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An Analysis of Airport Pricing and Regulation in the Presence of Competition Between Full Service Airlines and Low Cost Carriers

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Abstract

Despite the increasing trend of airport privatisation and deregulation in recent years, few studies have analysed how the pricing behaviour of unregulated airports affects downstream airline competition, especially the competition between airlines offering differentiated services such as the case of full service airlines (FSA) vis-à-vis low cost carriers (LCC). In this paper, a duopoly model is used to analyse and capture the differential competitive effects of changing airport user charges on FSAs and LCCs. Numerical simulations and sensitivity tests are performed in order to measure such differential effects. The analytical and numerical results found the existence of asymmetric effects of an airport's monopoly pricing on LCC and FSA. It is important for governments to take account of asymmetric effects when considering the form and extent of regulation or deregulation.

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1.0 Introduction

The competitive effects of input price increases form an important research and policy topic for two reasons. First, a lack of upstream competition may influence downstream competitiveness and reduce welfare. Second, markets with volatile input prices may be prone to effects on downstream competitiveness as well. Both features are clearly present in aviation, where airports with market power provide indispensable inputs to airlines.

This subject is primarily important for the regulation of privatised airports. Starting with the privatisation of the three airports in London area (Heathrow, Gatwick, and Stansted) and four other airports in the UK to form BAA plc. in 1987, many airports around the world have already been or are in the process of being privatised. The majority stakes in Copenhagen Kastrup International Airport, Vienna International Airport, and Rome's Leonardo Da Vinci Airport have been sold to private owners. Many other European airports are in the process of being privatised. Auckland International Airport and Wellington International Airport in New Zealand, and a large number of major Australian airports, have been privatised as well. South Africa, Argentina, Mexico, and many Asian countries including Japan are also considering privatising their airports.[1] Canada has been reviewing the regulatory oversight issues on its local airport authorities, which were set up as not-for-profit corporations to manage major airports.

Since the late 1990s economists have been arguing about whether privatised airports need to be regulated. Studies of country-specific options and experiences on this issue include Forsyth (1997, 2002a, b), Beesley (1999), Starkie and Yarrow (2000), and Starkie (2001). In particular, Beesley (1999) argues that the price-cap regulation is inappropriate, particularly in the case of London's Heathrow. Starkie (2001) further concludes that *ex-ante* regulation for airports might be unnecessary because the airports are less likely to abuse their monopoly power due to the existence of complementarity between the demand for aviation services and the demand for concessions and other commercial services.[2] The latter are usually associated with larger margins because of duty/tax free sales.

Indeed, some countries have moved towards a situation in which there is no formal price regulation but only monitoring of privatised airports (Forsyth, 2002b). For example, New Zealand and Australia do not

[1] See Hooper (2002) for the list of Asian airports that are being considered for privatisation.

[2] Besides *ex-ante* regulation (ROR, price-cap), there is also *ex-post* regulation (conduct regulation). It is important to point out that those economists who argue for deregulation usually have the former in mind and are not proposing that conduct regulation be abolished also.

formally impose any price regulation on their privatised airports. Instead, since 1988, Auckland, Christchurch, and Wellington airports have been required to disclose contractual terms, financial reports, and some performance measures. In Australia, primarily based on the recommendation of the Productivity Commission (2001),[3] the government ended the price-cap regulation on all privatised airports for a period of five years from 1 July 2002.[4] Towards the end of the five-year test period an independent review will be conducted in order to decide whether or not some sort of price regulation needs to be re-established.

Some evidence suggests that the airports attempted to raise prices after deregulation, and interested parties have been concerned that airports may abuse their market power. Three regulatory reviews were conducted in New Zealand after the 1988 deregulation, the last of which started in May 1998 and took five years to finish. In Australia, Virgin Blue applied to the Australian Competition Tribunal to declare airside services at the Sydney Airport as commercial services to be treated according to the Trade Practices Act of Australia (TPA). The declaration of the airside services at the Sydney Airport under the TPA would have forced the Sydney Airport's management to negotiate with the airlines before setting new fees or changing existing levels of airside service fees, including aircraft landing charges. If there is a major disagreement between the airport and the airlines, then the matter is referred to a binding arbitration by the Australian Competition and Consumer Commission (ACCC). Virgin Blue, a major LCC in Australia, believes that Sydney Airport under the current system has the ability and incentive to increase airside service charges substantially, and thus harm Virgin Blue's ability to compete. Interestingly, Virgin Blue's major competitor, Qantas Airlines, supported the Declaration Application.

The subject of the research treated in this paper has been motivated by our involvement in the Virgin Blue *vs.* Sydney Airport case before the Australian Competition Tribunal. This paper reports some analytical results obtained during the investigation for the case. In particular, we analyse how an increase in airport charges would affect the downstream airline competition, especially when competing airlines offer differentiated products (services) in the market place such as the case of competition between low cost carriers and full service airlines. A duopoly model with

[3] Unlike the Productivity Commission, however, the Australian Competition and Consumer Commission (ACCC) opposed the removal of price-cap regulation.

[4] At the same time, the Parliamentary Secretary to the Treasurer directed the Australian Competition and Consumer Commission (ACCC) to undertake formal monitoring of prices, costs, and profits (Price Monitoring) related to the supply of aeronautical services and related services at seven major airports: Adelaide, Brisbane, Canberra, Darwin, Melbourne, Perth and Sydney airports.

differentiated products is used to obtain analytical results. Due to strict confidentiality restrictions on the rich data to which we had access, however, we are not able to report empirical results obtained from using real market data. Instead, a numerical simulation and sensitivity tests on key parameters of our model are used to validate our analytical results on the differential effects of an identical increase in airside service charges on FSAs and LCCs.

Although we focus our analysis on the air transport industry, our approach to analysis is likely to have a wider application to other industries and markets where a monopolist provides an essential input to competing firms in downstream markets. Other network-oriented industries such as railroads, seaports, electric power industries, and telecom local loop have limited competition in upstream markets due to the natural monopoly nature of these networks. The third party access pricing issue has been an important research topic in some of such network sectors, notably in telecommunication and energy networks. Third party access to the network is an important condition for effective competition in network sectors.[5] Third party access refers to both the possibility of access and the conditions under which the access can take place. One important condition is the price under which access is granted, that is, the access fee.

