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COMPETITIVE INTERACTION BETWEEN AIRPORTS, AIRLINES AND HIGH-SPEED RAIL

ROUND TABLE

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ABSTRACT

This paper summarizes, structures and provides some context for discussions of the Round Table mentioned in the title. The first part of the paper focuses on sources of market power for airports and on policy responses. When an airport is congested and competition with other airports is limited, regulation may be justified, and the dual-till approach likely works best. In other cases, however, policy should establish conditions for competition to emerge as much as possible, instead of attempting to design a general regulatory framework. The second part of the paper discusses elements of climate change policy in aviation. Including aviation in emission trading schemes is a sensible idea, but should not be expected to produce major cuts in CO_2 emissions from aviation; containing its growth possibly is a more realistic, yet ambitious and not necessarily socially optimal, objective. High-speed rail is justified in some situations, but is not a general alternative for air travel and certainly not a second-best way to reduce greenhouse gas emissions from aviation.

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1. INTRODUCTION

Air travel has become a commodity over the last two or three decades. Travel volumes were boosted by a combination of income growth and lower real fares, and there is strong competition on many origin-destination pairs. Lower fares are the consequence of more intense competition, which in turn was made possible by deregulation, first in the US and later in Europe. While there is broad consensus that this evolution has increased the net benefits generated by air travel, concerns remain about the economic efficiency of the air transport industry. One such concern is that there may be excessive market power in some market segments. For example, the emergence of hub-and-spoke networks after deregulation has reduced costs, but it has also allowed dominant carriers to charge hub premiums and it may have helped them to deter entry. Another example relates to the up-stream services provided by airports. Airline competition does not imply airport competition, and airports may enjoy location- or congestion-driven market power. Institutional arrangements including regulation affect the way such market power plays out. Other market failures in aviation include Pareto-relevant externalities[2], such as marginal congestion costs, and environmental impacts, such as noise and CO_2 emissions. On the other hand, regulatory interventions to try to correct for market failure also impose costs and imperfect information might lead to separate distortions.

This paper discusses the efficient functioning of the air transport industry and some issues arising. Like most economic activity, air transport is characterised by multiple market failures. Here, we focus on the potential market power of airports (Sections 2 and 3), on climate change (Section 4), and on the competitive effect and the social desirability of high-speed rail (Section 5). In each case, we ask if the market failures are sufficiently serious to warrant implementation of costly and imperfect policy.

Section 2 starts with a basic observation on airports: the context in which they operate is very varied and market power is more likely in some cases than in others. When airport capacity in the region where an airport is located is scarce, that airport is served by a set of competing airlines, is not very strongly reliant on hub traffic, and most likely enjoys substantial market power. But when airport capacity is abundant, local demand is not of particularly great interest to airlines; airlines are strong, there is a large share of hub traffic and market power is likely to be very limited.

After the diagnosis in Section 2, Section 3 asks about the remedies. Is regulation required, and what type of regulation is available to avoid abuse of market power? In answering these questions, the aim is to strike a balance between market failure and regulatory failure. Competition, while not perfect, arguably works quite well in many situations. Furthermore, devising a regulation that alleviates one or several shortcomings of the market while maintaining appropriate incentives regarding prices, quality of service and system capacity, is no small feat. Given this trade-off, the preferable approach is to create an institutional environment stimulating competition and turn to regulation where necessary on a case-by-case basis, rather than attempting to come up with a general-purpose regulatory framework. In case regulation is required to contain location- or congestion-generated market power, care needs to be taken that good investment incentives are retained and excessive use of available capacity is avoided.

Among the archetypical forms of regulation, the dual-till approach seems best suited for major congested airports. These issues are the subject of a sizeable literature, and our treatment just touches upon some elements.

Aviation accounts for a small share of CO_2 emissions, e.g., some 3.2% in Europe in 2004 (Anger *et al*., 2008). This share is expected to grow fast, and aviation emissions cause greater radiative forcing than those from many other sources. For these reasons, the sector is widely expected to contribute to efforts to reduce greenhouse gas emissions. From a cost-minimization perspective, shares and growth patterns are not relevant as such. Instead, the question is how aviation abatement costs compare to those of other sectors. Section 4 discusses the potential impacts of greenhouse gas abatement policies on aviation. Aviation's abatement efforts should be guided by its abatement costs compared to the costs of other sectors, and including aviation in emission trading systems is one step in that direction. If aviation is confronted with prevailing carbon prices[3], it would most likely engage in a limited amount of abatement and would need to acquire permits in excess of its historical emission levels, at least when demand grows as expected. The reasons for the limited abatement potential are that demand for air travel is not very elastic in the aggregate, and that technological fixes are scarce – and most likely will remain so in the foreseeable future. Where capacity constraints are strictly binding, putting a price on carbon would affect volumes to an even smaller extent, instead triggering a transfer of scarcity rents to owners of carbon rights.

Given the limited scope for cheap greenhouse gas abatement in aviation, Section 5 asks if it makes sense to increase the availability of high-speed rail alternatives. High-speed rail can substitute for air transport on mid-range distances and produces fewer emissions per trip, especially when electricity is produced in non-carbon-intensive ways. However, life-cycle emissions, relevant in an *ex ante* analysis, for rail arguably are high, given the high emissions from track infrastructure construction (see, e.g., Chester and Horvath, 2008) and maintenance. However, a broader comparison of costs and benefits shows that (a) high-speed rail links are socially desirable in a certain set of circumstances and should not be viewed as a general alternative to air transport, and (b) environmental benefits play a fairly minor role in the overall evaluation of high-speed rail projects.

2. AIRPORT COMPETITION: REGULATION-RELEVANT AIRPORT CHARACTERISTICS

This section provides an overview of potential sources of market power for airports. The degree of competition faced by an airport varies strongly with market conditions. While this is an obvious statement, it is worth making explicit what market conditions one has in mind when analysing airport market power. We discuss the role of capacity constraints, relations with airlines and hub functions. Airports may also derive market power from their location. Overlap between airports' catchment areas limits this market power, and in "multi-airport regions" competition among airports can be intense. We touch upon these issues where relevant. This section also mainly focuses on airports' aeronautical activities. Non-aeronautical activities are an important source of revenue and the demand for such services is complementary to the demand for aeronautical services. Furthermore, for at least some non-aeronautical services, airports enjoy market power. These issues are addressed in Sub-section 2.1. Questions regarding how regulation, when required, should take account of interactions between aeronautical and non-aeronautical activities are the subject of intense debate among academics and practitioners, and are briefly discussed in Section 3.

2.1. Airport capacity constraints

Airports' physical capacity to handle flights is determined mainly by runway and terminal capacity. Investments in physical capacity are lumpy (e.g. it makes no sense to build half a runway) and projects often take a very long time to implement, so that capacity levels cannot be matched perfectly with changing demand levels[4]. Lumpiness implies that airports can have excess capacity or, when demand grows, can become congested for extended periods of time[5]. Airport congestion means that access to the airport is a rival good: an additional take-off or landing implies increased time and operating costs for other flights, or – when technical capacity is reached – requires another flight to be omitted. In other words, the opportunity cost of an additional flight is positive. Scarce capacity needs to be allocated somehow. Economics prescribes that charging the opportunity cost of a flight is an efficient allocation mechanism, but determining this cost is not straightforward[6] and few airports use congestion-dependent access charges.[7] Some US airports and many EU airports use slot constraints to manage capacity utilisation.

An airport that is not overly constrained by regulation or by bilateral agreements with airlines can set access charges in line with its objectives (e.g. maximising profit, revenue or output), of course subject to constraints imposed by demand for the airport's services and competition from other airports or transport modes. Scarcity of capacity, i.e. congestion, is a source of pricing power for the airport *vis-a-vis* airlines, because the airport has some degree of monopoly power over a scarce input to airline traffic. Pricing power means that an access charge can be set that is (inversely) related to an airline's elasticity of demand for access to the airport. Such pricing power can exist in multi-airport regions, if the joint capacity of the region's airports is low compared to the demand for air travel, and airports compete in Bertrand or Cournot fashion (Van Dender, 2005).

Does pricing power for airports lead to welfare losses that require a policy intervention? As noted above, when a facility of limited capacity becomes congested, it is efficient in the short run to charge a price for access equal to the marginal social cost. The main component of such an access charge is the cost of delays imposed on other airplanes seeking access to the airport during the congested period. It was also noted that the existence of congestion confers pricing power on airports, so it could in principle set a price equal to marginal social cost. However, it is generally not the case that profit-maximising airports charge welfare-maximising charges. If the airport is a profit-maximising monopolist, it will leverage the market power from scarce capacity to charge higher prices than the welfare-maximising ones (and thus withhold capacity). In oligopoly markets, this leverage is smaller but not absent. If the airport pursues other objectives than profit maximisation, other prices result and their relation to efficient charges changes accordingly. Output maximisation, for example, likely results in less than efficient charges.

Airports offer non-aeronautical services, which are complementary to aeronautical services, and for which the airport enjoys some market power. Consequently, profit-maximizing airports may reduce access charges in order to boost total profits. This effect pulls in the opposite direction of the pricing-power effect for access charges, moving the access charge in the direction of the efficient ones (without necessarily equating both). The interaction between aeronautical and non-aeronautical charges also depends on how one or both components are regulated (see Section 3).

The deviation between unregulated and efficient charges depends on various circumstances, and its direction and size cannot be determined in general terms. Oum and Fu (2008) point out that airport competition is a critical factor in determining the difference: an airport facing stiff competition from nearby airports will be inclined to set low aeronautical charges, whereas absence of such competition likely implies higher than socially optimal charges. In balance, whether any difference between profit- and welfare-maximizing prices justifies a regulatory intervention is not clear. If costless and perfect regulation were available, the recommendation would obviously be to introduce it. However, regulation is imperfect and costly. If, as may well be the case, allowing airports to introduce congestion charges as they please yields more efficient capacity use than is obtained when there are no congestion charges, then the welfare loss from having non-optimal charges may be small or non-existent compared to the costs of regulating those charges.

In the long run, airport capacity is variable. Of course, this does not mean that capacity should be expanded to eliminate congestion. Instead, it should be expanded to the point where the marginal costs of doing so equal the marginal benefits. Given the often very high costs of adding capacity (land, environmental impact, etc.), many airports are likely to remain strongly congested. At any rate, the argument for congestion-based access charges is just as valid for the long run as it is for the short run. A different question is whether airports will provide roughly optimal levels of capacity. Since airports can benefit from congestion, it seems likely they will provide less than socially optimal capacity, at least when they maximize profits. This suggests that congestion pricing is more attractive when it is constrained by (potential) competition. When airports pursue different objectives, and when they are subject to regulatory constraints, capacity decisions are obviously affected. Section 3 discusses some interactions between regulation and capacity provision.

In multi-airport regions, airports face joint capacity constraints in addition to airport-specific constraints: they partly share the same airspace and the same land-access transport network. Both of these facilities are congestion-prone. For the case of airspace, in a Cournot market structure congestion confers pricing power upon airports (i.e. the ability to set prices higher than marginal social cost, where the latter includes marginal congestion costs)[8]. The arguments on airport-specific capacity hence in principle extend to the case of shared airspace constraints.

Summing up, the argument in this section is that congestion at airports or airspace generates pricing power for (independent) airports and renders a congestion charge desirable for efficiency's sake. While there is no guarantee that a charge that is optimal from an airport's point of view is also the socially optimal charge, the welfare resulting from airports' setting unregulated charges may very well be higher than the welfare obtained when there are no congestion charges. Depending on one's view of the costs of regulation, it hence is not clear that congestion-based airport pricing for given airport capacity should be an object of specific regulation. However, decisions on capacity levels may require closer attention.

2.2. Airport-airline relations

In order to isolate the impacts of congestion effects, we assumed in sub-section 2.1 that airports are independent of airlines, i.e. airlines act as price-takers *vis-a-vis* the airport. However, vertical relations between airlines and airports may lead to deviations from such independence. Close vertical ties between an airport and one or several airlines reduce the airport's business risk of investing in long-lived sunk assets, but imply a risk of making entry by competing airlines more difficult. When there is sufficient competition among airports, the latter risk is small and there are likely to be net benefits. But when there is less airport competition, the costs of limiting competition may well outweigh the benefits of reducing business risk.

An airport serving a strong local market and subject to capacity constraint may enjoy market power, depending on which airlines serve the airport and on the nature of its relations with these airlines. For example, an airport served by a dominant network carrier may be in a weak bargaining position with that carrier (so that market power is effectively transferred to the airline), whereas an airport served by several network carriers tends to enjoy a stronger position because of competition among the carriers[9]. Airports that mainly depend on low-cost carriers are in a particularly weak bargaining position, because such carriers are much less tied to a particular geographical market (and hence to a particular airport) than network carriers (e.g. Starkie, 2008). Furthermore, airports and airlines serving smaller cities also face more price-elastic demand, limiting their capability to translate any market power into higher prices[10]. Low-cost carriers do benefit from dominating an airport, however, through lower airport charges (see below).

Starkie (2008) discusses how relations between smaller airports and low-cost airlines in the UK have been revolutionised through the emergence of vertical supply contracts. These are long-term contracts (up to 20 years) that stipulate access charges for low-cost carriers and are not exclusive (in contrast to many long-term vertical contracts in the US). The contracts allow airports to generate a normal rate of return and arguably make appropriate investments in quality and capacity, a commercial requirement imposed on them by the market for corporate control of commercial airports[11]. Given the market structure in which these airlines and airports operate, the absence of increasing returns to scale, and the satisfactory commercial market outcome, Starkie (2008) argues strongly that there is no need for regulation in this segment of the aviation industry.

The good performance of airports and airlines in these markets leads to spillovers elsewhere. Vertical relations between the main full-service carrier at Manchester Airport and the airport have been revised, similar models are used in commercial and publicly-owned airports (suggesting that competition matters more than ownership at the margin[12]), and the increased presence of low-cost carriers in long-haul markets may imply that this business model will be used outside the traditional short-haul segment served by low-cost airlines.

Is the UK model transferable to the rest of Europe and the US? The geographical prerequisites for the UK system to work – a large number of small airports with overlapping service areas – are present in much of continental Europe, though not everywhere. However, no country has the same long experience with privatisation as the UK, and this may render replication of the UK model less than straightforward.

In the context of major airports and full-service carriers, Oum and Fu (2008) emphasize that, while airports have little market power *vis-a-vis* an airline when that airline dominates the airport, the airport has an incentive to co-operate with such a carrier because such co-operation allows the airport to boost non-aeronautical revenues. As airports, for example in the US, are being "commercialised", they become geared towards the exploitation of non-aeronautical activities to maximise profits. While some US airports historically have been heavily dependent on airlines through exclusive gate use agreements, the development of common use infrastructure has increased their independence from airlines, allowing them to pursue strategies to benefit from integration with airlines. Hence, while integration between airlines and airports in the US does not disappear with commercialisation of airports, its form tends to be more advantageous for airports, because of the reduced grip airlines have on capacity decisions.

The above suggests that not all forms of vertical integration are per definition suspect from the airport's or regulator's point of view. However, integration should not mean loss of independence for either party. For example, Fraport (Frankfurt airport) became strongly integrated with its dominant airline, Lufthansa, when it acquired partial ownership of the airport. This evolution is seen as problematic from the airport's point of view and from a broader concern about market power. For example, such ownership forces Fraport to share information on performance and on pending strategic decisions with the airline[13]. Nevertheless, full vertical separation between airlines and airports is not necessarily required to maintain sufficient competition. Airlines could own terminals at an airport (and decide on its capacity) as long as there are common use facilities as well. With vertical integration, the main concern is to avoid exclusive access for the home carrier or, more generally, avoid limitations on access by competing airlines.

