))} \right. \\ \left. - \frac{2[3(1+b^2-2b)m^4 + 28(1-b)m^3 + 4(23-9b^2)m^2 + 128(1+b)m + 64(1+2b+b^2)]\ell_3}{(m+4)(3m(1-b) + 4(1+b))(m(1-b) + 4(1+b))} \right\}. \quad (\text{A-16})$$

The airline outside option is given by  $\bar{\pi}_{13}^{2 \times 2} = [p_3(0, q_2^{\times 2}, q_3^{\prime \prime \times 2}, q_4^{\times 2}) - \ell_3] \cdot q_3^{\prime \prime \times 2}$ . Similarly for the other

negotiations; from the FOCs of the two bargaining problems, we get

$$\ell_i^{2 \times 2} = \frac{1}{2} \frac{\beta}{1 + \frac{m[(3b\beta(1+b)+6(1-b^2-\beta))m^2+(20(1-\beta+2b)-22b\beta(1-b)-28b^2)m+4b(16-10\beta)+16(1-\beta)+24b^2(2-\beta)]}{2(m+4)(3m(1-b)+4(1+b))(m(1-b)+2(1+b))}} \quad \text{for } i = 1, \dots, 4. \quad (\text{A-17})$$

1  $\times$  2: The bargaining problem between airport  $AB$  and airlines 13 and 24 to set the *uniform* charge  $\ell_A$  is as follows

$$\max_{\ell_A} [\pi_{AB}^{1 \times 2}(\ell_A, \ell_B) - \bar{\pi}_{AB}^{1 \times 2}]^\beta \cdot [\pi_{13}^{1 \times 2}(\ell_A, \ell_B) - \bar{\pi}_{13}^{1 \times 2}]^{1-\beta}. \quad (\text{A-18})$$

The airport's outside option is positive and it is given by the profits obtained by serving routes 3 and 4. Since both airlines operating these routes are aware of the breakdown of the negotiation, they solve problem (A-11) and choose quantities as in (A-12). The airport's outside option is thus given by  $\bar{\pi}_{AB}^{1 \times 2} = q_3^{\times 2} \ell_3 + q_4^{\times 2} \ell_4$ . Similarly, given the consumer's readjustment, the airline's outside option is given by  $\bar{\pi}_{13}^{1 \times 2} = [p_3(0, 0, q_3^{\times 2}, q_4^{\times 2}) - \ell_3] q_3^{\times 2}$ . Similarly for the other negotiations; from the FOCs of the two bargaining problems, we get

$$\ell_h^{1 \times 2} = \frac{1}{2} \frac{\beta}{1 + \frac{2bm(1-\beta)(3m+4)(b+1)}{9(1-b)m^3+6(7-3b^2-2b)m^2+16(4-b^2+3b)m+32(1+b^2+2b)}} \quad \text{for } h = A, B. \quad (\text{A-19})$$

The problem between airport  $AB$  and airline 13 to set the *discriminatory* charge  $\ell_1$  is

$$\max_{\ell_1} [\pi_{AB}^{1 \times 2}(\ell_1, \ell_{-1}) - \bar{\pi}_{AB}^{1 \times 2}]^\beta \times [\pi_{13}^{1 \times 2}(\ell_1, \ell_{-1}) - \bar{\pi}_{13}^{1 \times 2}]^{1-\beta} \quad (\text{A-20})$$

The same players also bargain over  $\ell_3$ ; similarly, the same airport  $AB$  and airline 24 form two distinct bilateral bargaining units for the definition of  $\ell_2$  and  $\ell_4$ .

The airport's outside option (when bargaining over  $\ell_1$ ) is positive and it is given by the profits obtained by selling inputs 2 and 4 to airline 24 and input 3 to airline 13. In disagreement, airline 13 is clearly aware of the breakdown of the negotiation but airline 24 is not. The quantities sold by airline 24 are therefore  $q_2^{\times 2}(\ell)$  and  $q_4^{\times 2}(\ell)$ , as in (A-6), while airline 13 solves the problem (A-15), offering quantity  $q_3^{\prime \times 2}$  as in (A-16). The airport's outside option is therefore given by  $\bar{\pi}_{AB}^{1 \times 2} = \ell_2 q_2^{\times 2}(\ell) + \ell_3 q_3^{\prime \times 2}(\ell) + \ell_4 q_4^{\times 2}(\ell)$ .