The remainder of this paper is organised as follows. Section 2 discusses the theoretical derivation of the impact of an identical increase in input prices (for example, an airport's airside service fees) on competition in the downstream airline markets. A numerical simulation and results are presented in Section 3. The final section discusses the results and concludes.

2.0 Effects of Increase in Airport Charges on Competition in Downstream Airline Markets

As airports provide essential inputs to airlines, it directly follows that when the airport charge is increased above the socially optimal level (competitive level), air travel volume will be reduced below the socially optimal level, leading to a welfare loss. This issue has been extensively studied in the literature of double marginalisation and natural monopoly regulation. However, so far the impact of airport charges on downstream airline competition has received little attention. Even less attention has been given to the impacts of changing airport charges on the competition between Full Service Airlines (FSAs) and Low Cost Carriers (LCCs).

[5] See, for instance, Laffont *et al.* (1998), Lewis and Sappington (1999), and Granderson (2000).

This problem is worth scrutiny since LCCs' activities have been more sensitive to airport charges. Many LCCs around the world actually started their business by using secondary airports, taking advantage of their lower airport charges and congestion. For example, Ryanair could not have achieved such a successful service on the Dublin–London route if they had had to use Heathrow airport. Also, it is well known that Southwest typically starts its operations at secondary airports in the US. European LCCs, especially Ryanair, drive a hard bargain with airports and local business interests in order to extract the best charges and service conditions. Some LCCs are apparently successful in gaining a subsidy from the airport for an initial period of their service initiation. The agreement between Brussel's Charleroi Airport and Ryanair was investigated by the European Commission as the commercial assistance to Ryanair by the airport was regarded as constituting an illegal state subsidy (Piling, 2003).[6] Ryanair paid, on average, \$1 or less per passenger to eight provincial UK airports during the 1998–2000 period, while the average aeronautical revenue at major airports in Europe was above \$8 per passenger (Barrett, 2004). The LCCs' high sensitivity to airport charges is also evidenced by the fact that some LCCs choose to abandon an airport if they do not succeed in negotiating for a deep discount on airport charges, especially when an airport seeks to recover investments made during its 'promotional' periods. For example, Dublin, London Luton, and Manchester have experienced a reduction in LCC services after revising low airport charges they offered initially (see Francis, Fidato, and Humphreys, 2003; and Barrett, 2000). All this suggests that LCCs are more sensitive to the terms of airport access than FSAs. Meanwhile, LCCs have been credited as a major contributor to airline competition and air fare reduction, as documented, for example, in Dresner, Lin, and Windle (1996), Windle and Dresner (1999), Lin, Dresner, and Windle (2001), and Hofer, Dresner, and Windle, (2004). In particular, Morrison (2001) estimated that in 1998, the savings due to actual, adjacent, and potential competition from Southwest were \$12.9 billion. These savings amount to 20 per cent of the US airline industry's 1998 domestic scheduled passenger revenue, and slightly more than half the fare reductions attributed to US airline deregulation. Understanding the possible differential impacts of airport charge on LCCs and FSAs is, therefore, of great importance to airport regulators and airline competition policy makers. Below, we begin our analysis by constructing a duopoly model between an LCC and an FSA.

[6]In February 2004, the EC declared that certain elements of such support violated European Union state aid rules. Ryanair was asked to repay EUR 4 million to the airport, but the airline reserved the right to appeal. (*Aviation Daily*, 1 November 2004, p. 6).

2.1 A duopoly competition model with differentiated products

Most previous studies have analysed the effect of LCC entry and competition in airline markets without explicitly treating product differentiation between FSA and LCC. The implicit assumption that the competitors produce a homogeneous product is embedded in many such models and also in the reduced-form price equations often estimated by researchers. However, the assumption of a homogeneous product is not realistic for modelling the competition between FSA and LCC. Both FSA and LCC offer multiple products in the market. FSAs typically offer a combination of first-class and business-class, full fare economy, shallow discount, and some deep discount services. LCCs are well known for selling cheap deep discount tickets over point-to-point markets. Most LCCs do not offer on-line/interline connections or baggage transfer. Although LCCs also offer increasingly flexible services comparable to full fare economy and shallow discount tickets being sold by FSAs, overall FSAs offer a superior product compared to LCCs but at higher costs. Previous studies such as Windle and Dresner (1999) confirm that LCCs in general target more price-sensitive travellers with inferior services. In addition, LCCs and FSAs may behave differently in market competition, as evidenced by their different strategies shown by many previous pricing studies. Therefore explicitly considering product differentiation and firm conduct are crucial for the evaluation of any change in external conditions such as changes in input prices, taxes, security charges, and so on.

To analyse the competition between an FSA and an LCC taking account of the product differentiation formally, we constructed a differentiated duopoly model similar to those used by Dixit (1979) and Singh and Vives (1984). Throughout this section, we designate the FSA as firm 1 and the LCC as firm 2. These two firms face the following respective inverse demand functions over each city pair market:

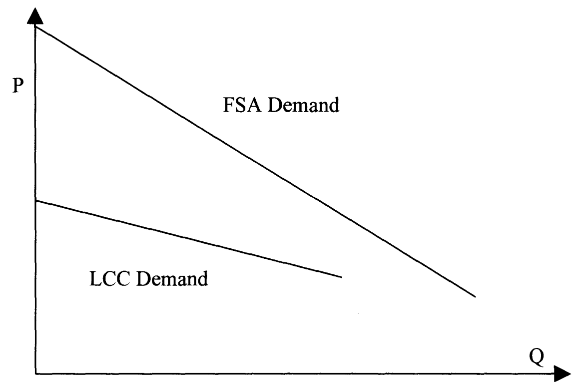
$$\begin{cases} p_1 = a_1 - b_1 q_1 - k q_2 \\ p_2 = a_2 - k q_1 - b_2 q_2 \end{cases}, \tag{1}$$

where p_i and q_i are the prices and quantity for airline i, respectively, while k measures the degrees of substitutability between the two airlines' services. The demand functions in (1) correspond to a representative consumer maximising a quadratic and strictly concave utility function

$$U(q_1, q_2) = a_1 q_1 + a_2 q_2 - \tfrac{1}{2}(b_1 q_1^2 + 2k q_1 q_2 + b_2 q_2^2) + q_0,$$

where q_0 represents the numeraire good (money). The concavity condition implies $b_1 b_2 - k^2 > 0$.