While vertical integration should not be avoided in general, it may generate considerable market power in some market segments. Integration between airlines and airports generates airline-airport bundles. Consumers may have a choice between various bundles, but they are imperfect substitutes[14], and airlines and airports may enjoy considerable market power in some market segments. The degree to which airline-airport bundles are substitutes also depends on passenger characteristics. For example, while leisure passengers in the UK may have various choices, it is arguable that the choice set is smaller for business travellers. Hence, some form of policy intervention may be justified in some situations.

2.3. Hub functions

Airlines use hub-and-spoke networks to connect origins and destinations between which demand is not sufficiently dense to allow profitable direct services. This implies that hub-and-spoke networks become less competitive when the density of demand increases (for example, because of income growth and continuing agglomeration of economic activity) and when the costs of providing service decline (e.g. with low-cost business models being applied in less dense markets). While hub-and-spoke structures save costs, they also are a source of market power for airlines, as suggested by the evidence on the existence of hub premiums[15]. But what about the relationship between hub status and airport market power?

Market power is weaker for an airport that focuses strongly on connecting traffic[16]. Airports compete for hub functions, and this weakens the position of airports with airlines. Furthermore, airlines offer competing hub-and-spoke networks, and this indirectly weakens the benefit of a particular hub's location. In general, hub functions are not very strongly dependent on location, so they are not strongly dependent on airport location. Airlines are particularly interested in combining hub functions and serving a strong local market in a single airport, so that hub airports with small local markets are in a particularly weak position with respect to their home carrier. In Europe, this classification arguably applies to most hub airports except London Heathrow and Paris Charles De Gaulle. The potential for market power in this situation lies mainly with the home carriers, less with the airports. Since generating competition within such hubs is difficult, competition between hubs and the creation of alternative airports in the hub's catchment area is desirable to limit hub-related market power.

The major, successful hub airports tend to be located where there is strong local origin-destination demand, because of complementarities between hub and local demand from the airline's point of view (allowing, amongst other things, airlines to charge hub premiums). In addition, the trend is for the number of hub competitors to decline, as the number of independent major airlines declines. One view is this means that the market is increasingly oligopolistic and a candidate for regulation[17]. A different view is that even with fewer major airlines, there usually is a competitive fringe that disciplines major carriers and therefore reduces the need for regulatory intervention. For this to hold, access conditions in major airports need to support the existence of such a fringe[18].

Apart from hub competition, mergers and alliances of airlines tend to weaken airports' positions, all else being equal. But if airports respond by co-operating, as may become the case for Aéroports de Paris and Schiphol, for example, then airports' countervailing power increases. Whether such horizontal integration is desirable from a broader social perspective is far from clear, however[19].

In summary, hub functions may generate market power, and this more likely accrues to airlines than to airports. In particular, airlines charge hub premiums to passengers for the airport's local market. This market power can partly be limited, e.g. through competition via secondary airports and maintaining competition between hub-and-spoke networks[20].

2.4. Summary

The degree of competition an airport faces depends strongly on the specific market environment it operates in. Some of the key market characteristics are scarcity of capacity, vertical relations with airlines and the importance of hub traffic.

Congestion at airports generates pricing power. A congestion charge is one way to attain efficient use of scarce capacity. A charge that is optimal for an airport is liable to differ from the efficient charge, but plausibly generates more welfare than where there are no congestion-related charges. Since regulation is costly, allowing airports to charge for congestion can be satisfactory. However, care needs to be taken with incentives to invest.

While full vertical separation between airlines and airports is not required to maintain sufficient competition, exclusive access for the integrating airlines should be avoided. Vertical integration may also generate considerable market power in some market segments, possibly justifying some form of policy intervention.

Hub functions may generate market power, mainly for airlines. Maintaining airport competition via secondary airports and between hub-and-spoke networks are ways to curb such market power.

Lastly, some experts doubt the extent to which the concepts outlined up to now can be applied empirically, because of a lack of suitable data (e.g. on prices at the origin-destination level, but also on the measurement of capacity) to settle the issue.

3. WHETHER AND HOW TO REGULATE

The previous section discussed several potential sources of market power in aviation and concerning airports in particular. Abuse of market power is a form of market failure, leading to a lower surplus than in a fully efficient market. If suitable policy interventions to restore efficiency are available and they are costless, they should be used. But policies are imperfect and costly, so the presence of market failures does not justify intervention in itself. Before turning to explicit policy interventions, including regulation, opportunities for competition should be played out as much as possible. Some examples of such conditions in aviation, including stimulating airport competition, avoiding exclusive arrangements between airlines and airports, and competition authorities' oversight of mergers and alliances, were mentioned in the previous section. Starkie (2008) provides evidence that creating competition is feasible in a substantial subset of aviation markets, including some large airports serving large urban markets (e.g. Manchester, Birmingham).

The governance priority should be to implement ownership structures that maximise competition, with further regulation only introduced when that solution is not satisfactory. The scope for competition among airports is broader than is often assumed by policy-makers, prompting the question of whether the application of competition law may be enough to handle problems in airport competition. Minimising *ex ante* regulation reduces the risk of discouraging the adoption of innovative business models[21].

Even when the policy priority is to maximise competition, airport regulation is still likely to be required in some situations. In deciding if and how to regulate an airport, the totality of constraints facing the airport operator needs to be considered, on a case by case basis. No single type of regulation can address all shortcomings of the market in a satisfactory and universal manner. The type of regulation used for Gatwick and Heathrow exemplifies some shortcomings of commonly proposed regulatory systems. The regulation is based on average accounting costs, which are below economic (forward-looking) costs. The consequence is that capacity expansion incentives for these airports are muted, despite severe congestion problems. Furthermore, even with capacity being scarce, the airport operator is rewarded for boosting passenger volumes, leading to more crowding, lower service quality and limited reliability ("sweating the assets")[22]. In light of the discussion in Section 2, regulation removes a congestion-prone facility's incentive to allocate scarce capacity well. In addition, it does not provide good incentives for capacity expansion in the long run.

One approach to avoiding regulatory failure is "light-handed regulation", used in Australia and New Zealand for major airports that are far apart and hence enjoy location-generated market power. This regulatory approach may be appropriate in cases where the airports' objectives do not lead them to abuse market power, and where there is a legacy of excess capacity. However, the approach meets with criticism (and litigation) from airlines and passengers because of high charges. Service quality and investment are "satisfactory". This outcome is in line with what the discussion in Section 2 suggests, for the case of a congestion-prone facility with a considerable degree of market power (in a sense, the opposite of the Heathrow-Gatwick case), with the proviso that theory predicts high quality and high prices, but not necessarily socially optimal levels of capacity (abstracting from lumpiness).

Oum and Fu (2008) argue for more forceful airport regulation, particularly in the case of major airports and where airports co-operate closely with airlines in order to exploit better complementarities between aeronautical and non-aeronautical services. Single-till and dual-till systems are both forms of price-cap regulation. Under a single till, charges to airlines for aeronautical services are determined taking (expected) non-aeronautical revenues into account[23]. Under a dual till, aeronautical activities are treated separately from non-aeronautical ones. Oum and Fu (2008) argue that single-till regulation outperforms dual-till regulation, as it allows the airport to optimise complementarities between both types of service, subject only to the limits included in the regulation. Dual-till regulation makes exploitation of the complementarities difficult, and poses the problem of how to allocate costs in a multi-product environment. However, single-till regulation may be problematic when there is congestion, since it produces charges lower than marginal social costs. This boosts traffic, whereas the charge should actually reduce it. More traffic also means more non-aeronautical revenue, implying further reductions of aeronautical charges when the price-cap is reviewed (see, e.g., Starkie and Yarrow, 2000). It appears then, that if a choice must be made between single and dual till, dual-till regulation is better suited for congested airports, while the single till may be preferable where there is excess capacity (cf. Czerny, 2006, for the latter case)[24]. However, congestion charges may outperform dual-till regulation, even if they are not regulated (sub-section 2.1).

Price-cap regulation is often thought to discourage investment (see the argumentation in sub-section 2.1; Starkie and Yarrow, 2008; and Oum *et al*., 2004, for some empirical evidence). While true in an abstract setting, the practical impact of price-caps depends on the estimated cost of capital. If the regulator overestimates the cost of capital, then overinvestment can result under a price-cap. Furthermore, the UK single and dual-till regulations are not pure price caps and contain elements of rate-of-return regulation. This too affects investment incentives in the direction of overinvestment.

Summing up, there is a fairly broad consensus that aviation policy should first focus on establishing governance arrangements that allow competition to emerge as much as possible, given the technology and cost structures prevailing in the industry. Doing so will not omit the need for regulation in all cases, but may limit it compared to current practice. Regulation is likely to be required for major airports serving large local markets and where capacity is scarce (at the level of the airport or at the level of the airports in multi-airport regions). It is noteworthy that regulation in these cases tends to have considerable effects on the distribution of scarcity rents. Since scarcity of capacity is the main source of market power here, dual-till regulation is likely to out-perform single-till regulation. However, allowing airports to charge for congestion may be a better approach.

4. CLIMATE CHANGE POLICY AND AIRLINE COMPETITION

Sections 2 and 3 focussed on market failures caused by market structure, i.e. by the cost structures and demand patterns prevailing in aviation. Aviation also produces external costs, including noise, polluting emissions and greenhouse gas emissions. External costs are a form of market failure (including the absence of markets), justifying a policy intervention in principle (possibly including the creation of markets).

This section focuses on greenhouse gas emissions, in particular CO_2. Climate change is an important policy concern, and aviation is widely expected to contribute to the abatement of greenhouse gas emissions. The principle that aviation should be included in overall efforts in order to arrive at cost-effective abatement, is disputed by few. In addition, many think that inclusion of aviation in emissions trading systems is an appropriate way of approaching cost effectiveness. Aviation would bear the costs of its emissions on the same basis as other sectors included in trading systems, so that overall abatement costs are minimised, and carbon prices provide a clear incentive for investing in less carbon-intensive technology[25]. But since climate change is a global problem and policy is regional, piecemeal and imperfect, overall cost effectiveness is hard to reach, and concerns about the impacts of economic instruments on countries', sectors' and companies' competitive positions, as well as distributional concerns, dominate policy discussions. Forsyth (2008) discusses these issues, focusing on the potential consequences of including aviation in emissions trading systems. Such inclusion is under serious consideration in the EU, Australia and New Zealand. A particular feature of the intended EU system is that it includes all flights departing or arriving outside the EU, not just intra-EU traffic. New policy views on climate change issues in the US may lead to similar initiatives.

At a price of 20€ per ton of CO_2-equivalent, and when carbon costs are fully passed through to consumers, fares can be expected to increase by 1-5% when no cheap abatement options are available (Forsyth, 2008, Table 3). If the demand for aviation increases, as generally expected, given that the aggregate elasticity of demand for air travel is rather low and given that the technological scope for emissions reductions is limited, including aviation in trading systems will probably force the sector to acquire permits in excess of its historical emissions level. Even if permits are given away for free on the basis of historical emissions, aviation hence will be a net buyer of permits[26].

Whether pass-through is complete depends on market structure (which differs between routes), on the time-frame (allowing sufficient time for firms to exit or not) and on whether airport capacity is scarce or not. We consider non-constrained situations first. In competitive markets there is no pass-through in the short run but full pass-through after profitability has been restored through exit. In monopoly markets, pass-through is incomplete and depends on the elasticity of demand and of marginal costs. Oligopoly markets are usually in between those extremes, but it is noteworthy that pass-through can be more than 100% in the long run because exit reduces the intensity of competition in the market. Overall, when capacity is abundant, this suggests that putting a price on carbon causes a short-run profitability problem for the industry, but that long-run profitability is not jeopardized.

In the polar case, where an airport capacity is strictly binding, fares are determined by the capacity constraint and in many cases will not increase with the introduction of a carbon price. Instead, scarcity rents will fall by the amount of tax revenue, and flight volumes remain unchanged. The general lesson is that capacity constraints, whatever their source, tend to limit the extent of pass-through of carbon costs into fares. Given that such constraints prevail at many major airports and on some international routes, on average, fares are likely to increase by less than the cost of carbon. This implies a transfer of rents from airlines to holders of permits, but the effect on air travel demand and emissions from aviation is limited. Distributing permits for free potentially reduces the impact of pricing carbon as well, because it may weaken incentives for airlines to exit certain markets (the lock-in effect).

The impact of putting a price on carbon on the sector as a whole is expected to be fairly limited: see, e.g., Forsyth (2008) and Adler *et al.* (2008) for some estimates. Anger *et al.* (2008) use a macroeconomic model to estimate the impact of including aviation in the EU ETS, and find limited effects: aviation is a net buyer of permits, requiring about 2.5% of the total supply of permits; at a permit price of 40€, demand for airline services is estimated to be 1% lower than the baseline in 2020, while emissions drop by 7.5%. The authors point out that if permits are auctioned, the revenues should not be recycled to non-ETS sectors, as this potentially undoes carbon savings.

Including aviation in the EU ETS affects airlines differentially. The EU plans to include all flights bound for or departing from the EU in the trading system. This may allow some airlines to improve their competitive position by intensifying the use of hubs close to jurisdiction of the EU ETS, thus limiting the emissions accounted for within the trading system. More generally, carriers that are mostly active within the EU may see a worsening of their competitive position compared with carriers with a large share of non-EU operations in markets where they compete directly, as the latter can cross-subsidize from markets where there is no price for carbon.

5. AIR-RAIL COMPETITION AND THE SOCIAL DESIRABILITY OF HIGH-SPEED RAIL

Some policy-makers in the US and especially in the EU are concerned about the sustainability of prevailing interurban and interregional transport patterns. Road and air transport are perceived to generate excessive emissions of conventional pollutants and greenhouse gases, and the networks are excessively congested at some times and places. Given imperfections in road and air pricing to handle external costs, the provision of rail services is seen as a second-best policy to increase the net benefits from interurban and interregional transport. For passenger transport, high-speed rail is seen as sufficiently attractive to change the modal split in these markets.

De Rus (2008) questions the general social desirability of high-speed rail, pointing out that for a generic high-speed rail connection the benefits are well below the costs, unless rather favourable assumptions are made on demand and costs. The construction of new lines requires a high volume of demand, with enough economic value to compensate the high cost involved in providing capacity. It is not only that the number of passengers must be large, but a high willingness-to-pay for the new facility is required as well, i.e. one needs many users who obtain high benefits when switching mode or travelling more. This suggests that careful evaluations of projects are required on a case-by-case basis. The benefits from high-speed rail mainly take the form of time savings compared to other modes, and possibly of congestion relief in competing modes. Environmental benefits are minor[27]. In fact, the benefits are outweighed by the costs (in particular the high fixed costs), except in cases where there is a high density of demand and there are pressing capacity problems in air and road alternatives[28].

The French situation was mentioned as one where capacity in aviation was a crucial factor in the assessment of high-speed rail projects. Some French TGV connections brought about a substantial shift from air to rail[29], freeing up scarce capacity (valuable slots) in aviation[30]. This effect occurs irrespective of whether low-cost or other carriers might provide service between the cities linked by the high-speed rail connection. Furthermore, since high-speed rail uses separate facilities, it can also free up capacity for rail freight and for regional passenger transport. It was noted, however, that in many cases the main (expected) modal shift in response to a high-speed rail connection is from road to rail, not from air to rail.

Low-cost carriers might respond to the emergence of a high-speed rail alternative by increasing the frequency of service. A similar improvement on the rail side would be very expensive given the cost of trains, and this would reduce rail’s market share and profitability. In addition, low-cost carriers can provide services between regions instead of cities (so avoiding the need to acquire expensive slots at centrally located airports). This is effectively what happened after the high-speed rail service between Paris and London opened. The potential strategic responses from low-cost carriers reinforce the view that high-speed rail may be justified where densely populated origin-destination pairs exist, but is not a general model for interurban and interregional transport.