The airline's outside option (when bargaining over  $\ell_1$ ) is also positive and it is given by the profits obtained by the serving route 3 from airport  $B$ . The quantity sold along this route is to be determined exactly in the same way just above described and therefore the airline's outside option is given by  $\bar{\pi}_{13}^{1 \times 2} = [p_3(0, q_2^{\times 2}, q_3^{\prime \times 2}, q_4^{\times 2}) - \ell_3] q_3^{\prime \times 2}$ . Similarly for the other negotiation; from the FOCs of the four bargaining problems, we get

$$\ell_i^{1 \times 2} = \frac{1}{2} \frac{\beta}{1 + \frac{m(1-\beta)}{m+4}} \quad \text{for } i = 1, \dots, 4. \quad (\text{A-21})$$

*Summary of equilibrium.* Equilibrium landing charges are given in (A-8), (A-13) and (A-19) in case of uniform charges, and in (A-9), (A-17) and (A-21) in case of discriminatory charges. It is also useful to look at these same expressions for specific values of our market parameters,  $b$  and  $m$ . When  $b = 0$  and  $m = 0$  the equilibrium landing charges are identical across the different market structures, as already commented in Section 4.1 in the main text. They are given in (12) for  $m = 0$ ; this expression is also valid when  $b = 0$  for the uniform case. For  $b = 0$ , discriminatory landing fees are given by (13). The expressions for the limiting cases corresponding to  $b = 1$  and  $m \rightarrow \infty$  are instead provided in Table 1.



Table 1. Landing charges under Cournot competition when  $b = 1$  and  $m \rightarrow \infty$

	$b = 1$		$m \rightarrow \infty$	
	<i>Uniform</i>	<i>Discriminatory</i>	<i>Uniform</i>	<i>Discriminatory</i>
$\ell^{2 \times 2}$	$\frac{1}{2} \frac{\beta}{1 + \frac{4m[(36-27\beta)m^2 + 4(54-36\beta)m + 32(8-5\beta)]]}{16(3m^2 + 32 + 24m)}}$	$\frac{1}{2} \frac{\beta}{1 + \frac{m(8-5\beta)}{16}}$	$\frac{1}{2} \frac{\beta}{1 + \frac{b(2-\beta)}{2(1-b)}}$	$\frac{1}{2} \frac{\beta}{1 + \frac{b(2-\beta) + 2(1-\beta)}{2(1-b)}}$
$\ell^{1 \times 2}$	$\frac{1}{2} \frac{\beta}{1 + \frac{m(1-\beta)(3m+4)}{3m^2 + 24m + 32}}$	$\frac{1}{2} \frac{\beta}{1 + \frac{m(1-\beta)}{m+4}}$	$\frac{1}{2} \beta$	$\frac{1}{2} \frac{\beta}{2-\beta}$
$\ell^{2 \times 4}$	$\frac{1}{2} \frac{\beta}{1 + \frac{m(2-\beta)}{m+8}}$	$\frac{1}{2} \frac{\beta}{1 + \frac{m(3-2\beta)}{m+8}}$	$\frac{1}{2} \frac{\beta}{1 + \frac{b(2-\beta)}{3-2b}}$	$\frac{1}{2} \frac{\beta}{1 + \frac{2b(2-\beta) + (6-4b^2)(1-\beta)}{2(3-2b)}}$

Once landing charges are known in each situation, we can derive all the variables we analyse and compare in Propositions 1-5. In particular, the equilibrium quantities at a symmetric equilibrium, derived from (A-3) and (A-6), simplify respectively to

$$q_i^{\times 2}(\ell) = \frac{(1+m)(1-\ell)}{(3m+4)(1+b)},$$

$$q_i^{\times 4}(\ell) = \frac{(1+m)(1-\ell)}{2bm + 3m + 4 + 4b}.$$

The price of each good is then obtained from (2), and it is simply

$$p_i = 1 - 2(1+b)q_i.$$

The consumer surplus of the representative consumer is obtained subtracting the total expenditure from (1), obtaining

$$CS = 4(1+b)q_i^2.$$

The profits for each agent are also immediately derived.