Figure 1
Stylised Demand System



The system of demand functions in (1) can be rewritten as:

$$\begin{cases} q_1 = \dfrac{1}{b_1 b_2 - k^2}[(a_1 b_2 - a_2 k) - b_2 p_1 + k p_2] \\ q_2 = \dfrac{1}{b_1 b_2 - k^2}[(a_2 b_1 - a_1 k) + k p_1 - b_1 p_2] \end{cases}. \qquad (2)$$

The condition of positive output quantities for both firms implies:

$$(a_1 b_2 - a_2 k) > 0 \quad \text{and} \quad (a_2 b_1 - a_1 k) > 0. \qquad (3)$$

The demand functions can be depicted as in Figure 1, based on our empirical knowledge of FSA and LCC markets. Since LCCs focus on price-sensitive customers, they face more price-elastic demand. Utilising the fact that, in general, a change in a firm's price impacts more on the quantity of its own product than on the quantity of the substitutes (competitor's output), the following additional constraints can be imposed:

$$\begin{cases} a_1 > a_2 > c_1 \\ b_1 > b_2 > k > 0 \end{cases}. \qquad (4)$$

Where c_i are firms' constant marginal costs. We restrict to the case where two firms produce substitutes to compete, which implies $k > 0$ and $a_2 > c_1$ used in (4).[7] Although mathematically, our duopoly model does not need condition $c_1 > c_2$, this condition is likely to hold in airline markets.

[7]If $k = 0$, then the two firms offer totally independent products (no substitutability). As k approaches 1, two firms offer increasingly homogeneous products.

With these demand functions, the two firms maximise their profits $\pi_i = (p_i - c_i)q_i$. Assuming that both firms maximise profits by setting output quantities, then the First-Order Condition (FOC) for firm i may be written as:

$$\frac{\partial \pi_i}{\partial q_i} = -\left(b_i + k\frac{\partial q_j}{\partial q_i}\right)q_i + a_i - b_i q_i - kq_j - c_i = 0, \tag{5}$$

where we can denote firm is conduct parameter as

$$v_i = \frac{\partial q_j}{\partial q_i}.$$

These conduct parameters measure how aggressively firms compete. The larger the negative conduct parameter, the more aggressive is the firm's competition strategy.[8] Firm 1 and 2s FOCs define their respective reaction functions, which constitute the following system of equations:

$$\begin{cases} a_1 - (2b_1 + kv_1)q_1 - kq_2 - c_1 = 0 \\ a_2 - kq_1 - (2b_2 + kv_2)q_2 - c_2 = 0 \end{cases}. \tag{6}$$

When the two firms do not collude in the market, we have $-1 \leqslant v_i \leqslant 0$, which implies:

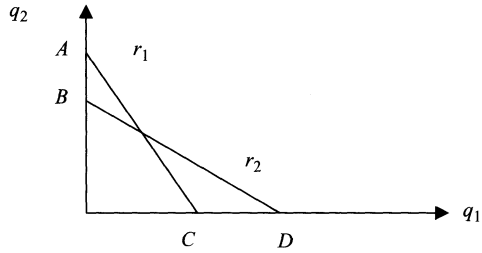
$$\begin{cases} m = (2b_1 + kv_1) > b_1 > k > 0 \\ n = (2b_2 + kv_2) > b_2 > k > 0 \end{cases}. \tag{7}$$

Note that our earlier restriction that $b_1 > b_2$ implies that $m > n$ for all $v_1 \geqslant v_2$. Solving the system of First-Order Conditions leads to firms' equilibrium outputs given each firm's conduct parameter:

$$\begin{cases} q_1 = \dfrac{n(a_1 - c_1) - k(a_2 - c_2)}{mn - k^2} \\ q_2 = \dfrac{m(a_2 - c_2) - k(a_1 - c_1)}{mn - k^2} \end{cases}. \tag{8}$$

[8]In particular, a zero conduct parameter corresponds to Cournot competition, while the value of -1 corresponds to *Bertrand* competition. When firms collude such that one airline's output reduction is accompanied by its competitor's output reduction, both firms' conduct parameters will be positive. We have not analysed the case of collusion between the duopoly airlines in our model, that is, the case of positive conduct parameters for firms 1 and 2, because none of the past empirical studies have found collusive behaviour between an FSA and an LCC in a deregulated air transport market.

Figure 2
Two Firms' Reaction Functions Intersect



That is, each firm's output depends on the degree of product differentiation (as measured by k),[9] firms' costs and conduct. Since $(mn - k^2) \geqslant [b_1 + (b_1 - k)][b_2 + (b_2 - k)] - k^2 > 0$, positive output implies that:

$$\begin{cases} n(a_1 - c_1) - k(a_2 - c_2) > 0 \\ m(a_2 - c_2) - k(a_1 - c_1) > 0 \end{cases}. \tag{9}$$

Restrictions in equation (9) ensure that two firms' reaction functions intersect each other so that a unique Nash Equilibrium exists. This is depicted in the stylised Figure 2. In Figure 2, r_1 and r_2 are firm 1 and 2's reaction functions respectively, and

$$A = \frac{a_1 - c_1}{k},\ B = \frac{a_2 - c_2}{n},\ C = \frac{a_1 - c_1}{m},\ D = \frac{a_2 - c_2}{k},$$

are the points where these reaction functions intersect with each firm's output axis.