De Rus’ (2008) analysis considers high-speed rail projects at the level of individual links. In contrast, Adler *et al.* (2008) analyse a European network of high-speed rail connections (a 300km/h TEN network and a 160km/h conventional network), where the shape of the network is determined within the analysis. They find that the TEN network produces net benefits (and higher benefits than an all-air network), at least when access charges are based on short-run marginal costs (and the train operator maximises profits in a deregulated environment). If rail is required to break even, the network is not worthwhile. Instead, if deficits resulting from short-run marginal cost pricing are financed from costly public funds, the network passes the cost-benefit test. The difference between the outcomes of both studies is attributable to network effects and to assumptions on pricing rules and budgetary constraints, and not so much to different assumptions on costs, demand and discounting.

6. CONCLUSIONS

The first part of the paper focused on the question: what are the circumstances in which airports might have market power and what should be the policy responses? The preferred policies will be shaped by the underlying economic conditions. For example, when an airport is congested and competition with other airports is limited, regulation may be justified, and the dual-till approach likely works best. In other cases, however, policy should establish conditions for competition to emerge as much as possible, instead of attempting to design a general regulatory framework. Since *ex-ante* rules and principles cannot reflect the diversity of market conditions, good, evidence-based analysis is a prerequisite for good policy-making.

The second part of the paper discussed elements of climate change policy in aviation. Including aviation in emissions trading schemes is a sensible idea, but should not be expected to produce major cuts in CO_2 emissions from aviation; containing its growth by diktat may be more easily realised, but potentially at substantial economic cost. High-speed rail is justified in a number of situations, but is not a general alternative for air travel or a second-best way to reduce greenhouse gas emissions from aviation.

NOTES

1. This summary was drafted by the JTRC taking account of participants' comments. The usual disclaimer applies.

2. A Pareto-relevant externality is an external effect whose removal, by one or other intervention, would lead to a potential Pareto-improvement, i.e. an increase in overall economic welfare.

3. Prices prevailing at the time of the Round Table – current prices are lower because of reduced overall economic activity.

4. Technological improvements may decrease the lumpiness of airport capacity.

5. The polar cases where capacity is always abundant or there is always excessive congestion are unattractive from an economic point of view.

6. Apart from difficulties in defining cost functions, there is the question of to what extent airlines with large market shares at an airport internalise part of the congestion cost at that airport. Brueckner and Van Dender (2008) show how incentives to internalise depend on market structure. The existence of a small competitive fringe is sufficient to destroy internalisation incentives. Daniel and Harback (2008) provide evidence of limited or no internalisation at major US airports, suggesting that Pigouvian charges are desirable in many cases.

7. The paucity of congestion charges at airports may be related to regulation (allowing weight-based charges only), to a lack of welfare- or profit-maximizing behaviour at airports (perhaps as a consequence of interest-groups' lobbying efforts), or to agreements between airlines and airports. Furthermore, slot allocation mechanisms, such as those in operation throughout Europe and at some US airports, can substitute for congestion charges to some extent, in principle. Whether prevailing slot allocation mechanisms can mimic congestion charges is a point for debate, but without a well-functioning secondary slot market they most likely do not.

8. Adapting the framework of Van Dender (2005) to the case of shared congestion-prone facilities shows there is pricing power when airports are Cournot competitors, but not when they are Bertrand competitors. However, Cournot (quantity or capacity) competition seems the more reasonable assumption for airspace competition. In the case of ground access, airports share the network with non-airport users, and this undoes market power.

9. LAX is an example of an airport serving several network carriers. Experts observe that LAX is not managed very efficiently but still does well, a situation presumably made possible by its market power. ATL is very efficiently managed, maybe partly because of the weaker market position it holds, with a single dominant carrier.

10. Apart from lower willingness to pay for air travel in smaller markets, the high price elasticity facing an airport or airline derives from overlap between airports' service areas. Even if different airports or airlines in fact serve separate destinations, potential entry into overlapping destinations may be sufficient to discipline incumbents.

11. Concentration of airport ownership may emerge in this market, and could form a basis for oversight by competition authorities.

12. However, the competition among regional airports in the UK is generated by outbound passengers using low-cost carriers. It is not clear that this market segment would have developed as strongly under more widespread public ownership of airports, and in this sense ownership is not neutral with respect to competition.

13. It is also conceivable that Lufthansa and Fraport have differing views on the desirability of capacity expansion at Fraport and on Fraport's relationship with nearby Hahn airport (used by a low-cost carrier and for freight). Fraport gave up its ownership of Hahn airport in early 2009.

14. Imperfect substitution follows from differences in service quality (airport access times, parking costs, expected delays, flight frequencies, etc.; see Ishii *et al.,* 2009) and from consumer loyalty programmes such as frequent flier programs. Product differentiation can also occur within airports, e.g. with similar but not identical services offered by low-cost and full-service carriers.

15. Hub premiums may reflect quality or cost differences instead of, or in addition to market power. Borenstein (2005) presents suggestive evidence that hub premiums are smaller in multi-airport regions in the US, so that factors other than pure product characteristics and costs may be involved.

16. The ticket tax introduced in The Netherlands in 2008 illustrates the importance of hub competition (for Schiphol Airport), as the tax is four times higher for long-haul traffic than for European traffic. Transfer passengers are fully exempted from the charge. In early 2009, political debate on the desirability of the ticket tax as such re-emerged after reports on Schiphol's loss of market share, and the tax will be abolished as of July 2009.

17. Consolidation probably will reduce the number of hubs (e.g. the DL-NW alliance may very well eliminate one or more of its current six hub airports), so that airline consolidation leads to concentration of traffic at airports, with potentially detrimental effects on competition.

18. Daniel (1995) and Daniel and Harback (2008) find no evidence of internalisation of congestion costs at major US airports and attribute this finding to the existence of a competitive fringe.

19. The recent decision in the UK to separate ownership of the three main London airports reflects the view that the benefits from competition outweigh any gains from co-operation on investment decisions and operations.

20. These remedies do not fully erode market power, because secondary airports do not offer entirely similar services to main airports, and because hub carriers limit substitution through frequent flier programmes. Whether better mechanisms to curb market power exist is not clear. Furthermore, some would argue that allowing some market power is one way to allow companies to survive where there are network economies.

21. However, *ex post* oversight requires access to data to monitor performance, and such information is lacking in some countries.

22. It was noted that the particularly low capacity-to-volume ratio at Heathrow, and the resulting poor quality of service, is sustainable only because of particularly strong local demand. Similar conditions prevail in New York, but probably nowhere else.

23. The single-till approach is supported by ICAO and is widely used in Europe.

24. The choice criterion here is efficiency. Since single-till regulation implies lower aeronautical charges, it is clear that the choice of regulatory approach also implies a different distribution of scarcity rents, with airlines being better off under the single till. Distribution obviously matters in the policy debate.

25. Pricing carbon, through trading or taxes, tackles the carbon externality. However, there may be other market failures that affect emissions and require their own solutions. For example, research into and take-up of technological innovations may be slower than would be expected in an efficient market. Such arguments have been made for car transport (cf. Van Dender, 2009, for some discussion) and may apply in aviation as well.

26. This situation, where airlines buy permits but do not reduce emissions, may generate a problem of political acceptability in itself (i.e. the least-cost principle is not necessarily deemed fair by policymakers).

27. French studies find that net reductions of CO_2 emissions represent 2-3% of total benefits.

28. With very high densities of demand, costly technologies like Maglev may be justified, as is possibly the case in the main Japanese corridors.

29. Domestic air traffic in France declined by 7% between 2000 and 2007, and this is mostly (not only) attributable to the increased availability of TGV connections. Domestic CO_2 emissions declined by 23%.

30. The costs of congestion in aviation in most of Europe are difficult to measure because there is active slot management, so that measurable delays are small. This of course does not imply there is no congestion.

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Impacts of Airports on Airline Competition: Focus on Airport Performance and Airport-Airline Vertical Relations

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SUMMARY

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ABSTRACT

This paper examines revenue structure, regulation and the market power of airports, how they affect airport's services to airlines and influence the form of vertical relationship between airport and airlines, and thus, eventually on competition in airline markets. In addition, we also examine the competitive consequences of common ownership, co-ordination or alliance among multiple airports in a region.

The key findings are:

- Concession revenues are of increasing importance to airports. The positive externality of air traffic on the demand for non-aeronautical services, along with competition among both airlines and airports, induces a vertical co-operation between airports and the dominant carrier at the airport.
- Airports have substantial market power due to the low price elasticity of their aeronautical services. However, such airports' market power is moderated by competition in both the airline and airport markets.
- There are benefits for both airports and airlines from entering into long-term relationships. Airports can obtain financial support and secure business volume, which are important for daily operation as well as for long-term expansion. Airlines can secure key airport facilities on favourable terms, essential for making long-term commitments/investment at an airport. This, along with the positive externality of the demand for airport's aeronautical services on commercial services, provides incentives for the airport and the dominant carrier to strike exclusive deals, harming competition in the downstream airline market if unchecked. Such airport dominance allows an airline to obtain a substantial hub premium. On the other hand, co-operation between a hub airport and the dominant carrier may enhance the competition between airline networks formed by different airport-dominant carrier combinations. In other words, airport-airline co-ordination or alliance is a double-edged sword for downstream airline competition: there is a need for careful further examination on the issue in order to design an effective regulatory oversight.

The issue of co-operation or alliance between two or more hub airports in a region needs more careful analysis because, while co-operation and co-ordination may improve customer service and efficiency, it is also likely to reduce competition, not only between airports in the region but also between carriers in the downstream airline market.

1. INTRODUCTION

In recent years, airports have been under growing pressure to be more financially self-sufficient and less reliant on government support. Many airports around the world have been commercialized and/or privatized so that airports are operated more like a business (Carney and Mew, 2003; IATA, 1997). Most countries have created regulatory agencies separately from airport operators. These changes introduced strong incentives for airport managers to increase revenue and reduce costs. The changing objective and strategy of airports, together with the evolving regulatory policies and governance structures influence airports' performance and their services to airlines. These changes are posing new challenges to airport managers and the regulation system. In order to design a proper regulatory system, it is important to examine the determinant factors of airport performance, and the effects on the competition in downstream airline markets.

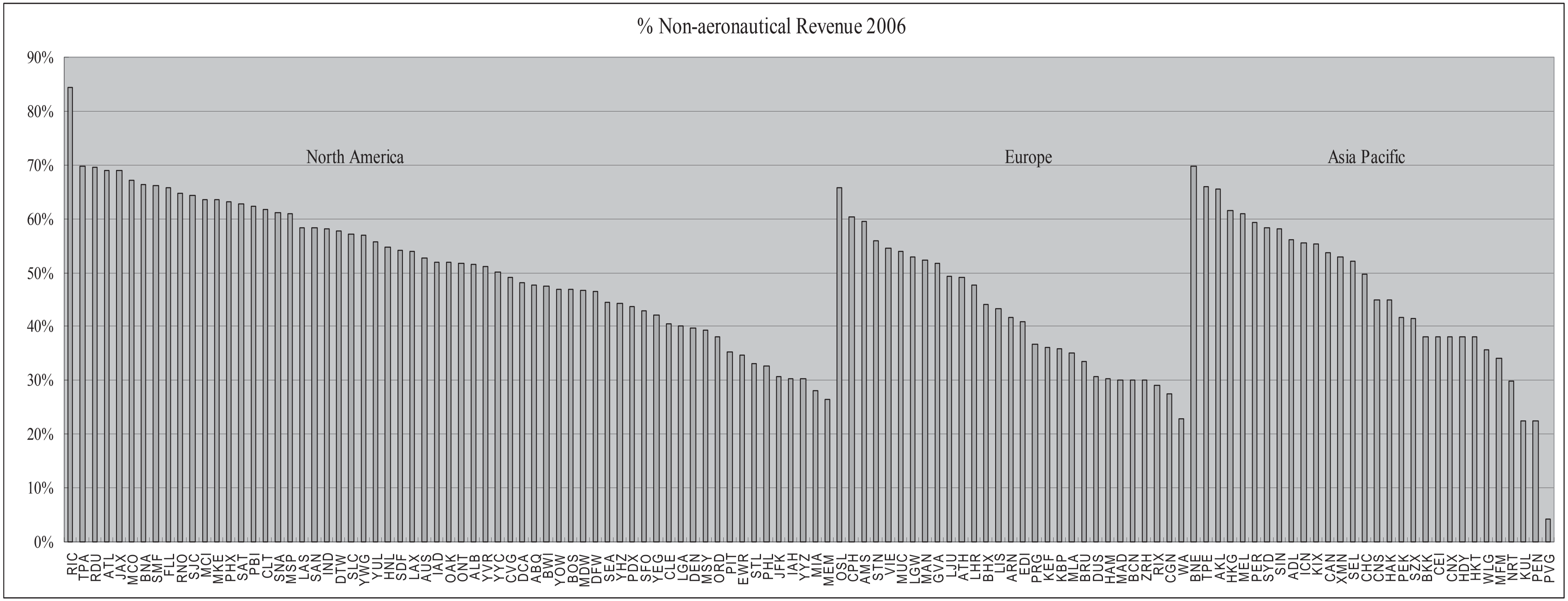
This paper seeks contributions in the following two areas:

First, we review the key determinant factors for airport performance, and how they affect airport pricing and services to airlines. The issues reviewed include revenue structure, market power and regulatory regimes of airports.

We then examine how airport services and business strategies influence competition in the downstream airline market, and the interactive effects between airline-airport vertical relations and the horizontal competition in airline and airport markets.

The paper is organised as follows. In Section 2, we study the revenue structure of airports, and its interactive effects with the regulatory regime. This allows us to study airport pricing and services to airlines which affect airline performance. Section 3 discusses sources of airport market power, and how such market power is affected by the types of airlines using the airport, as well as by the airline and airport market structures. Section 4 examines evidence on airline hub premiums, and how the existence of a high hub premium may promote co-operative relations between a dominant airline and the airport. Section 5 reviews the alternative types of vertical relations between airlines and airports, and how they influence competition in the airline and airport markets. The last section concludes and summarizes the paper.

Figure 1. **Percentage of non-aeronautical revenue , 2006**



Source: The Air Transport Research Society (ATRS, 2006).

2. AIRPORT REVENUE STRUCTURE, REGULATION AND PRICING

An airport derives its revenue from two sources: charges for aeronautical services, such as aircraft landing (take-off) fees, aircraft parking and taxiway charges, passenger terminal and facility charges, etc., and the revenue from non-aeronautical sources, such as concessions and other commercial services, car parking, office rentals, and other income from airport buildings and development of airport lands. As aeronautical charges are usually regulated, airports rely on commercial and other non-aeronautical services to bring in an increasing portion of their total revenues. For example, the Air Transport Research Society's global airport performance benchmarking project (ATRS, 2006) reports that most of the major airports around the world generate anywhere between 45% and 80% of their total revenues from non-aeronautical services, a major portion of which is concession revenue.

The increasing importance of commercial revenue has significant implications for airport operation and pricing. Since there are economies of scope in producing commercial and aviation services jointly at an airport, airport management that focuses on commercial revenue opportunities tends to achieve higher efficiency, as shown in Oum, Zhang and Zhang (2004) and Oum and Yu (2004). High concession revenues allow airport management to reduce charges for their aviation services. In addition, since airports rely on airlines to bring in traffic, there is a positive externality of demand for aviation services (air traffic) on demand for commercial services. Starkie (2001) argues that airport businesses have a "built in" incentive not to exploit their market power *per se* because of the complementary nature of the demand for air services and retail spending by passengers, together with the existence of location rents. Therefore, *ex-ante* regulation for airports might be unnecessary. Countries such as Australia and New Zealand have adopted a light-handed regulatory approach, in which price monitoring has replaced formal regulation (Forsyth, 1997, 2002a, 2002b).