2.2 Analytical results on firms' outputs

As in the previous section, let us look at the effect of an identical increase in input prices (that is, $dc_1 = dc_2 = dc$) on both firms' outputs. By applying such an input price increase to the system of equations in (8), we obtain:

$$\begin{cases} dq_1 = \left(\dfrac{\partial q_1}{\partial c_1} + \dfrac{\partial q_1}{\partial c_2}\right) dc = -\dfrac{n - k}{mn - k^2} dc \\ dq_2 = \left(\dfrac{\partial q_2}{\partial c_1} + \dfrac{\partial q_2}{\partial c_2}\right) dc = -\dfrac{m - k}{mn - k^2} dc \end{cases}. \tag{10}$$

[9]More precisely, the degree of product differentiation depends on the relative values of k, b_1 and b_2 in equation (1). In fact, k^2/b_1b_2 may be regarded as a more appropriate measure of product differentiation.

Note that it can be shown that $\partial^2 q_i/\partial c \partial v_i > 0$, implying that a firm's rate of output reduction caused by an identical input price increase[10] (dq_i/dc) will accelerate as its conduct parameter v_i becomes larger in negative value, meaning that the firm becomes a more aggressive player.

It can be seen that when two firms engage in equally aggressive competition ($v_1 = v_2 = v$), $k < (n = 2b_2 + kv) < (m = 2b_1 + kv)$, which implies that $|dq_1| < |dq_2|$. This result means that when duopoly firms adopt a similar strategy in setting quantity (same conduct parameter), then the firm facing less price-elastic demand will reduce its output less than its competitor (the firm facing higher price-elastic demand). In our case, when an FSA and an LCC engage in equally aggressive competition, the equilibrium passenger volume of the LCC will be reduced more than that of the FSA when an identical increase in input prices occurs to both firms. It is important to note that this finding is strengthened if we assume that the LCC competes more aggressively than the FSA, implying $0 \geqslant v_1 > v_2 \geqslant -1$.

Then, what can be said about the relative reduction in outputs of the two firms from equations (10)? To answer this question, we express equation (10) in relative terms below:

$$\begin{cases} \dfrac{dq_1}{q_1} = -\dfrac{n-k}{n(a_1 - c_1) - k(a_2 - c_2)} dc \\ \dfrac{dq_2}{q_2} = -\dfrac{m-k}{m(a_2 - c_2) - k(a_1 - c_1)} dc \end{cases} . \tag{11}$$

It can easily be shown that $(a_1 - c_1) > (a_2 - c_2)$ is a sufficient condition to ensure that the LCC's output is affected proportionally more than the FSA's output.

As c_i denotes the constant marginal costs of carrying one additional passenger, whereas a_i is the highest evaluation (for the first unit of consumption) for the service, we should have $a_i \gg c_i$, which in general leads to $(a_1 - a_2) > (c_1 - c_2)$ when two firms' services are fairly differentiated. However, if firm 1 and firm 2 offer almost homogeneous product (implying $a_1 \approx a_2$), then one can see that the firm with the higher marginal cost will lose proportionally more output.

2.3 Analytical results on firms' prices

Let us now turn our attention to the effects of the identical input price increase on air fares. With each firm's outputs at the equilibrium, the

[10] Let $dq_i/dc = (\partial q_i/dc_1 + \partial q_i/\partial c_2)$ be firm i's rate of output reduction caused by an identical input price increase given two firms' conduct parameters.

prices of each product can be obtained by substituting the equilibrium outputs in equation (8) into the respective demand functions:

$$\begin{cases} p_1 = \dfrac{(a_1 n - a_2 k)(m - b_1)}{mn - k^2} + \dfrac{b_1 n - k^2}{mn - k^2} c_1 + \dfrac{k(m - b_1)}{mn - k^2} c_2 \\ p_2 = \dfrac{(a_2 m - a_1 k)(n - b_2)}{mn - k^2} + \dfrac{k(n - b_2)}{mn - k^2} c_1 + \dfrac{mb_2 - k^2}{mn - k^2} c_2 \end{cases}. \tag{12}$$

Each firm's equilibrium price increase caused by the input price increase dc can be written as:

$$\begin{cases} dp_1 = \left(\dfrac{\partial p_1}{\partial c_1} + \dfrac{\partial p_1}{\partial c_2}\right) dc = \dfrac{b_1 n - k^2 + mk - kb_1}{mn - k^2} = \left(1 - \dfrac{(m - b_1)(n - k)}{mn - k^2}\right) dc < dc \\ dp_2 = \left(\dfrac{\partial p_2}{\partial c_1} + \dfrac{\partial p_2}{\partial c_2}\right) dc = \dfrac{kn - k^2 + mb_2 - kb_2}{mn - k^2} = \left(1 - \dfrac{(m - k)(n - b_2)}{mn - k^2}\right) dc < dc \end{cases}. \tag{13}$$

This means that when the two firms' input prices increase by an identical amount, neither firm will fully pass the cost increase to passengers. This result is consistent with the fact that both firms face negatively-sloped demand curves as depicted in Figure 1.

2.4 Analytical results on firms' profits

Thus far, as we have shown, an identical increase in input prices is likely to harm an LCC more than it will harm an FSA. Similarly, it can be shown that in general, the FSA's profit will be proportionally less harmed by an identical increase in input prices. To show this, the two firms' profit functions can be written as:

$$\begin{cases} \pi_1 = (p_1 - c_1) q_1 = \dfrac{m - b_1}{(mn - k^2)^2} [n(a_1 - c_1) - k(a_2 - c_2)]^2 \\ \pi_2 = (p_2 - c_2) q_2 = \dfrac{n - b_2}{(mn - k^2)^2} [m(a_2 - c_2) - k(a_1 - c_1)]^2 \end{cases}. \tag{14}$$