However, the effectiveness of such "built in" incentives depends on the (potential) competition among airports. There is evidence that the airports in New Zealand and Australia attempted to raise prices after deregulation. Three regulatory reviews were conducted in New Zealand after the 1988 deregulation. The one started in May 1998 took five years to finish. In the cabinet paper published in 2007, the New Zealand Minister of Transport and the Minister of Commerce Stated that: "*We consider that the current regulatory regime is unsatisfactory. In our view it does not lend itself to outcomes that would be sustainable in a workably competitive market*[1]." In Australia, the Australian Competition Tribunal sided with Virgin Blue (and Qantas) and declared airside services at Sydney Airport to be under the Federal Trade Practices Act. This forced 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[2].

The unsatisfactory outcome of deregulation/light-handed regulation in New Zealand and Australia is most likely due to the lack of competition among airports. In these two countries, their populations are concentrated around several major cities, with airports separated by long distances. The fact that Virgin Blue enters into expensive litigation with airports indicates that the carrier, despite being the second largest airline in Australia, has very limited countervailing power. As Forsyth (2006) points out: "*...there is no viable alternative airport within 150 km – the airline simply has no* *alternatives*." Zhang and Zhang (2003) and Oum, Zhang and Zhang (2004) have shown that the presence of concession revenue does alleviate an airport's incentive to increase aeronautical service charges. However, Oum, Zhang and Zhang also concluded that an unregulated profit-maximizing airport, when not under competitive pressure from other airports, would have an incentive to charge a price higher than the socially optimal level, and even higher than the price that a publicly-owned airport under breakeven financial performance requirements would charge. These findings do not necessarily reject Starkie's (2001) conclusion, as he considered mainly the cases of western European cities, where many airports compete with each other for airlines' business as well as competing with high-speed passenger railways. Instead, our investigation in the following section will show that the effects of an airport's concession revenue on airside service pricing are moderated by airline market structure, competition among airports, and the vertical relationships between airline(s) and airport(s).

The form of regulation influences pricing behaviour and performance of an airport significantly. Although various forms of airport regulation have been adopted by different countries around the world, the most widely used regulatory regimes are: (a) single-till price-cap regulation; (b) Dual-till price-cap regulation; (c) Rate of return regulation; and (d) light-handed regulation (usually price and performance monitoring along with threat of regulation). A detailed discussion on the application of these regulations in various countries is available in Annex A.

Many studies have compared the performance of these regulatory regimes. A key issue in the debates on airport regulation has been on the merits of single-till versus dual-till price cap regulation. The advantages and disadvantages of each approach are discussed in Starkie and Yarrow (2000), Australian Productivity Commission (2002), UK CAA (2000 and 2003), and Niemeier (2002). Beesley (1999) questioned the appropriateness of single-till regulation. He argued that regulation should concentrate on activities that are characterized by a natural monopoly, and therefore should not involve commercial activities. At the same time, since he doubts that it is possible to isolate the aeronautical activities from other airport activities, he generally rejects the applicability of price cap regulation on airports. Starkie and Yarrow (2000) suggest that the adoption of the single-till approach results in inefficiencies at capacity constrained airports, because non-aeronautical revenues keep aeronautical charges at a low level, and subsequently excess demand is artificially stimulated. They propose that a better outcome would be for aeronautical charges to be set at the level that provides a clear signal to enable resources to be efficiently allocated. Lu and Pagliari (2004) argue that the dual-till approach is desirable when an airport's aeronautical capacity is fully or over-utilised, while the single-till approach is preferable in the presence of excess capacity. In principle, under the dual-till system, the possible (excess) profits earned by airports from non-aeronautical services can be utilised to expand capacity and improve service quality. However, there is no easy answer to how to provide incentives for airports to do so. Czerny (2006) shows that an unregulated airport with excess capacity would tend to reduce charges for commercial services and raise aeronautical charges. The intuition is that price elasticity of demand for commercial services is higher than the price elasticity of the demand for airside services. Czerny further points out that single-till regulation dominates dual-till regulation at non-congested airports, in the sense that single-till regulation comes closer to maximizing welfare than does dual-till regulation.

Overall, single-till regulation appears to be superior to other regimes in terms of setting appropriate prices. The notion of regulating only the monopoly services (aviation services) is appealing in theory. However, dual-till regulation ignores the economies of scope for airports in providing aviation and concession services jointly. More importantly, dual-till regulation does not internalise the demand complementarity between aviation and commercial services. As airlines that bring passengers to the airport may not benefit directly from the concession sales, they may ignore such a positive demand externality in their decisions. On the other hand, under a single-till regulation, concession revenue may be used to cross-subsidize aeronautical charges.

For congested airports, Starkie and Yarrow's (2000) recommendation of dual-till regulation appears to be reasonable. However, the best remedy for capacity utilisation may be peak-load pricing, or some sort of congestion pricing of the facilities, such as slots, checking counter and bridges, etc. The extra revenue generated from such pricing may be used for capacity investment. In practice, however, such policy changes may be difficult due to the influence of vested interests[3].

While firms under rate-of-return regulation tend to over-capitalise their asset bases (Averch-Johnson effect), a major problem with price-cap regulation, either single-till or dual-till, is that in the long run airports tend to under-invest in airport capacity. Oum, Zhang and Zhang (2004), using an econometric analysis of the ATRS' (Air Transport Research Society) global airport efficiency benchmarking data, conclude that after controlling for the effects of factors beyond management control, airports under price-cap regulation tend to under-invest on capacity.

Although all regulatory schemes discussed may be applied to any airport, actual regulation and intervention tend to be less strict and less explicit for government-owned and operated airports[4]. For example, many airports in the United States are owned by municipal governments and operated by city aviation departments. In principle, the Federal Aviation Act requires that airside fees cover only the costs associated with providing aeronautical services. The Federal Aviation Administration (FAA) was awarded the power to regulate the prices of US airports. In practice, however, FAA has rarely exercised these powers, as there is little to be gained by regulating a government undertaking which operates as a not-for-profit entity, and therefore lacks incentives to set unfair prices (Graham, 2004).

While an airport's aeronautical charges become an input price to airlines, the effect of airport capacity is a more complex matter. A capacity shortage will lead to airport congestion, implying a reduction of service quality to all carriers and passengers. On the other hand, capacity constraints could have differential impacts on different airlines using the same airport. A dominant carrier at an airport usually controls a significant proportion of key resources such as landing slots, check-in counters and gates. Capacity shortage at the airport may help the dominant firm to keep potential competitors out of the market. Therefore, from the current literature, it is not clear what is the best way of allocating such precious resources, especially between incumbents and entrant airlines.

Airport pricing and services directly influence the performances of airlines. Our review of the revenue structure, regulatory regimes and pricing behaviour of airports suggests the following:

- Concession and other non-aeronautical revenues are of increasing importance to airports. The positive externality effects of the demand for aviation services on the demand for commercial services reduces an airport's incentive to exploit its market power and set high aeronautical charges. However, without competitive pressure and explicit regulation, airports will increase their aviation service charges above the social optimal level, given the very low price elasticity of the demand for airport services.
- The regulatory and governance structure of airports is very complex and diverse. Single-till price-cap regulation appears to perform better than other approaches, as it provides incentives for an airport to internalise the demand complementarity between aviation services and commercial services. However, in the long run, airports under price-cap regulation tend to under-invest in capacity expansion. This may increase congestion and thus reduce service quality, as well as providing more opportunities for a dominant airline to prevent competitive entry.
- The actual pricing and performance of an airport are subject to a combination of many factors, some of which are beyond management control. Therefore, it is important to identify those true determinant factors in order make proper policy choices.

Another issue not addressed in the literature on airport regulation is the effect of the timing of changes in the regulatory regime. Suppose a country changes the regulation of a privatised airport from single-till to dual-till price-cap regulation after the airport has already been privatised. Then it would create windfall gains for the owners of the airport because, theoretically, the value of the airport will increase by the present value of the stream of increased future profits from the non-aeronautical business. Such a windfall gain would create inefficiency. But, if the decision on dual-till price-cap regulation is made at the time the airport is privatised, then the future airport owners should not be able to make a windfall gain because the bid prices on the airport would reflect a larger amount of the future profits to be made from non-aeronautical services under the dual-till than under the single-till price-cap regulation.

3. AIRPORTS' MARKET POWER

In the past, most airports were owned and operated by government branches, public sector agencies or corporations, probably because airports were regarded as a natural monopoly, characterised by substantial economies of scale. Such a belief has now been disputed widely. Doganis (1992) states that economies of scale are probably exhausted at an annual output of about 3 million passengers. Jeong (2005) shows empirically that a constant return to scale sets in at US airports at about 3 to 5 million passengers. Starkie (2001) even suggested that an airport's long-run unit cost may be an increasing function of output[5]. Since the natural monopoly argument for economic regulation may not hold in the case of airports, their market power is likely to come from the fact that it takes several decades to plan, environmentallyreview and construct a new airport, especially near a major metropolitan area. The rapid growth of air traffic often creates capacity shortage, which in turn gives the airport pricing power.

Major airports have substantial market power for their airside services, because the price elasticity of the demand for airside services is very low, airport charges accounting for a relatively small portion of an airline's total cost. Gillen, Oum and Tretheway (1988) conclude that the price elasticity ranges between -0.01 and -0.1 depending on aircraft size/payload. This implies that airports can increase their aeronautical charges substantially without losing much traffic. Therefore, in the absence of regulation, a profit-maximizing airport may be able to even double its aeronautical charges without losing much traffic (Fu, Lijesen and Oum, 2006). However, the actual market power of an airport depends largely on the following factors:

- Airport capacity available in the region as compared to the rising demand for capacity;
- Airline market structure and competition at the airport and in the region;
- Share of connecting passengers;
- Intermodal competition, especially between airlines and high-speed rail;
- The extent and nature of competition with other airports, whose traffic catchment areas overlap significantly with the airport under consideration.

3.1. Airport capacity and demand for that capacity

In a majority of the major metropolitan areas in Europe, the US and Asia, current capacity and future expansion plans are generally not sufficient to meet the rising demand for capacity, since air passenger and freight transport demands increase at the average rates of 4-5% and 5-6% per year, respectively. Congested airports have an even greater incentive to raise airside prices, since a reduction in traffic would lead to an improvement in service quality. Naturally, these factors increase the market power of most airports in major metropolitan regions.

3.2. Low-cost carrier airports

On average, the per-seat cost of easyJet was £40.48 during the first half of 2008. Airport and ground handling costs added up to £11.14, more than 25% of the total cost[6]. Clearly, low-cost carriers (LCCs) specialising in short-haul markets will be far more sensitive to airport charges. Also, since LCCs utilise point-to-point networks without connecting services, it is less costly for them to switch airports if things do not work out with an airport. This reduces the market power of airports. Since LCC airports attempt to attract passengers in order to capitalise on the positive externality of air traffic on commercial services, low-cost carriers have substantial bargaining power in negotiating fees with these airports.

Since major LCCs tend to have wider catchment areas than Full Service Airlines (FSAs), their choice of an airport in a region is quite flexible and as such, can be largely influenced by the deals on aeronautical charges and what they can extract from the airport and/or the community, in exchange for bringing new business to the airport and community. For example, after the Cold War, many military airports in western Europe were commercialised. This introduced competition among airports whose catchment areas overlap. On the other hand, Ryanair and easyJet have emerged as the two dominant LCCs in Europe. This allows them to negotiate good deals with competing airports. Ryanair paid, on average, $1 or less per passenger to eight provincial UK airports during the 1998-2000 period, when the average aeronautical revenue at major airports in Europe was more than $8 per passenger (Barrett, 2004). Furthermore, these LCCs were able to use their market power (as a big buyer) even to attract subsidies from airports. The European Commission has opened investigations into the possible state subsidies offered to easyJet and Ryanair by some airports, such as Belgium's Charleroi Airport, Berlin's Schoenefeld and Luebeck's Blankensee airports in Germany, and Tampere Pirkkala in Finland. In the United States, some community airports heavily depend on a couple of Full Service Airlines (FSA) to link their airports to major carriers' hubs. In such case, airports offer favourable prices to these carriers to ensure connectivity to major airline networks.

3.3. Airline market structure and competition

Since a primary hub airport for full service airlines provides very different services compared to a secondary airport targeting LCC services[7], the substitution effects between these airports, such as the case of Heathrow and Luton airports in the London area, are not as strong as the case when similar airports compete with each other.

The market power of even a monopoly airport would be curtailed if one airline gets to dominate this airport. The dominant carrier can turn the airport-airline relation into one of bilateral-monopoly (monopoly-monopsony). Each side, namely the dominant airline and the airport, commands market power. In such a case, the negotiated outcome between an equally powered buyer and seller is usually socially efficient. The market outcome dictated by one dominant party (airport or airline) is inefficient.

In reality, it is more likely that a monopoly airport may take advantage of the hub carrier's inability to move away from a natural hub airport. It is difficult and expensive for an FSA to move away from existing hubs. The UK Office of Fair Trading (OFT, 2007) states "*Carriers offering extensive long-haul services, particularly those serving the US market, saw limited scope for substitution away from Heathrow*", for the following reasons:

- Airlines in alliances, which schedule their flights to allow interconnection with other airlines in the alliance group, cannot realistically switch airports independently of other alliance members: 21 of the top 30 airlines (by airport revenue) at Heathrow are members of Star Alliance, Oneworld Alliance or SkyTeam Alliance;
- Only Heathrow has the infrastructure to support hub activities;
- Heathrow is close to the large, wealthy population living along the M4 corridor, in north-west London and Buckinghamshire;
- In many circumstances, switching airports on international services is restricted by air services agreements (ASAs).

As a result, a major airport tends to have more power over FSAs even if the airline is the dominant carrier at the airport[8]. The monopoly power of an airport becomes much larger when a major airport has no apparent hub carrier, with market shares at the airport being shared almost equally among a number of carriers. A good example is Los Angeles International Airport (LAX), which is almost equally shared among major US carriers.

3.4. Share of connecting passengers

When a high proportion of an airport's traffic is connecting traffic, the monopoly powers of both airlines and airports are limited on connecting traffic. This is because connecting passengers have choices to travel via different hubs. As a result, they constrain the market power of airlines and airports. FedEx, for example, had established its Asian hub in Subic Bay. Since there is little local traffic, the carrier didn't experience much business loss when it decided to relocate the hub to Guang Zhou. Another extreme example is provided by the airports of Honolulu and Anchorage. Historically, these two airports had been major transit hubs since trans-Pacific flights needed to effect technical stops there. However, their importance quickly diminished when non-stop flights became possible. Because of this market power differential, we often find that it is considerably cheaper to fly, say, from Vancouver to Berlin via London than Vancouver to London. Similar examples on the Pacific market would be that Vancouver to Shanghai via Tokyo is often considerably cheaper than Vancouver to Tokyo. Since both airlines and airports share a common objective of attracting more connecting passengers, the higher the proportion of connecting passengers (in a major airline's hub airport) the higher is the incentive for both the airport and airlines to co-operate with each other. This issue will be taken up further in the next section when we discuss airport-airline vertical relations.

3.5. Intermodal competition, especially between airlines and high-speed rail

The relationship between airlines and railway services can be competitive as well as complementary. It is likely that high-speed rail (HSR) poses more competition to airlines in short-haul markets (e.g. Amsterdam-Paris; Brussels-Paris) rather than being complementary. As such, an increase in HSR services would reduce the market power of airlines and airports.

3.6. Competition among airports in the same metropolitan region

Obviously, common ownership of several airports located in a metropolitan area or a region is likely to increase the market power of those airports collectively. The UK Competition Commission decided to order BAA plc to divest Gatwick and Stansted, and either Edinburgh or Glasgow. This is consistent with its effort to reduce BAA airports' market power in these two regions[9]. The City of Chicago's plan to privatize Midway Airport (MDW) is certain to create competition with Chicago's O'Hare Airport (ORD), although the main motivation for this privatization was financial. Since no substantial economy of scope has been observed for placing more than one airport in the same region under a common ownership[10], it appears more socially efficient to place each airport under separate ownership and management.

The presence of alternative airports under different ownerships can reduce airports' market power in the following way. Due to the competition among airports, the (firm-specific) price elasticity of demand faced by each airport, ε_i, is determined by the formula:

$$\varepsilon_i = \frac{\varepsilon}{S_i(1+v_i)},$$

where ε is the price elasticity of market demand for airport services in the region, S_i is airport i's market share, and v_i is the conduct parameter which measures the nature of competition between airports. When v_i takes values 0, -1 and 1, the competition among airports assumes *Cournot, Bertrand* and *collusive* behaviour types (Oum, Zhang and Zhang, 1993). Although empirical verification is necessary, the fact that airports compete with limited capacities suggests that they are likely to compete in *Cournot* fashion[11]. This implies that where three symmetric airports compete with each other when the price elasticity of the market demand ranges between -0.01 and -0.1, each airport will face a firm-specific price elasticity in the range of -0.03 to -0.3 for their aeronautical services. This level of very low price elasticity would still allow these airports to increase prices significantly without losing much traffic.

When alternative airports are owned by the same (private) company, these airports will behave collusively such that v_i approaches 1, making the airport-specific elasticity approach close to the market elasticity. This allows airports under common ownership to retain market power. Therefore, the recent move by the UK Competition Commission on BAA's ownership of the London area and Scottish airports is pro-competitive. The common ownership and management of the three major airports in the New York and New Jersey metropolitan areas [John F. Kennedy (JFK), Newark (EWR) and LaGuardia (LGA)] has caused similar problems for the US Department of Transportation (Oum, Yan and Yu, 2008).

An interesting and relevant question is, without government intervention, will adjacent airports under separate ownerships behave competitively, or would they rather collude or form an alliance? If airports would prefer to work together with each other, even in an area being served by multiple, independently-owned airports, there may be a need for regulation. Studies on merger and alliance formation (Stigler, 1950; Salant *et al*., 1983; Rodrigues, 2001; Horn and Persson, 2001) suggest that the actual outcome depends on many factors: such as whether firms produce substitutes or complements; whether there are significant economies of scale in production; whether firms provide homogeneous or differentiated services; the conduct of competitors; the structure of the upstream and downstream markets, etc. Without a detailed and country-specific study, it is difficult to predict the behaviour of competing airports. Other than the possible incentive of collusion, airports' alliance/co-operation may lead to some synergy. Co-operation between two or more nearby airports is likely to help allocate traffic more efficiently between those airports. Tokyo's Haneda Airport focuses on intra-Japan flights while Narita Airport focuses on international flights. Seoul's Gimpo (domestic) and Incheon (international) airports, and Shanghai's Hong Qiao (domestic) and Pudong (international) airports are similar cases. There is a recent proposal to link Hong Kong's International Airport with Shen Zhen Airport in southern China via high-speed rail for a similar division of flights[12].

Therefore, the relations among airports in the same region need to be analysed carefully. While co-ordination may improve customer service and the operational efficiency of the combined airport group, it will reduce competition not only between airports in the region but also in the downstream airline markets. In short, the strategic behaviour of airlines will need to be considered when examining the full impacts of allowing (or disallowing) competing airports to form alliances or merge with each other.

Airports derive two types of revenue: revenue from aeronautical charges and commercial and other non-aeronautical revenues. As in most previous studies, we have not discussed the market power of airports on commercial operations since this is likely to be an empirical question. Concession services at airports are imperfect substitutes for similar services offered in the city. Therefore, airport and concession service providers may have some market power. Certain developing countries allow airports to charge a premium for concession services, probably with the perception that those services are usually consumed by high-income and/or business travellers, whose price elasticities tend to be low. Even in these markets, however, market power tends to be unsustainable in the long run. Prices have to be reduced in order to stimulate concession consumption. Shanghai's Pudong International Airport has recently decided to reduce concession prices, in the hope that the airport can derive a higher proportion of revenues from non-aeronautical services in the future.

4. AIRPORT DOMINANCE, AIRLINE HUB PREMIUM, AND IMPLICATIONS FOR AIRLINE-AIRPORT CO-OPERATION

Since the deregulation of the US domestic market, airlines were given the freedom to optimize their route structures. As a result, hub-and-spoke networks have been expanded extensively by major network carriers. Such a change is accompanied by major shake-ups in the industry. Massive mergers, acquisitions, and liquidations occurred in the industry during the first ten years after the 1978 deregulation, as surviving major carriers were trying to strengthen their dominance in existing hubs and to expand continental market coverage. For example, many airlines based in the central and eastern United States acquired carriers based in the western United States[13].

Dominance at an airport allows a carrier to achieve a substantially higher mark-up above costs. Such a benefit to the dominant carrier is referred to as the "hub premium" in the literature. Borenstein (1989) studied airline pricing for local traffic to/from major US hubs in 1987. He found that the dominance of one or two carriers at major airports would result in higher fares for consumers who want to fly to or from these airports. Such strongholds insulate the dominant carrier from competition[14]. This phenomenon has been confirmed by subsequent studies, albeit with varying magnitudes of hub premium, ranging from well below 10% ((Dresner and Windle, 1992; Morrison and Winston, 1995; Lee and Prado, 2005) to around 20% (GAO. 1989, 1990; Lijesen, Rietveld and Nijkamp, 2004). Other than market power, alternative sources of hub premium, such as the Frequent Flyer Programme (FFP), passenger mix and product differentiation (Lederman, 2008; Lee and Prado, 2005; Berry, 1990) are proposed over the years. The US Department of Transportation (DOT, 2001), however, believes that these rationales commonly used to explain high fares in hub markets only apply if price competition is not present[15]. It is the lack of price competition, not these rationales, that explain high prices at hub markets. DOT (2001)[16] concluded that "*...from a consumer perspective, the primary disadvantage of network hubs is the level of market power that the hub carrier is capable of amassing and the higher prices consumers pay as a result. This stems from the fact that no airline with a similar cost structure can compete effectively at another airline's hub. DOT and others have reported on the prevalence of high fares paid by passengers at hub airports dominated by a network carrier; indeed, no credible study concludes otherwise.*"

Regardless of the source of hub premium, such a benefit gives airlines a strong incentive to dominate an airport. As shown in Table 1, except for Chicago's O'Hare Airport, virtually no major airlines share their hubs with others[17].

Table 1. **Share of enplanements of the dominant carrier at concentrated hub airports, 1978, 1993**

	1978		**1993**	
Airport	**Share**	**Carrier**	**Share**	**Carrier**
Atlanta	49.7	Delta	83.5	Delta
Charlotte	74.8	Eastern	94.6	USAir
Cincinnati	35.1	Delta	89.8	Delta
Dayton	35.3	TWA	40.5	USAir
Denver	32.0	United	51.8	United
Detroit	21.7	American	74.8	Northwest
Greensboro	64.5	Eastern	44.9	USAir
Memphis	42.2	Delta	76.3	Northwest
Minneapolis-St. Paul	31.7	Northwest	80.6	Northwest
Nashville	28.5	American	69.8	American
Pittsburgh	46.7	Allegheny	88.9	USAir
Raleigh-Durham	74.2	Eastern	80.4	American
St. Louis	39.4	TAW	60.4	TWA
Salt Lake City	39.6	Western	71.4	Delta
Syracuse	40.5	Allegheny	49.5	USAir

Source: Morrison and Winston (1995).

Meanwhile, while an airline often utilises multiple hubs overall, they cannot afford to have more than one hub in a region. Airneth (2005) observed that the closest distance between two major hubs in a successful dual-hub system is 900 km, i.e. the case of Northwest's Minneapolis-St. Paul and Detroit. British Airways attempted to share the hub functions of London-Heathrow Airport with Gatwick Airport, mainly to relieve congested Heathrow. However, they soon realised that it was not a winning game and, as a result, they decided to de-hub Gatwick (O'Connell, 2008). BA found that long-haul routes could be much more profitable by moving them to Heathrow, and duplicating a short-haul feed network from Gatwick was costly. It is an example of the failure of duplicating hubs in the same city. When Air France and KLM applied for merger, the Dutch Government was concerned since it might be of the merged airline's interest to reduce hub functions in Amsterdam (AMS). AMS is too close to Paris to be successful as a dual hub, as shown in Figure 2. In addition, Paris-CDG has a much larger population base to support a super-hub of the combined carrier. Therefore, the Dutch Government imposed the condition that the combined AF-KLM should maintain a minimum of 42 major international key destinations from Amsterdam at least for the next five years. Consequently, until 2010 the combined AF-KLM will not be able to make any major network restructuring involving international destinations or connecting services.

Figure 2. **Air France and KLM merged network: Paris and Amsterdam**

In summary, airport dominance allows a carrier to achieve a hub premium and enjoy other related advantages[18]. Any airline prefers to have its own exclusive hub rather than to share the same airport with another carrier's hub function. While a carrier may set up an optimal multiple hub network for continental coverage, it cannot afford to have more than one hub within a region. All of these factors indicate the following:

- Network carriers will be competing in each of the major markets by setting up their hubs in different airports in each major market of the continent. These airports in each region will have substantially overlapping catchment areas. Some airports may be in the same city.
- The above provides a strong incentive for airports and their respective dominant airlines to co-operate with each other (vertical co-operation between airports and airlines) in order to compete successfully with other airport-hub airline combinations in the region.

5. AIRPORT-AIRLINE VERTICAL RELATIONSHIP

Despite some conflicting interests, especially with regard to aeronautical service charges, many airports have developed close relationships with airlines. The following types of relationship are often observed in practice:

– ***Signatory airlines***. Many governments now require airports to be financially independent. Since those airports are free from government subsidy, many have chosen to work with airlines. Carriers who sign a master use-and-lease agreement are awarded so-called *signatory airline status*. Those airlines become eventual guarantors of the airport's finance. In the case of a "residual" agreement, the signatory airlines pledge to cover the full cost of airport operations required for the airport to break even. The aeronautical service charges are determined by the "residual cost" remaining, after the revenues from non-signatory airlines and non-aviation sources have been deducted from the airport's total costs (debt service, interest and operating expenses). In other cases, the main contribution from signatory airlines is service guarantee and usage commitment. This reduces uncertainty over future airport revenue, and thereby allows the airport to reduce financing costs when securing long-term bank loans. In return, signatory airlines are given varying degrees of influence over airport planning and operations, including slot allocation, terminal usage, capacity expansion projects and exclusive or preferential facility usage.

– ***Airlines own or control airport facilities.*** Some airlines hold shares in airports or directly control airport facilities. For example, Terminal 2 of Munich Airport is a joint investment by the airport operating company, FMG (60%) and Lufthansa (40%), the dominant airline at the airport. Lufthansa has also invested in Frankfurt Airport, and holds a 29% share of Shanghai Pudong International Airport Cargo Terminal. By 2006, Thai Airways had invested over US$400 million at the new Bangkok International Airport[19].

– ***Long-term usage contract.*** There are many cases where airlines and airports secure their co-operation via long-term contracts. In recent years, the Low Cost Carriers (LCCs) have organised this type of long-term contract with airports. Many secondary airports offer LCCs favourable usage terms in order to attract their traffic. However, once an airline incurs sunk costs in establishing its services out of the airport, the airline loses bargaining power because of the high cost of switching to a new base. Therefore, many LCCs choose to sign up long-term contracts with airports in order to lock in the favourable terms. Long-term contracts can also be helpful to airports. They encourage an airline to make a long-term investment to develop a more extensive network, thus securing airport traffic in the long run. Therefore, most airports are willing to sign such long-term contracts. In 2002, for example, Melbourne Airport and Virgin Blue reached a ten-year agreement for the airline to operate from the former Ansett/Southern Domestic Terminal.

– ***Airport revenue bonds.*** Many airports now choose to issue Special Facility Revenue Bonds (SFRB) to finance specific capital improvement programmes[20] (e.g. fuel farms, maintenance facilities, terminals, etc.). In these project financing arrangements, airports retain asset ownership but transfer the right for exclusive usage to the project sponsor, under long-term lease agreements. The tax-exempt SFRBs are exclusively secured by the specific project's revenue stream, which is guaranteed by the project sponsor. The airport is without any obligation to SFRB bondholders in case of default. Therefore, much of the risk associated with the project is transferred from airports to airlines. In turn, SFRB gives airlines preferential or exclusive rights over key airport facilities.

5.1. The costs and benefits of airport-airline integration

The effects of vertical relationships between firms have been studied extensively in the economic literature. For example, vertical co-operation/integration may have positive efficiency effects such as the removal of double-marginalization (Tirole, 1988), co-ordination of optimal production and inventory in supply chains (Cachon and Lariviere, 2005; Dana and Spier, 2001), etc. Vertical integration among firms may also bring negative effects on competition, such as market foreclosure and price squeezes (Greenhut and Hiroshi, 1979; Salinger, 1988, 1989; Schmalensee, 1973), etc. However, vertical relations between airlines and airports have received little attention in the literature thus far. This is probably due to the fact that price discrimination on aviation services is prohibited by the International Air Transport Association (IATA) rules. That is, an airport is required to charge all airlines the same price for identical services. Such a restriction, together with the historical public utility status of most airports, has often excluded airports from the anti-trust investigation lists until the recent privatisation wave. Nevertheless, as airports provide an essential input to airlines, such airline-airport co-operation, especially when offering exclusive deals to specific airlines, raises anti-competitive concerns.

In general, inter-firm relationships can be complex when one considers an upstream (airport) market and a downstream (airline) market jointly. Several studies model passenger travel choice over a region being served by multiple airports. In such a case, passengers choose a combination of airports and airlines, rather than airline services only (Ashford and Bencheman, 1987; Caves, Ndoh and Pietfield, 1991; Pels, Nijkamp and Rietveld, 2000, 2001, 2003b). Pels, Nijkamp and Rietveld (2001) point out that an airline faces two types of competitor: competitors operating from the same airport; and those operating from other airports. The airlines operating from the same airport may have conflicting interests as each tries to expand its market. But as opposed to airlines operating from other airports, they may also have the same interest in making the airport attractive in order to attract more passengers to route their travel via the airport, and divide up that traffic among themselves.

While the above studies investigated competition among airline-airport combinations, there have not been many studies on the endogenous formation of the airport-airline combination mechanism (i.e. the process during which airlines choose particular airports to serve, or the process during which airports attract particular airlines to establish home bases). As discussed in Section 4, airports do have incentives to ally with a particular airline. When an airport faces competition from other airports, either an adjacent airport sharing the same catchment area, or another major airport competing for connecting traffic, it is in each airport's interest to ally with one airline, normally the dominant carrier. The airport can secure its future traffic and revenue once a major carrier has decided to establish its hub there, a much needed commitment to an airport facing competitive and financial challenges. It does not help much for an airport to treat other carriers equally well, since the existence of a hub premium discourages airlines from sharing their own hubs with competitors.

On the other hand, airlines also have strong incentives to ally with an airport. The support and preferential treatments from airports allow a dominant carrier to secure the key resources needed for operation, and to gain a competitive advantage over other carriers.

Thus, when there are competitive pressures in both the airline and airport markets, both airports and airlines have incentives to form vertical alliances. Such vertical co-operation, or possible tacit collusion, would further strengthen the dominant carriers' market power at the airport. This has raised some competitive concerns. In 2004, for instance, the European Commission ruled against the agreement between Belgium's Charleroi Airport and Ryanair, claiming that the favourable terms offered by the airport constituted illegal state aid.

Morrison and Winston (2000) and Dresner, Windle and Yao (2002), among others, found empirical evidence that a dominant airline's control over key airport facilities, such as slots and gates, is likely to impose significant entry barriers to other potential competitors. Gonenc and Nicoletti (2000) studied 102 air routes, connecting 14 major international airports. In a large number of international airports, they found that congestion phenomena are reported to exist and a single airline controls more than half of the available slots. This implies that dominant carriers are frequently in a position to use slot dominance at congested airports to close out competitors or raise costs for rivals on certain routes. As a result, few international routes are truly open to competition.