Therefore, an identical increase in input prices dc will change the firms' profit by:

$$\begin{cases} d\pi_1 = \left(\dfrac{\partial \pi_1}{\partial c_1} + \dfrac{\partial \pi_1}{\partial c_2}\right) dc = -2 \dfrac{m - b_1}{(mn - k^2)^2} [n(a_1 - c_1) - k(a_2 - c_2)](n - k) dc \\ d\pi_2 = \left(\dfrac{\partial \pi_2}{\partial c_1} + \dfrac{\partial \pi_2}{\partial c_2}\right) dc = -2 \dfrac{n - b_2}{(mn - k^2)^2} [m(a_2 - c_2) - k(a_1 - c_1)](m - k) dc \end{cases}. \tag{15}$$

As before, $(a_1 - c_1) > (a_2 - c_2)$ is a sufficient condition to ensure that the full service airline is proportionally less affected. However, as we have shown, the firms' positive outputs imply the following:

$$\begin{cases} n(a_1 - c_1) - k(a_2 - c_2) > 0 \\ m(a_2 - c_2) - k(a_1 - c_1) > 0 \end{cases}.$$

From this, it immediately follows that $d\pi_1 < 0$ and $d\pi_2 < 0$ whenever $dc > 0$. That is, although the FSA will be proportionally less harmed by such an identical input price increase, its profitability will always be reduced. As such, unless the FSA is sure that such an identical input price increase will drive the LCC out of the entire market, it is not in the FSA's interest to adopt the strategy of 'Raising Rival's Cost', at least not in the form of encouraging an airport to raise the user charges it imposed on airlines (in such a way as to increase marginal passenger costs of both airlines by an identical amount). This may explain why Qantas joined Virgin Blue's declaration application. Although a price increase by Sydney airport would harm Virgin Blue more than it would Qantas (thus creating some competitive advantage for Qantas), it is unlikely that Virgin Blue would be forced to abandon all markets to/from Sydney airport.

Although these results are derived from the assumption that firms have constant marginal costs, our general conclusions are likely to hold because fixed costs at route level are likely to be small both for FSAs and LCCs. Note that our results derived from the route-level analysis may not hold at company-wide or even at airport-level decisions.

2.5 Summary of analytical results

From the duopoly model of FSA *vs*. LCC competition with product differentiation, we find that:

- An identical increase in input prices will harm an LCC more than an FSA as the former suffers proportionally more reduction of its output and profit than the latter.
- Neither the FSA nor the LCC can fully pass on such an external input price increase to consumers. Therefore, both firms suffer loss in their profits.
- If the LCC competes at least as aggressively as the FSA, an identical increase in input prices would lead the LCC to reduce its output quantity by a larger amount than the FSA, implying more serious harm to the LCC.

That is, an identical input price increase will proportionally harm the LCC more.[11] Although such an identical input price increase, such as a per-passenger airport service charge or a government imposed per-passenger security charge, is likely to constitute only a small proportion of the total unit costs, its impacts may be non-trivial. As most airlines are currently operating at barely breakeven level, such an input price increase would further reduce these airlines' profitability, possibly forcing them to reduce service levels or cease operations on some routes altogether.

We have shown that, in theory, although an FSA's outputs and profits will suffer less by an external factor leading to an identical increase in per-passenger marginal cost (input price) to both FSAs and LCCs (and thus creating a competitive advantage over an LCC), an FSA will not adopt the 'Raising Rival's Cost' strategy by encouraging airports to raise airside user charges, unless it is sure that such a cost increase will drive the LCC totally out of the market.

3.0 Numerical Simulation and Sensitivity Test

Many cases involving competition between an LCC and an FSA pose special challenges for empirical analysis because of the frequent disequilibrium nature of market data. For example, an LCC enters the market with significantly lower prices than FSAs. In this situation, FSAs often respond to the challenge by allocating more seats to their deep discount fare category and thereby lowering their average price. At the same time, FSAs lose their market shares (and often traffic volumes) as they reduce their average air fares progressively, while the LCC keeps its initial low prices at a similar level for some time. The market data on Qantas and Virgin Blue revealed such a disequilibrium in the market during our sample period. In other words, Qantas was losing passenger shares while it reduced air fares, but Virgin Blue was gaining passenger shares although it maintained similar (low) prices introduced at the time of entry. Because it is impossible to estimate a sensible econometric model from such a short-term data set we had to rely on numerical simulations in order to measure

[11] In practice, many LCCs use secondary airports, which typically charge lower prices. However, consumers may value such services less (smaller a_2, and possibly smaller b_2) and/or treat them as an inferior substitutes to FSA services (smaller k). Although our general conclusions are likely to hold even in such cases, the extent of differential impact on an LCC *vs.* an FSA in such cases is really an empirical question that depends on demand and cost parameters of the LCC and the FSA as well as the existing pricing structures of the primary and the secondary airports.

the differential effects of increasing airside service charges on Qantas and Virgin Blue, as well as validating our analytical results.[12]

The parameter values used in this section mimic a realistic air transport market, but they do not represent any particular city pair market studied because of the confidential nature of the route-specific data received from Qantas and Virgin Blue. All parameters used in our model met the assumptions and constraints described in Section 2, and reflect the best estimate based on our understanding of air transport markets, in particular in the markets where an FSA and an LCC compete.

3.1 Assumptions

We start with the likely values for some of the parameters so that the differentiated duopoly model described in Section 2 can be calibrated. This base case provides some numerical results that enable one to appreciate the differential impacts of an identical increase in input prices on an LCC and an FSA. Sensitivity tests are used so that we are sure these results hold for any reasonable ranges of the parameter values. The assumptions we made for the base case are:

- Conduct Parameters: We limit our analysis to non-collusive games, thus limiting ourselves to non-positive values for v_1 and v_2. The base values we choose are $v_1 = v_2 = -0.5$.
- b_1, b_2 and k: constraint (4) requires $b_1 > b_2 > k$. Parameter k measures the difference in the services provided by the two firms. Let $k = t \cdot b_1$ $(0 < t < 1)$, then if $t = 0$ the two firms' services are not substitutes at all, while $t = 1$ indicates that the FSA and the LCC produce perfectly homogeneous services. Our base case assumes $t = 0.7$. We also assume $b_2 = (b_1 + k)/2$ so that constraint (4) is always satisfied.
- Market price elasticity for air travel: -1.4.
- Each firm's equilibrium price: we assume FSA's price is $p_1 = \$100$ while the LCC's price is assumed to be 25 per cent lower, that is, $p_2 = \$75$.
- Each firm's equilibrium output: we assume that at equilibrium the FSA has a 60 per cent market share carrying 60,000 passengers each month.