In the United States, the Charlotte/Douglas Airport Authority believed that it had benefited from having a single dominant carrier (US Airways) – the carrier was regarded as a "partner" of the airport. The US Federal Aviation Administration (FAA), however, expressed concern that US Airways exercised too much control over airport facilities and operations, such as landing slot allocation and passenger terminal usage. The mayor of Charlotte appointed a task force to address the issues of airline competition. Additionally, the Aviation Department, pursuant to a directive from the City's Advisory Committee, hired a consultant to evaluate the competitive situation at Charlotte and to develop strategies for improvement (FAA, 1999).

In general, the FAA is concerned about an airport offering exclusive deals to a particular airline, because such special treatment may harm competition in downstream airline markets. Specifically, the FAA is against the airports' practice of giving exclusive or preferential facility usage to particular airlines, and suggests that airports recover exclusive facilities for public usage. Airports are allowed to levy a Passenger Facility Charge (PFC) to finance non-exclusive facilities. In order to fully benefit from such revenue, large airports with a "dominant" carrier must submit a plan to the US Department of Transportation (DOT) showing how they intend to promote airport access, entry and competition (FAA, 1999). The requirement of submitting a competition plan was incorporated into the "Wendell H. Ford Aviation Investment and Reform Act for the 21st Century", legislated in 2000. According to this Act, large and medium airports that exceed a certain threshold of concentration are required to submit competition plans.

With growing pressures for airports to improve their financial performance, new patterns of airport-airline relations emerge. For example, since concession revenue is increasingly important, airports and airlines now use various agreements to internalise the positive demand externality between aviation services and concession services. Since 2000, Tampa International Airport has been sharing concession revenues with its signatory airlines. On the airline side, Ryanair identified airport car parking as one of its major business opportunities, and co-operates with the leading airport parking company, BCP (Ryanair, 2005; Davy Securities, 2006). In its negotiations with some airports, Ryanair asked for shared parking revenue as a condition to initiate services at these airports[21]. Fu and Zhang (2008) studied analytically various forms of concession revenue sharing arrangements. One of their findings is that when a carrier has significant competitive advantages over other carriers, a price-regulated airport can enhance its own profit by co-operating with the dominant airline. This allows the dominant airline to strengthen its market power, in terms of increased market share and profit, at the expense of its competitors. The intuition is that concession revenue sharing provides competitive advantage to a sharing airline, who can internalise demand externality, and benefits from its competitors' output expansion in terms of getting more concession revenue. Since dominant carriers can exploit such competitive advantage more, an airport is more likely to work with them. Overall, Fu and Zhang (2008) found that co-operation between airlines and airports, such as the case of revenue sharing, may be a source of welfare gains. However, it may have negative effects on airline competition. In some cases, the airport and dominant airlines have incentives to collude with each other at the expense of other carriers.

In recent years, airlines and airports have developed various forms of vertical relations in order to reduce risk, internalise demand externalities and gain competitive advantages over other airlines/airports. Co-operation between an airport and an airline, however, may harm competition. The effects of these vertical relations are two-sided, which warrants further investigation. Imposing strict regulations at the current stage is likely to hinder innovation and reduce dynamic efficiency in the long run. Therefore, probably the best choice for regulators is to intervene only when there is clear evidence of negative effects. A simple and effective way to deter bad behaviour is to require the disclosure of exclusive contracts between airports and airlines. Transparency and public scrutiny are cost-effective alternatives to "immature" regulation.

6. SUMMARY AND CONCLUSION

In recent years, airports have been under growing pressure to be more financially self-sufficient and less reliant on government support. The process of privatisation and commercialisation strengthens the desire of managers to enhance airport performance, while requiring a streamlined, cost-effective regulatory system. Since airports provide essential inputs to airlines, performance in the airport market will have important impacts on the downstream airline market. In this paper, we attempted to achieve two main objectives: First, we studied the key determinant factors for airport performance, and how they affect airport pricing and services to airlines. Three key factors were reviewed, namely, revenue structure, regulatory regimes and the market power of airports. Secondly, this paper reviews how airport services, business strategies and airport-airline vertical relations influence downstream airline competition.

Our investigations lead to the following conclusions:

– **Airport revenue structure:** Concession and other non-aeronautical revenues are of increasing importance to airports. There is economy of scope to produce aeronautical and non-aviation services jointly. Airports expanding concession and other non-aeronautical service activities are likely to achieve higher efficiency and better financial performance, which thus allows them to reduce aviation user charges to airlines and passengers. In addition, the positive externality of the demand for aviation services on the demand for concession services reduces an airport's incentive to exploit its market power *vis-à-vis* airlines. However, even without competitive pressure and explicit regulation, airports will still increase their service charges above socially optimal levels.

– **Airport regulation:** The regulatory and governance structure in the airport industry is complex and diverse. In terms of pricing, single-till price regulation appears to perform better than the alternatives, since it mandates airports to internalise the demand complementarity between aviation services and commercial services. Dual-till regulation can be more efficient by pricing air services separately in congested airports. However, in the long run, airports under any kind of price cap regulation tend to under-invest in capacity. This may reduce airport service quality, and facilitate a dominant airline to close out competition from potential entrants.

– **Airport market power:** In general, airports possess substantial market power over aviation services due to the extremely low price elasticity. The availability of alternative airports will reduce airport market power, but not in the case of common ownership. However, the market power of airports is substantially reduced in the case of short-haul markets served by LCCs, or airports dominated by one or only a few airlines.

– **Airport-airline vertical relation:** There are benefits for both airports and airlines from entering into long-term relationships: Airports can obtain financial support and secure business volume, which are both important for daily operation as well as for long-term expansion. Airlines can secure key airport facilities on favourable terms, which are essential conditions for them to make a long-term commitment/investment at an airport. This provides incentives for the airport and the dominant carrier to strike exclusive deals, harming competition in the downstream airline market if unchecked. Such a dominance of one airline at an airport allows the airline to obtain a substantial hub premium.

– **Co-operation and competition between two or more airports in a region:** Co-operation between two or more airports is likely to help allocate traffic more efficiently between those airports. This issue needs more careful analysis because while the co-operation and co-ordination may improve customer services and the operational efficiency of the airports, it is likely to reduce competition not only between airports in the region but also between carriers in the downstream airline markets.

In summary, our findings suggest that the airport industry and its relations with airlines are experiencing major changes, which have important implications for airport management and regulatory policies. While the performance of airports directly determines their pricing and services to airlines, there are also interactive impacts between the two markets, as evidenced by the vertical relations between airlines and airports. Therefore, there is a need to recognise the upstream-downstream relations between airports and airlines when one evaluates airport performance, or designs regulatory policies for airports and airlines.

NOTES

1. Commerce Act Review – Airports. Cabinet Paper by the Offices of the Ministers of Transport and Commerce, available at: www.med.govt.nz/templates/MultipageDocumentPage____32495.aspx

2. Virgin Blue's application (which Qantas joined) to the Australian Competition Tribunal was triggered by Sydney Airport's proposal for a price increase, shortly after a previous price increase implemented just before privatisation of the airport.

3. For example, the US Department of Transportation (DOT) announced its plans to auction some slots of the three airports in the NY-NJ metropolitan area, in the hope that this would encourage entry of competing airlines and generate revenue to upgrade air traffic control systems. However, this plan has received strong opposition from the airport management and the Ports Authority of New York and New Jersey, the owner of the airports, who threaten to file a law suit to stop the Federal Government from selling "something it does not own". In reality, a resource allocation model must be in line with state laws as well as being consistent with economic intuition.

4. There are alternative forms of government ownership and control over airports. A brief summary is available in Annex B.

5. The majority of empirical studies on airport cost functions cannot be relied on for measuring economies of scale because of one or more of the following problems: (a) non-aeronautical services outputs, which account for 40-80% of total revenues of an airport, are ignored; (b) airside services output from terminal services is artificially separated; and (c) unrealistically simple capital input calculation is used.

6. EasyJet 2008 Interim Report. No breakdown of airport service charges and handling costs was available at www.easyjet.com/EN/Investor/investorrelations_financialreports.html.

7. For a discussion of the different requirements for airport services by FSAs and LCCs, see Gillen and Morrison (2003).

8. One former chief executive of a major Canadian airport stated openly in an academic conference in the United States that there is no need to consult with airlines when planning airport capacity. There is no need for airport management to listen to what airlines say. This may be an extreme example, but it illustrates that major airports have market power over even the dominant hub airlines.

9. The UK's Office of Fair Trading (OFT, 2007) pointed out that "*Carriers offering extensive long-haul services, particularly those serving the US market, saw limited scope for substitution away from Heathrow*". Even after considering alternative remedies for BAA's joint ownership in the London area, OFT (2007) believes that "*Heathrow would retain market power due to its hub*

status (and possibly other factors including its size, reputation and good surface access from central London)."

10. We have not seen any empirical estimates on the economies of scope for an agency or firm to operate multiple airports in a metropolitan region. However, it appears that the negative effects of an agency's monopoly ownership of multiple airports in a region is likely to exceed the positive effect on society of allowing a monopolist to operate multiple airports in a region.

11. Kreps and Scheinkman (1983) proved that if firms first make a pre-commitment on quantity, and then compete with price, the equilibrium outcome will be equivalent to Counot competition.

12. There are five adjacent airports near Hong Kong: Hong Kong (HKG), Guang Zhou (CAN), Shen Zhen (SZX), Macau (MFM) and Zhuhai (ZUH). In 2006, the Hong Kong Airport Authority (HKAA) acquired 55% of the Zhu Hai Airport for a price of USD 24.75 million. HKAA's control over the two airports is achieved via the ownership of the Zhuhai-Hong Kong Airport Management Company Ltd, a joint venture formed by the HK Airport Authority and the state owner of Zhu Hai Airport. The joint venture will manage and operate Zhu Hai Airport for 20 years.

13. For example, Delta acquired Western Airlines in order to expand their market coverage in the western United States and to secure Salt Lake City as its western hub, while American Airlines strengthened its Dallas-Fort Worth hub and acquired Air California. US Air acquired Piedmont and Pacific Southwest. On the other hand, Northwest acquired Republic in order to increase dominance of its Minneapolis-St. Paul hub and surrounding markets. Annex C summarizes the consolidation process of the US airline industry.

14. Borenstein (1989) found, *ceteris paribus*, a dominant airline on a route with a 70% share of the traffic might be able to charge from 2% to 12% higher prices than its rivals which only have 10% shares. A hub premium is even more evident for flights connecting two hubs of the same carriers. An airline with 50% of the traffic at each endpoint of a route is estimated to charge high-end prices of about 12% above those of a competitor with 10% of the traffic at each endpoint.

15. DOT (2001) concludes that "*In dominated hubs as a whole, 24.7 million passengers pay on average 41% more than do their counterparts flying in hub markets with low-fare competition*."

16. http://ostpxweb.dot.gov/aviation/domestic-competition/hubpaper.pdf

17. AirTran maintain a hub at Atlanta, but its market power is not comparable to Delta, which has established its super-hub at the same airport.

18. Other researchers studied the effects of hub-and-spoke networks in general, and concluded that such a network would indeed allow hub carriers to price and compete more strategically (Spiller, 1989; Berry, 1990; Bittlingmayer, 1990; Brueckner and Spiller, 1991; Brueckner *et al*., 1992; Zhang and Wei, 1993; Oum *et al.*, 1995; Zhang, 1996; Hendricks *et al*., 1997).

19. Many other airlines control or own airport facilities, especially in their domestic hubs. Qantas owns terminals in both Sydney and Melbourne airports. LAPA Airways holds a minority share in Airport Aeropuertos, Argentina. In 1994, a consortium of four international airlines (Air France,

Japan Airlines, Korean Air and Lufthansa) invested in Terminal 1 of JFK International Airport in New York.

20. In general, there are three types of revenue bond: general airport revenue bonds (GARBS), special facility revenue bonds (SFRBs) and PFC-backed bonds.

21. In other cases, revenue sharing is in effect when airlines hold shares in airports or directly control airport facilities. For example, Terminal 2 of Munich Airport has about 110 stores and restaurants. Profits, including those from the lease of areas for catering and retail, are shared by FMG and Lufthansa (Kuchinke and Sickmann, 2005).

ANNEX A

Alternative Forms of Economic Regulation of Airports

Single-till price regulation: Price regulation usually takes the form of a *price-cap* applied to revenues deriving from airport charges per passenger. With single-till price regulation, a price cap is applied only to aviation services. However, both aeronautical and commercial revenues and costs are considered in determining the level of aeronautical charges. There is, therefore, a cross-subsidy for aeronautical services with revenues arising from commercial activities.

The single-till principle was recommended by ICAO and has been widely used in Europe, including the UK, Austria, France, Ireland, Norway, Spain, Portugal, Sweden, and most airports in Germany. In the UK, the Civil Aviation Authority (CAA) sets price caps on airport charges every five years, at airports designated by the Secretary of State, using the RPI-X formula. Price-cap regulation outside the UK is generally based on the CPI-X formula, and the regulatory review periods vary from between three to five years.

With single-till price regulation, air carriers would share part of the airport's commercial revenues by paying lower aeronautical charges because of the cross-subsidization of aeronautical services from commercial services. This is a major reason why single-till price-cap regulations are widely supported by airlines. However, this leaves aeronautical service prices below provision costs, which poses a problem, especially at a congested airport.

Dual-till price regulation separates aeronautical from non-aeronautical functions. It determines the level of aeronautical charges by considering aeronautical revenues and costs only. Consequently, the corresponding asset base includes aeronautical assets only. Aeronautical charges will more likely be set at a higher level under a dual-till approach, especially at a congested airport, than under a single-till approach, where cross-subsidization from non-aeronautical revenues will help offset some of the costs of the aeronautical services.

The price cap for Hamburg Airport was the first to be set on a dual-till basis in 2000 with the argument that regulation should be confined to the monopolistic bottleneck and incentives for developing the non-aviation business should not be stifled (Niemeier, 2002). Other airports that adopted dual-till regulation are Frankfurt, Copenhagen, Malta and Budapest.

Rate-of-return regulation benchmarks the profitability of regulated activities to the average of reference airports or businesses. It tends to be complex, unresponsive and expensive to administer due to the lengthy regulatory hearings involved. Currently, it is used in Belgium and the Netherlands.

It should be noted that the shares of the operator of Amsterdam Airport, the Schiphol Group, are held by the State of the Netherlands, the City of Amsterdam and the City of Rotterdam. However, Schiphol Group is a financially independent, commercial company that is subject to corporation tax, effective from 1 January 2002. The fact that the Schiphol Group is government-owned may alleviate the complexity and conflict of interests in implementing the rate-of-return regulation.

Price monitoring and threat of regulation is currently implemented in Australia and New Zealand. The regulators use a trigger or "grim strategy" regulation, where a light-handed form of regulation is used until the subject firm sets prices, earns profits or reduces quality beyond some point, and thus triggers a long-term commitment to intruding regulation.

Australia initially imposed dual-till price-cap regulation on all privatised airports. Primarily based on the recommendation of the Productivity Commission (2001), on 1 July 2002, the government ended the price-cap regulation on all privatised airports for a period of five years (Fu, Lijesen and Oum, 2006). The larger airports, including Sydney, are now subject to price monitoring, and the smaller airports are not subject to any controls.

New Zealand does not subject its privatised airports to formal price regulation. Airlines have been very critical of the pricing policies at some regulated airports (Productivity Commission, 2006, Bisignani, 2006).

In the UK, a system of light-handed regulation applies to airports at which annual turnover has exceeded £1 million pounds in two of the previous three financial years, excluding those airports designated for price-cap regulation in London and Scotland.

ANNEX B

Forms of Government Ownership and Private Ownership

In practice, the following forms of government ownership and control have been most frequently observed in the airport industry:

- ***Owned and operated by national government – as both regulator and operator***
  Examples: Spain (Aeropuertos Españoles y Navegación Aérea (AENA) is in charge of 48 airports (McCarthy and McDonnell, 2006) as well as the Air Traffic Control system; Singapore: Singapore Changi Airport is owned and operated by the Civil Aviation Authority of Singapore (CAAS). CAAS acts as both the regulator and operator of Changi Airport.