[12] Even though FSAs and LCCs have been competing in US airline markets for a long time few empirical industrial organisation studies have been carried out on the differentiated product competition between LCCs and FSAs, probably because of the fact that detailed airline and route specific cost data are often not accessible by researchers.

Table 1
Derived Parameter Values for Base Case

Parameters	b_2	c_1	c_2	a_1	a_2	e_{11}	e_{22}
Value	0.00068	68.7	58.9	170.7	136.1	−4.9	−6.48
Parameters	k	m	n	π_1	π_2	e_{12}	e_{21}
Value	0.00056	0.00133	0.00108	1,880,357	642,857	3.02	6.05

Table 2
Changes in Market Equilibrium Caused by Different Airport Charge Increase

Airport Charge Increase	*$1*	*$2*	*$3*	*$5*	*$6*
$\%\Delta q_1$	−0.8%	−1.6%	−2.3%	−3.9%	−4.7%
$\%\Delta q_2$	−1.7%	−5.1%	−6.0%	−8.5%	−10.2%
$\%\Delta p_1$	0.8%	1.5%	2.3%	3.8%	4.5%
$\%\Delta p_2$	1.0%	1.9%	2.9%	4.8%	5.8%
$\%\Delta \pi_1$	−1.5%	−3.1%	−4.6%	−7.6%	−9.1%
$\%\Delta \pi_2$	−3.4%	−6.7%	−9.9%	−16.3%	−19.4%
$\%\Delta P$	0.9%	1.8%	2.7%	4.5%	5.4%
$\%\Delta Q$	−1.1%	−2.3%	−3.4%	−5.7%	−6.9%

3.2 Base case model results

With the above assumptions, other parameters of the model can be derived as follows:

- Market output $Q = q_1 + q_2 = 100,000$ passengers per month.
- Market price $P = (p_1 q_1 + p_2 q_2)/Q = \$90$.
- b_1: when both firms experience an identical price change $dp_1 = dp_2 = dp$, or an equivalent market price change of $dP = dp$, from the demand equation in (1) the total change in market output can be obtained as $dQ = dq_1 + dq_2 = (2k - b_1 - b_2)/(b_1 b_2 - k^2)dp$. As market elasticity $e = dQ/dP \cdot P/Q$ is known, one can derive $b_1 = -3P/e(2t+1)Q = 0.0008$.
- Table 1 reports the base case values of other parameters that we derived.

Note e_{ii} are firm's own price elasticity, while e_{ij} measures firm i's cross elasticity with respect to firm j's price. They have the correct signs and are within a reasonable range.[13] With all the parameter values, it is straightforward to calculate the impact of an identical increase in input prices. The results are summarised in Table 2.

[13] Few studies have empirically estimated firm specific elasticity for airlines. Oum, Zhang, and Zhang (1993) reported that UA and AA's firm specific elasticities are significantly above market elasticity. In many leisure routes the two firms' firm specific elasticity were as high as around −10.

As expected, Table 2 shows that the reductions in the LCC's outputs and profits are larger than those of the FSA for all levels of increases in airport charges simulated, implying proportionally larger negative effects on the LCC. Although the market price elasticity in the base case is only assumed to be -1.4, the corresponding LCC's firm-specific price elasticity is much larger in absolute value ($e_{22} = -6.48$). Together with its low cost, it is not surprising that even a moderate increase in an airport charge will reduce its profitability significantly. One should note that the LCC's price for the base case was assumed to be \$75. The reduction in airline's profitability will be more moderate for longer-distance (more costly) routes. In the base case, the FSA loses fewer passengers and passes on a greater proportion of the cost (airport charge) increase to passengers. These findings are, of course, entirely consist with our analytical results.

There are two major assumptions in our simulation: the value of firms' conduct parameters, and parameter $t(k)$ that measures the extent of product differentiation between the LCC and the FSA. Few studies have estimated differential conduct parameters empirically using airline data on LCCs and FSAs. Haugh and Hazledine (1999) and Hazledine, Green, and Haugh (2001) are exceptions. Although their studies found that the LCC does behave more aggressively in the trans-Tasman market (as evidenced by the LCC's lower conduct parameter), they obtained this result based on calibration of their models instead of estimating the model parameters empirically from real data. Although their finding supports our view that LCCs use more aggressive strategies (equivalent to a lower value of conduct parameter) than FSAs, it is necessary to conduct a sensitivity test on a plausible range of conduct parameter values in order to study the sensitivity of our results.

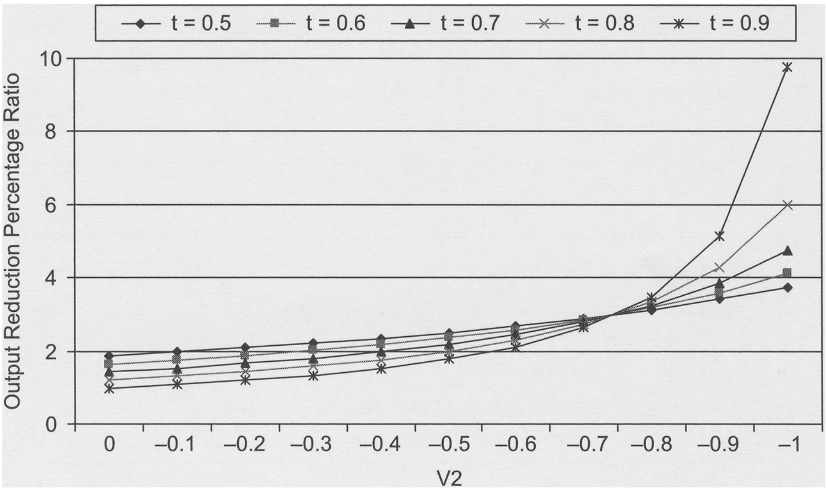
First, we set firm 1's conduct parameter to -0.5 ($v_1 = -0.5$) and simulate market equilibrium as we change firm 2's conduct parameter v_2 from 0 to -1, with an interval of 0.1. We calculate all the model parameters corresponding to each pair of conduct parameters, and then simulate the effects of increasing marginal costs for both carriers by \$1. Such tests are repeated for the t values of 0.5, 0.6, 0.7, 0.8, and 0.9, so that k takes values in the range of $[0.5b_1, 0.9b_1]$, respectively.

We plot curves for ratio of the two firms' passenger reduction percentage

$$y = \left(\frac{dq_2}{q_2}\right) \Big/ \left(\frac{dq_1}{q_1}\right) = \frac{\%\Delta q_2}{\%\Delta q_1}$$

in Figure 3. All the curves showing the ratio of percentages of the LCC–FSA output reduction are upward sloping, implying that the more aggressively the LCC behaves, the higher will be its relative output reduction from

Figure 3
Output Reduction Ratio ($dc = \$1$)*
(*The ratio is defined as $y = \%\Delta q_2/\%\Delta q_1$, firm 2's conduct parameter v_2 changes while v_1 fixed as -0.5)

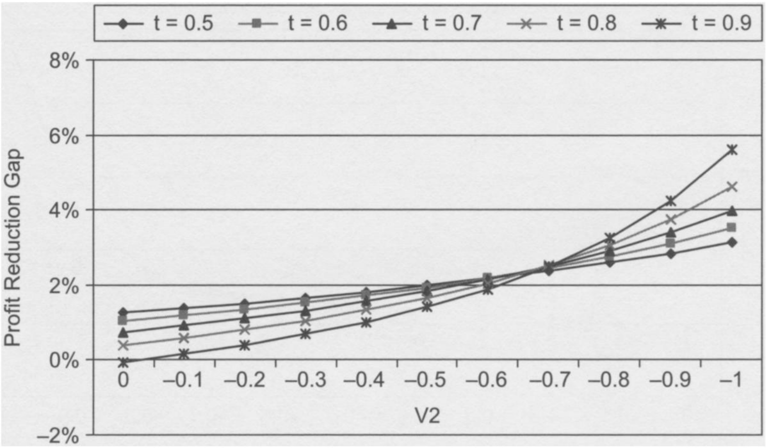


an identical increase in input prices. Figure 3 shows also that the curve for a higher value of t is steeper than the ones for lower t values at the higher absolute values of the conduct parameter. This indicates that competition becomes more important as products become closer substitutes. Let us consider the extreme case (not in the figure) where the goods are no longer substitutes (namely, $t = 0$). In this case, the output reduction ratio curve in the figure would become a horizontal line, implying the absence of any effect of changing conduct parameters for the LCC (v_2). This makes sense, since $t = 0$ implies that both firms are monopolists in their respective markets.

The corresponding differential changes in two firms' profits, $|\%\Delta\pi_2| - |\%\Delta\pi_1|$ are plotted as in Figure 4. Note that since $\Delta\pi_i$ is negative for both firms, a positive differential number indicates that the LCC suffers more profit reduction proportionally.

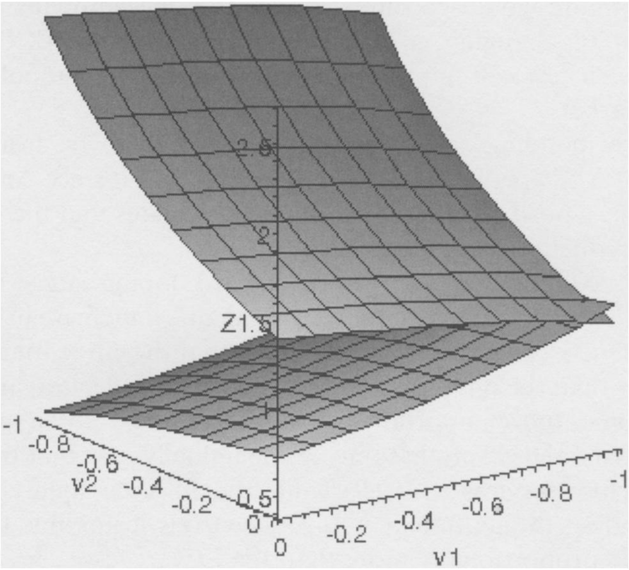
The profit reduction ratio curves are upward sloping, suggesting that the LCC's profit will be reduced more from an identical increase in input prices as it behaves increasingly aggressively. Note that the curve for a high value of t is steeper than the ones for lower t values. This reflects again that competition becomes more important as products become closer substitutes. It can be seen from the graph that only in the unlikely case that the two firms offer fairly close services ($t = 0.9$) while the FSA competes much more aggressively than the LCC ($v_1 = -0.5$, $v_2 = 0$), is it possible for the FSA to lose profits proportionally more than the LCC.

Figure 4
Profit Reduction Gap (dc = $1)*
(*The profit reduction gap is defined as $y = |\%\Delta\pi_2| - |\%\Delta\pi_1|$, firm 2's conduct parameter v_2 changes while v_1 fixed as -0.5)



Using the same numerical simulation assumptions but changing the two firms' conduct parameters simultaneously, let us compare the proportional output reductions between LCC and FSA, as depicted in the surface graph Figure 5. v_1 and v_2 represent values of conduct parameter for FSA and

Figure 5
Output Reduction Proportions in Percentage (dc = $1)
(The output reduction percentage is defined as $z = |\Delta q_i|/q_i$)



LCC, respectively, while the Z axis corresponds to the percentage of each firm's output reduction, $z = |\Delta q_i|/q_i$. The upper plane in Figure 5 corresponds to the LCC's proportional output reduction, while the lower plane corresponds to the percentage reduction of the FSA's output. It can be seen that the LCC always loses proportionally more output except in the unlikely cases where the FSA competes far more aggressively than the LCC (for example, $v_1 = -0.99$, $v_2 = 0$).