- ***Owned and operated by national government – Separate regulator and operator***
  Examples: Finland (regulator: Finnish Civil Aviation Authority; Operator: the former Finnish Civil Aviation Administration, renamed as Finavia); Sweden (Regulator: Swedish Civil Aviation Authority; Operator: Luftfartsverket – LFV Group).

- ***Owned and operated by local government departments***
  Example: In the United States, many airports are owned by the local governments. In general, these airports rely heavily on private sector contracting as well as airline investments in the operation and financing of infrastructure. FAA has the authority to regulate at federal level.

- ***100% government corporation***
  Examples: Norway, through the Ministry of Transport and Communications, controls 100% of the share of Avinor, which owns and operates 46 airports in Norway. Hong Kong International Airport is operated by Airport Authority Hong Kong (AA), wholly owned by the Government of the Hong Kong Special Administrative Region (HKSAR). The authority has, for all practical purposes, operated as a government corporation (Cheung, 2006). Other examples include the Incheon International Airport Corporation (IIAC) and Dublin Airport Authority (DAA).

- ***Not-for-profit airport authority***
  Examples: Canada and the US. The term "airport authority" is not clearly defined. In Canada, it refers to a not-for-profit private sector entity that operates airports under long-term lease contract. In the United States, the term generally is used to mean a quasi-government agency that operates airports at arm's length from a municipal or county government (Tretheway, 2001).

- ***Multi-government ownership***
  Examples: Germany, New Zealand, Japan, the Netherlands. Munich Airport is operated by Flughafen München GmbH, which is jointly owned by the Free State of Bavaria (51%), the Federal Republic of Germany (26%) and the city of Munich (23%).

In recent years, some countries have fully/partially privatised their airports. An incomplete list of these airports is provided below:

- ***Fully-privatized:***
  Examples: Most airports in the UK, except the Manchester Group, Newcastle (49% private interest) and Luton (30-year concession contract); Australia (most of the medium to large airports are privately owned, smaller airports are owned by local governments); Italy (Rome). Fully privatised airports refer to those where governments no longer have any ownership interest in the airports. The airports may be fully traded on the stock markets or fully owned by a private group or consortium.

- ***Mixed ownership with private majority:***
  Examples: Belgium, Denmark, Austria, New Zealand (Wellington and Auckland), Switzerland (Zurich). In many countries, full privatisation is restricted, as the former public owners (i.e. national governments) want to secure certain public interests to be guaranteed by a golden share or a wide ownership clause.

- ***Mixed ownership with government majority:***
  Examples: Germany (Frankfurt, Hamburg), France (de Gaulle and Orly), China (Beijing and Shanghai), Japan (Kansai International). In most cases, governments retain a majority stake in privatising their airports. This is the most prevalent ownership form outside the UK, Australia, and New Zealand.

ANNEX C

US Airline Industry Consolidation Within a Decade After 1978 Deregulation

Year	*Carriers*	*Status*[a]
1987	USAir-Piedmont	Approved by DOT
	American–Air California	Approved by DOT
	USAir–Pacific Southwest	Approved by DOT
1986	Delta-Western	Approved by DOT
	Texas Air–People Express	Not-anticompetitive finding by DOJ Approved by DOT
	Texas Air–Eastern	Approved by DOT after sale of slots to Pan Am Shuttle
	Trans World Airlines–Ozark	Opposed by DOJ Approved by DOT
	Northwest-Republic	Opposed by DOJ Approved by DOT
1985	United–Pan American[b]	Opposed by DOJ Approved by DOT
1982	Air Florida–Western	Approved by CAB Not consummated
1981	Continental-Western	Approved by CAB Not consummated
	Texas International–Continental	Approved by CAB
1980	Republic–Hughes Air West	Approved by CAB
1979	Pan American–National	Approved by CAB
	Texas International–National	Approved by CAB Not consummated
	Eastern-National	Anticompetitive finding by CAB Not consummated
	Continental-Western	Rejected by CAB
	North Central–Southern	Approved by CAB

Source: Morrison and Winston (1989).

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THE AIRPORT INDUSTRY IN A COMPETITIVE ENVIRONMENT:

A UNITED KINGDOM PERSPECTIVE

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SUMMARY

London, July 2008

1. INTRODUCTION

The paper provides an overview of UK airports from the perspective of a business enterprise. Its object is to show, through the medium of the UK industry, that effective competition between airports is possible and that a competitive industry can be financially viable. In the UK case, viability is achieved at all levels of output, thus refuting the suggestion that high fixed costs are a significant barrier to positive returns, particularly for airports of limited output. This viable industry operates for the most part in the private sector of the economy, and it has evolved without the imposition of a strategic plan. It is competition that has driven the dynamics of the industry; an industry that in its symbiotic relationship with the airline industry has been an economic success story, helping to produce strong economic growth in the service sector of the UK economy.

The structure of the paper is as follows: the first section provides a snapshot of the UK airports industry, from which it is evident that economies of scope are important[1]. This is followed by a section on the ownership structure of the industry, drawing attention therein to the market for corporate control (with its implications for productive efficiency). Section 3 outlines the relationship between airports and airlines, stressing the recent development of long-term contracts which are important for understanding the current nature of competition. Section 4 places competition in a spatial setting by summarising recent analyses of hinterlands or catchments from which the individual airports attract traffic; it is shown that most of these catchments overlap to form a chain of substitution. Section 5 analyses the financial performance of the industry; its conclusion is that airports at all levels can operate without subsidy and, overall, the industry's profitability is similar to that for the non-financial sector of the UK economy. Section 6 concludes the paper by arguing that governments should encourage competition in the market for basic airport services, if necessary by restructuring and by unbundling concentrated ownership. Economic regulation, even when well designed, is very much a second-best solution.

2. SIZE AND DIVERSITY

In spite of its relatively small area, the UK in general and England in particular, have a surprisingly large number of airports with scheduled passenger services; in 2007 there were about 40 such airports. With reference to passenger numbers, their size distribution is bi-modal, with four large airports dealing with more than 20 million and the remainder with less than 10 million passengers. There is one major transfer (connecting) hub, London Heathrow, which of course is a supreme example of its genre. The author could continue to cut and slice the data on UK airports in countless ways and possibly bore you in the process. Instead, he would refer you to the comprehensive airport data on the UK Civil Aviation Authority's website[2]. The author is more interested in the "airport" as a business entity, or enterprise, operating as the UK airports do within a competitive market economy with economic regulation limited to three co-owned London airports; this gives the analysis of the data a particular slant.

We have already referred to passenger numbers and it is a common practice to use this as the defining characteristic of an airport's size, but to do so tends to diminish the fact that airports are in most cases multi-product entities supplying to the market a bundled group of services (OFT, 2006). Apart from handling passenger traffic, other activities include shipping airfreight (including mail), providing for air-taxi services and general aviation, acting as a base for flying training, aircraft maintenance, flight testing and corporate jet activity, and providing for a large number of other specialist aviation services. Further complexity is added because the activities of the airport company can extend beyond the supply of airport services *per se*. The property assets within the airfield boundary might also serve non-aviation-related activities. At the smaller airfields, it is not unusual to find former hangars and similar obsolete or stranded assets used for storage or as units for light industry.

Looked at in business terms, a more appropriate measure of firm size is turnover. Table 1 ranks selected UK airports by turnover in 2005/6. (There are probably another dozen relatively small airports exceeding the minimum turnover threshold shown, £5mn, for which financial data are not readily available). The range of turnover is huge, as one might expect, and, although there is a high correlation between this statistic and passenger numbers for medium and large airports, there are, nevertheless, cases where financial turnover relative to passengers is disproportionately high; Nottingham East Midlands, Cardiff and London City are examples. For small airports the relationship between passengers numbers and turnover is less close[3] and a further indication of this is the relative proportion of Air Transport Movements, those with a passenger focus, to total aircraft movements which for these airports is often less than half (see Table 1, columns 3 and 4).

But, small airports are of greater significance than their size suggest. In a competitive airport environment (about which more later) they are a source of competition for the larger airports. The industry is dynamic and rapid growth from a small base is not uncommon; Liverpool, for example has experienced exceptional growth during the last decade which has had repercussions for other airports in its region. A competitive challenge has also come from newly established civil operations at former military bases using the stranded assets of the defence "industry" (Doncaster, Newquay, Manston) and at airfields located alongside aircraft manufacturing plants (Belfast City), as well as from the occasional new airport on a greenfield site, such as London City and Sheffield City. But there has been exit from the industry as well and the latter example is a case in point.

3. OWNERSHIP AND CAPITAL MARKETS

Until little more than twenty years ago, virtually all runway and terminal assets at UK airports were owned by the public sector (although the private sector often played a major role, through concession agreements, in the running of the airports or, more typically, parts of them). The transfer in 1987 to the private sector of all the share capital of the British Airports Authority, a corporate enterprise owned by central government, was the first important change of ownership in the UK industry. This transfer, by flotation of shares on the London stock exchange, established BAA plc, (confusingly referred to as a public quoted company) with a substantial capitalisation. Between 1993 and 1999, many local government-owned airport assets were also sold. This was a period when strict controls were imposed on local government spending on airport assets so that, to expand such airports, private capital was needed, but further privatisations have occurred since removal of the capital spending constraints (see Table 2). Unlike the public flotation of BAA, disposals by local governments to the private sector took the form of trade sales, that is, sales to existing trading entities.

The majority of the financial transactions have been outright sales to the private sector, but with some exceptions. Local government retains a majority share in Newcastle-upon-Tyne Airport; a minority share in Birmingham Airport and a tiny share in Blackpool Airport; whilst London Luton Airport has a 30-year concession agreement. The latter commenced in 1998 and recent events suggest that this approach is not without its problems. The concession holder, ACDL, has now decided not to pursue earlier plans for major investment, citing as a reason the limited period remaining before the end of the concession agreement (although central government's support for, arguably, premature expansion of near-by London Stansted has probably complicated matters). Not all airports have been sold to the private sector or introduced private equity capital. Manchester (UK's fourth largest) which belongs to a consortium of local governments in North-West England is a significant exception. The UK airport industry is thus a mixed private-public sector industry but one currently dominated by the private ownership of assets.

An important feature of the market in UK airport assets (and indeed the assets of the privatised utility industries in general in the UK) is that it has a global reach, the final impediments to which disappeared in 2006: when BAA was privatised the government capped the amount of shares that any one shareholder could hold to 15% but, following a ruling by the European Court of Justice that this restriction impeded the free movement of capital in the European Union, it was removed. The take-over of BAA soon followed when a consortium led by Ferrovial, the Spanish construction, infrastructure and services group[4], outbid Goldman Sachs, the US investment bank. Another Spanish led consortium has an interest in Belfast International and Cardiff airports as well as holding the Luton airport concession; Macquarie Airports, an investment trust which is part of the Australian bank of that name, owns Bristol airport; a New Zealand investment group has an interest in two smaller airports; Copenhagen airport (in which Macquarie also has an interest) holds the minority stake in Newcastle airport and private equity groups have been involved in the two most recent privatisations of local government airports, Leeds Bradford and Exeter. Both these latter sales took place at a price of about 30 times earnings (before allowing for interest, tax, depreciation and amortization). This suggests high expectations by the purchaser that substantial cost efficiencies can be achieved and/or strong market growth is attainable.

The market for corporate control generally in the UK is a very active one and this characteristic applies equally to the market in airport assets. Ownership by unquoted private companies (BAA plc was the exception) has not prevented several of the airports changing hands since they were first transferred to the private sector, some several times (see Table 2). It would be reasonable to suppose, therefore, that as a consequence much of the industry is subject to capital market disciplines which bear in particular upon its productive efficiency: the acquiring firm will aim to increase the profitability of the airport taken over, securing a good investment return by improving the airport's operational efficiency. And, in so far as the remaining (corporatized) public sector airports find themselves competing in the market for air transport services with (for-profit) private sector airports, competition for private sector airport assets in the global capital markets will have had the effect of increasing the productive efficiency of the sector as a whole.

4. COMPETITION FOR CONTRACTS

It was expected that liberalisation of European air transport, the final phase of which was completed in 1997, would lead to a much more competitive air transport market throughout Europe. Not anticipated was the role that the Low Cost Carrier (LCC) would play in driving these market reforms, nor the profound effect the carriers would have on the airports industry. The consequence has been to greatly increase competition between airports and to increase the bargaining power of the airlines. The catalyst in this transforming process has been the introduction of formal, specific (long-term) contracts between the airport and downstream airline customers. These vertical supply contracts, arguably, should rank alongside the use of on-line internet booking systems and the introduction of cheap one-way fares (which undermine the ability of the legacy carriers to price discriminate), as a major innovation in contemporary civil aviation. The privatised UK airport industry has played a key role in their introduction.

Vertical supply contracts between airport and airline have long been a familiar feature of civil aviation in other parts of the world, such as in Australia (long-term leases on terminals) and, especially, in the United States (gate leases and "majority-in-interest" clauses, giving airlines some control over capital expenditure). But the focus of contractual developments in Europe since liberalisation, initially in the UK and then more generally, is novel; it has been a focus on negotiated *charges* for the long-term use of basic airport infrastructure.

The traditional relationship between airport and airline user has had at its core a posted tariff of charges (the most important of which are generally structured to reflect aircraft weight) together with associated "conditions of use". The interesting feature of this traditional approach is its informality: users do not need a contract with the airport but in paying the published tariff they also accept the "conditions of use" (Condie, 2004; Graham, 2001). Under this arrangement, the airport is, in effect, assuming the long-term traffic risk. This was not of concern to airport owners when air services were subject to general regulatory controls on route entry and thus operated in a less competitive, stable environment. But liberalization of aviation has increased the risk of airport assets being stranded by the opportunistic behaviour of airlines that are now free to change routes and switch airports at will. Consequently, there is now an incentive for the airport to establish with its downstream airline customers negotiated long-term[5] contracts for supply that achieve a better balance of risks. These contracts are not dissimilar to those that exist in other industrial sectors faced with similar economic circumstances; the shipping and ports industry, for example[6].

Besides specifying charges, the negotiated contract usually covers issues such as the quality of service the airport is to provide, for example, minimum turn-round times; the amount of marketing support the airline is to receive; and a commitment by the airport to future investment, the nature of which is sometimes specified in detail. Conversely, as part of the agreement, the airline commits to basing a certain number of aircraft at the airport; to roll out, per schedule, a route network; and sometimes to guarantee a minimum level of traffic, effectively take-or-pay contracts[7]. The average charge paid by the airline in these contracts is usually much less than the average that would result from the use of the published tariff. Payments are also structured in such a way that traffic risks are shared, for example, by using a per passenger charge only. The published tariff, of course, is still used for charging those airlines for which a negotiated contract is less suitable or inappropriate.

The negotiated contract has led to a fundamental change in the nature and intensity of competition between most UK airports. Although airports still compete to attract linking air services provided by airlines based at other airports, the prime competitive focus has shifted to encouraging airlines (and associated entities such as express freight carriers) to establish an operating base at which aircraft would be positioned overnight, and to develop from this base a route network. The effect of this has been to greatly increase the bargaining power of many airlines *vis a vis* the airports.

Prior to liberalization, those airlines now commonly referred to as "legacy" airlines tended to focus their base operations on a specific geographical market. This was especially true of the so-called flag-carrying airlines with their capital-city focus. If they had been required to negotiate commercial contracts with their base airport – and generally the issue did not arise because of the symbiotic relationship between what were usually two public sector entities – the airline(s) would have had little countervailing power unless the city happened to be served by multiple airports with different owners. In contrast, LCCs have no specific interest in a particular geographical market; their objective is to choose locations across Europe that maximize the return on their capital (aircraft) assets. The effect is to increase considerably the countervailing power of such airlines in negotiations; the airline can credibly threaten to take their "capital on wings" to a different location. The point is exemplified by Ryanair's frequent practice of announcing a short list of airports at which it might base its next *tranche* of aircraft and then to hold a "beauty parade" in order to secure best terms. Thus, competition between airports is no longer simply and only a matter of competition between spatially adjacent airports; competition in the new regime takes place over a very wide geographic market, which reflects, in particular, the willingness of the LCCs to open new bases throughout Europe.