In summary, the numerical simulation and sensitivity tests on key parameters of our duopoly model demonstrate the reliability of our analytical results within reasonable ranges of the key parameter values. More importantly, the numerical simulations also give the estimated values of the differential effects of an identical increase in input prices (for example, due to an increase in an airport's airside service charges, including landing fees) on an FSA and an LCC, and thus on the competition in downstream airline markets an airport serves.

4.0 Discussion and Conclusion

With the worldwide trend of airport privatisation and commercialisation, the extent and form of airport regulation are becoming an important issue for policy makers and regulators. The level of an airport's user charge affects not only air travel demand and social welfare, but also competition in the downstream airline markets to/from that airport. This latter aspect of the effect of airport user charges has been overlooked and thus has not been incorporated in the analysis of airport pricing and regulation. This paper attempts to fill this gap in the literature by showing that the level of competition in downstream airline markets will be reduced when an airport increases its airside service charges (such as aircraft landing fees) by the same amount to all airlines, because such an increase would reduce equilibrium outputs and profits of LCCs proportionally more than those of FSAs.

In Section 2, using duopoly models we have derived the following analytical results:

- When two airlines compete with differentiated products, such as the case where an FSA and an LCC compete with each other, the LCC will lose its output and profits proportionally more than its FSA competitor. As a result, such an increase in airport user charges would harm competition in the downstream airline markets to and from that airport.

- We have analysed the influences of the extent of product differentiation (substitutability), the extent of difference in unit cost levels, and the difference in the two firms' conduct parameters, on the equilibrium outcomes. In addition, although an increase in an airport's airside fee can increase the competitive advantage of an FSA vis-à-vis an LCC, it is still not in the FSA's best interest to encourage airports to increase airside user charge in order to take advantage of its increasing competitive advantage.

Our numerical simulation and sensitivity tests on key parameters confirmed all our analytical findings. The simulation experiments further indicated the following empirical results:

- The ratio of an LCC's output reduction percentage relative to an FSA's increases as the LCC's conduct parameter (v_2) moves from zero towards -1. This implies that the more aggressively the LCC behaves, the greater will be the reduction of its output relative to that of the FSA when caused by an identical increase in input prices.
- Competition becomes more important as the two firms (FSA and LCC) compete with closer substitutes.
- The differential in the percentage of profit reduction between an LCC and an FSA increases as the LCC's conduct parameter (v_2) moves from 0 towards -1.0. This implies that the LCC's profit reduction relative to the FSA's profit reduction will increase as the LCC behaves progressively more aggressively.

Although in this paper we cannot compare our simulation results explicitly with those of our work on the Virgin Blue *vs*. Sydney Airport case before the Australian Competition Tribunal, because of the confidential nature of the data and results, we are satisfied that our simulation results in this paper are consistent overall with the aggregate results we obtained using the real airline and airport data. In the Australian work, we obtained the results on the duopoly routes to and from Sydney. Our simulation results in this paper and our Australian work indicate clearly that an increase in an airport's user charges will harm LCCs significantly more than FSAs by reducing the LCC's outputs and profits significantly more than those of the FSAs. This may be a major reason why LCCs guard against airport user charge increases by seeking long-term contracts on fees and charges with the airport. For example, in some cases Ryanair has very long contract arrangements with specific airports.

Our results indicate clearly that unregulated airside service pricing by a monopoly airport is likely to impact negatively on the competition in the downstream air transport markets to and from that airport. Therefore, future analysis on airport pricing and price regulation should consider this aspect of additional welfare loss that monopolistic airport pricing may cause. It is noted, however, that our results were obtained under the assumption that the airport has a considerable monopoly power. In the case where there is strong competition among alternative airports for the majority of the traffic they handle, our results may need to be re-evaluated. For example, Starkie (2002) points out that when there are opportunities for substitution between airports (and other modes of transport) such as the case in western European cities, airports have less incentive to exploit their market power.

Some economists argue that since the incentives for generating non-aviation revenues, including concession and car parking revenues, would constrain airport management from charging monopolistic airside service charges, there is no need to impose any price regulation on privatised airports. However, recently Oum, Zhang, and Zhang (2004) have shown that the airside service charges of an unregulated profit-maximising airport are higher than those of a public airport under a breakeven budget constraint, even after the effect of concession profits is taken into account. In addition, because of the extremely low price elasticity of air travel demand with respect to airports' user charges[14] any profit-maximising airport management will have incentives to raise airside user charges at least several hundred percentage points beyond the current levels, even after considering the effect of the demand complementarity between aircraft landing and concession activities. Therefore, governments should consider carefully whether or not they need to impose some form of price regulation on privatised airports.

Finally, although further research is needed, our results suggest that economic welfare may be improved by applying lower markups on the airside service charges to low cost carriers than to full service airlines. This is consistent with the results obtained from previous airport Ramsey pricing studies such as Morrison (1982), Oum and Tretheway (1988), Forsyth (1997, 2002a) and Martín-Cejas (1997). Although arguably the weight-based landing fee structure being applied in many airports may be regarded as having a flavour of Ramsey pricing, the IATA's restrictions on price discrimination may limit the scope and extent of any formal application of the second best airport pricing principle.[15]

[14]Gillen, Oum, and Tretheway (1998) report the elasticity ranging between −0.01 and −0.1 depending on the aircraft size.

[15]With weight-based airport pricing, larger aircraft are charged a higher landing fee. This may lead to a higher per passenger charge for an FSA than for an LCC, as the latter often use small aircraft configured to accommodate a large number of seats. It is, however, difficult to quantify such charge differentials. Furthermore, other airport services such as terminals and gates are often charged on a per-passenger basis.

While we have argued the need for some sort of price regulation on privatised airports, we have not evaluated the types and extent of regulation. Instead, we pointed out that policy makers and regulators need to take into account the effect of airport pricing on competition in the downstream airline market when decisions on price regulation or deregulation of privatised airports are considered. Obviously further research, especially empirical research, is needed on this subject.

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