Once such a base has been established, the airline will have sunk a certain amount of costs but, at least until the end of its contract period, it will be protected from the airport behaving opportunistically and, as already mentioned, these contracts are usually of long duration. It is also likely that the airport will wish to compete against rivals to attract the basing of future increments of capacity (not already prescribed in an existing contract) and this too will constrain its behaviour. Of course, at the end of the contract period the airline will be in a different position and will face switching costs, but it will have a stable and known environment prior to the contract termination date in which to negotiate a replacement contract or to make other arrangements; this in itself should reduce transitional costs[8]. Equally, at the end of the contract the airport also faces losing a chunk, possibly a large chunk, of its business in circumstances where most likely it is faced with a level of fixed costs much higher than the (location-specific) fixed costs faced by the airline. There will be incentives for both parties, therefore, to negotiate new contract terms and it is not immediately obvious that either the airport or the airline will have the upper hand; the most likely outcome is that the bargaining positions will be reasonably balanced.

In contrast, airlines that established operating bases at a time when negotiated contracts were not available, and that operate essentially by reference to the published tariff and associated conditions of use, appear more vulnerable to increases in posted charges or other forms of opportunistic behaviour on the part of the airport, and there has recently been much discussion between airlines and regulators concerning the size of the switching costs that might be involved in moving flight operations between airports. But what is to be emphasized is that it is the *net* cost of switching that is the important factor and financial inducements, such as marketing support by competing airports which reduce this net cost, should be taken into account. There is no reason to suppose that base airlines currently paying the published tariff and thus supposedly stranded by their switching costs would not be subject to inducements from rival airports. Thus, insofar as those airports strongly associated with "legacy" airlines find themselves competing with (low-cost) airports willing to enter into long-term contracts with airlines, they too have to respond to competition by adjusting prices for their established airline customers.

Manchester Airport provides a very good example of this. It is now of very similar size to London Stansted, having been in the past much larger than the latter: it also used to be head and shoulders above other airports in its North-West region, which is no longer the case. For a time, Manchester shunned the LCCs and declined to enter into negotiated contracts with them. It preferred to continue to focus on serving the legacy airlines (British Airways had a base there) and, in this capacity, it served some long-haul routes as well as many European and domestic services (the latter including an important shuttle service to and from London Heathrow); it was also an important base for inclusive tour (charter) traffic[9]. But in the last ten years or so it has faced increasing competitive pressures from, first, Liverpool and then, more recently, from Leeds-Bradford and the new Sheffield-Doncaster airports, so that its growth rate slowed and its overall share of UK passenger traffic stagnated (at around 10%). It was forced to respond and it did so by selectively supporting a large number of airlines in the form of either a reduction in airport charges (or rebates), or by making large contributions to joint marketing campaigns. Between 1998 and 2003, for example, about 75 different airlines received support, although this was highly skewed, with 20 airlines receiving over 90% of the expenditure. Importantly, to prevent reductions in services, it provided support (to the extent of nearly one-quarter of the total support budget in 2002-3) to airlines (and charter carriers) "*…that would otherwise have ceased or reduced services…*"[10].

Because the UK was at the vanguard of air services liberalization and the synergistic LCC revolution, competition between airports to attract airline operating bases soon followed and today there are a large number of such bases in the UK. Table 3 shows the UK operating bases for four non-legacy[11] airlines, easyjet, Ryanair, Flybe and Jet2, in the summer of 2008. Between them, these four airlines have 32 bases in total, spread across 19 airports. It is not an exhaustive list of operating bases in the UK: bmibaby, another quasi-LCC, currently has four; VLM bases aircraft at London City Airport; Aer Lingus has just opened a base at Belfast International; and, of course, British Airways has a number of bases. However, the table shows those bases most likely subject to negotiated long-term contracts along the lines described above. Gatwick and Stansted are known exceptions, as BAA currently declines to enter into such contracts. The list also indicates that the use of long-term negotiated contracts now extends beyond the type of airline that essentially pioneered the approach.

5. COMPETITIVE HINTERLANDS

The attractiveness of an airport to an airline and thus the contractual terms an airline is prepared to accept in order to establish an operating base there (or serve it as an end point on a network, the hub of which is located elsewhere) depends on a number of factors, including those that could affect operating performance and those that bear upon the anticipated average fare yield. The airline will be cognisant of the airport's infrastructure [its runway length, the standard ("category") of its instrument landing system (ILS), terminal facilities], how much spare capacity the airport has, its potential for future expansion and its freedom from operating restrictions. The fare yield will depend upon the presence of potential competitors already at the airport or at a nearby airport, and, of course, upon its perceived attractiveness to potential passengers. This latter, in turn, depends foremost upon the airport's location in relation to a market demand, the extent and depth of which is determined by factors such as population density, income levels, business activity, international trade links, tourism potential and the quality of the transport links, particularly of the regional road network, which will determine airport access times.

Access times are important in determining the overall size of the regional market and the UK CAA has suggested that a significant number of leisure passengers are, in general, willing to tolerate access times of around two hours to reach a chosen airport (CAA, 2006, 22.17), although for business travel, one to 1.5 hours is thought to be more appropriate. Its analysis indicates that a two-hour driving time accounts for around 80 to 90% of passengers using an airport[12]. These statistics are derived from data for the larger (and more leisure oriented) airports in the UK, each of which serve a large number of destinations. Consequently, they might draw from a larger than average area of "catchment". On the other hand, airports with a smaller volume of passenger traffic might draw most of it from a more restricted catchment, perhaps within one to 1.5 hours driving time of the airport.

From a competitive viewpoint, the issue is whether and to what extent the catchments of different airports overlap. The author has previously pointed out (Starkie, 2002) that airports (and airlines) cannot segment their customer base by residential/business location; that is to say that they do not have the ability to price discriminate between customers according to where the latter are located with respect to the airport. The consequence of this is that even a small degree of catchment overlap might have a potent effect on prices. The point is illustrated in Figure 1. This shows stylised catchments for two airports (A and B) that overlap in the shaded area. Within this latter area, air services from the two airports compete directly for customers. However, passengers located at point z (well outside the catchment area of airport A and thus captive to airport B) are potential beneficiaries of the price set for customers located in the area of direct competition. Unless it is possible to separate passengers at z into a market separate from those in the overlapping zone, the former passengers when using airport B will also benefit from the competitive price offered to passengers in the overlapping catchment.

The CAA has undertaken detailed analysis of the degree to which airport catchments overlap in both the London and North-West (Manchester) regions of the UK. The analysis, based on driving times, reveals that there are extensive overlaps between the various London airports for both the one and two-hour "isochrones" and, for the latter, overlaps with airports outside the London region, particularly with airports located to the north and west. In the case of the North-West region, again there is a strong overlap. Manchester is by far the largest airport in this region with a turnover about tenfold that of nearby Liverpool (see Table 1) but the overlap of its catchment with those of other airports is considerable and this remained generally the case when the analysis was repeated for different market segments (domestic, long-haul etc.).

The UK Competition Commission (CC) has also conducted a broadly similar analysis of the London and Scottish airports in relation to its *Emerging Thinking* Report (Competition Commission, 2008)[13]. However, it made use of a different methodology and, in particular, it did not depend upon the analysis of driving times but used instead the results of passenger surveys. The CC's starting point was to assume that if a significant percentage of passengers originating from a district used a particular airport, then it could be inferred that all passengers in that district were potential customers of airlines operating from that airport. For the initial analysis, the threshold of significance was set at 20%. Therefore, the CC measured the degree of catchment area overlap by measuring the percentage of an airport's passengers that came from local authority areas where another airport accounted for 20% or more of its passengers. In terms of Figure 1, one would calculate for Airport A, the percentage of its passengers from the shaded area when Airport B attracted at least 20% of the shaded area's passengers.

Subject to the availability of survey data, this analysis can be refined further. For example, it can be repeated for different market segments, leisure, business, etc., and the CC did do this (although when judging whether such a disaggregated approach is really necessary, again one should be mindful of constraints on the ability of airports and airlines to segment and thus price-discriminate in spatial sub-markets). The CC also carried out a yet more stringent examination, deriving catchment areas only for those passengers travelling on air routes served from more than one airport. However, the author's view is that this approach is too stringent. For (short-haul) leisure passengers it ignores the issue that many such passengers are purchasing a commodity with certain attributes, so that an airline route to destination

X is a substitute for a route to destination Y. There are also market dynamics to consider: that in a liberalized, competitive airline market, airlines are free to enter in response to perceived opportunities so that the picture regarding parallel route competition is fluid. Also, in the longer term, improvements in transport infrastructure change the shape and size of catchment areas.

The initial conclusions of the CC following its analysis of the London region airports match, in large measure, those of the CAA: that in the regions analysed there should be significant potential for airport competition (para. 167), although the common ownership of three London airports by BAA is likely to adversely affect competition between them. With respect to the Scottish airports, the CC's current view is that there is potential for competition between Glasgow and Edinburgh (para. 274) and probably also between them and Aberdeen, but again joint ownership of these three airports by BAA is a feature that adversely affects competition.

The analyses of both the CAA and the CC have a particular regional focus (London, North West England and Scotland) because each was serving a particular purpose. In order to examine the potential for competition between airports more generally**,** the author has carried out an analysis of driving times between significant airports across England and Wales as a whole (Starkie, 2008). Table 4 shows driving times between proximate English/Welsh airports[14]. Included in the database are all those airports with scheduled passenger services and with more than 400 000 passengers in 2005-6; a total of 21. The entries in the table show times between those airports that are within two hours' drive of each other (unless the nearest neighbouring airport exceeded two hours' driving time). For this purpose, driving times are taken from the RAC's *Route Planner* and are based on assumed speeds of 60mph (96kph) for motorways [the national speed limit is 70mph (112kph)] and 30mph (48kph) for all other roads; times, therefore, are derived from very conservative speed estimates.

In spite of this conservative estimate of travel times, many airports are in surprisingly close proximity to at least one other airport (although, as noted, in South-East England as well as in Scotland, most proximate airports are owned by BAA); bear in mind that, for example, a driving time of up to two hours between two airports implies that residents located halfway (in terms of driving time) can get by car to either airport within one hour. There is, in fact, only one airport, Norwich, lying more than two hours from its closest neighbour; all of the remaining 20 airports lie within 1.5 hours of at least one other airport (and, in some cases, several airports), The average driving time beween airports is slightly more than one hour, implying an average journey time of about 0.5 hours for passengers located at the half way point on the fastest routes. This, of course, is well within the time criteria set by the CAA.

Overall, the results of these three separate analyses of airport hinterlands suggest that in the UK there is a large degree of overlap of general catchments for passenger traffic and, in this context, the airports industry appears to have a potentially competitive structure (which will limit the average fare yield that the airlines can expect and, in turn, will influence negotiated contact prices). There will, of course, be a degree of differentiation in the market. Not all airports have the infrastructure to serve long-haul destinations (although a surprising number do have this capability). For environmental reasons some have restrictions on their hours of operations, and the market for freighter operations is concentrated on only a few airports[15]. But, on the whole, the market for the provision of airport services in the UK appears to be strongly, if imperfectly, competitive; the one possible exception is the sub-market for international connecting traffics in which London Heathrow has carved out for itself a national dominance[16].

6. FINANCIAL PERFORMANCE

If the structure of the UK's airport industry is strongly competitive (at least outside the London region and Scotland, where BAA is dominant), individual airports will have limited market power and are more likely to be price-takers, especially when it comes to negotiating contracts to attract new business. But if, as received wisdom will have us believe, airports are subject to very high fixed costs and thus pronounced economies of density (as well as supposed economies of scale), such competition can be expected to result in airports with small traffic volumes, and perhaps even not-so-small airports, generating financial losses. In part of mainland Europe it is this belief that competition will lead to average prices below average costs for many airports, that has encouraged a planned rather than market-led approach to the development of the airport industry.

To examine whether airports in a competitive environment are generally loss-making (or whether airports are so differentiated and competition so imperfect that profits are excessive), summary statistics have been used on the financial performance of UK airports, compiled by the Centre for Regulated Industries at the University of Bath. These data have the great advantage that they are subject to consistent (UK) accounting standards, but, nevertheless, their use is not without its problems. First, in spite of the data being compiled on an annual basis, comparison between years is difficult because of changes in accounting standards[17]. Second, and more importantly, airports have often reported year-by-year results covering different periods of time, either: 9 months, 12 months or 15 months. Third, different airports have different depreciation policies. Finally, there are two sets of accounts available, one based on Company House returns and the other based on returns to the CAA for regulatory purposes; the two sets are, for the most part, the same but there are a few differences. The following analysis focuses on Company House data for 2005-6, which has the virtue that all airports are reporting 12 months results.

There are 27 *individual* airports reporting financial data in the series, ranging from Southend to the east of London with a turnover of just less than £5m at one extreme, to London Heathrow with in excess of £1bn of annual sales[18]. But, there is a discontinuity in the size range. The four airports, Heathrow, Gatwick, Stansted and Manchester, are very much larger than the remaining 23; because of this, the fact that the financial performance of medium-sized and small airports is of more interest and especially because in 2005-6 all four of these airports were subject to price controls[19], they have been excluded from the following analysis. This gives a range of turnover for the remaining airports of between £5m to £111m.

Pertinent data for the 23 airports is shown in Table 5. Listed are: turnover, operating profit/loss (after allowing for depreciation), net profit/loss (after allowing additionally for tax and interest), operating profit as a percentage of turnover, and operating profit as a percentage of fixed assets (except for Coventry which was excluded because of anomalies in the data). These data refer to all the activities engaged in by the respective airports, including what the economic regulatory accounts refer to as non-operational activities.

The data show that, in 2005-6, of the 23 airports nearly all were profitable; only two, Blackpool, with a turnover of £6.3m, and Durham Tees Valley, with a turnover of £10.8m, made an operating loss *and* a net loss overall[20]. Coventry, with a turnover of £14.1m, also made an operating loss but recorded a net profit, whilst Cardiff, with a turnover of £22.1m, made an operating profit, large in relation to turnover, but an overall net loss[21]. Humberside also recorded a net loss on a more modest turnover of £10.9m[22].

Although the few airports recording losses of one sort or another are among the smaller airports in the group examined, there are seven other airports falling within a similar range of turnover (up to £22m) that made both an operating profit and a net profit. These include the smallest airport, Southend; a small turnover *per se* does not appear to be an impediment to profitability. On the other hand, the margin of profit does appear to increase with turnover, but so too does the ratio of fixed assets to turnover; consequently operating profits expressed as a percentage of fixed assets, a broad indication of the return on capital employed, do not show such a strong association with turnover (see Figure 2).

Generally speaking, the better return on fixed assets were produced by airports occupying the middle range of turnover but, overall, the performance measure in Figure 2 does not suggest an inability of small to medium-sized airports to make a decent return on fixed assets; the ratio of operating profits to fixed assets was over 32% for the relatively small Biggin Hill, for example. Most probably, the ability of such airports to perform well is assisted by the multi-product nature of the industry and associated economies of scope.

Nor do the performance measures suggest, as do proponents of the "airports are natural monopolies" school, that if no price controls are imposed the industry will make excessive returns. The average return (operating profits as a percentage of fixed assets) for the 22 airports is 15.3 (or 10.9 if we exclude the single most positive and negative outlier). This is very similar to the overall return for the non-financial sector in the UK in 2005 and 2006. To extend the comparison, non-financial *service* sector companies in the UK made an average net return of 17.9% in 2005 and 19.5% in 2006, whilst the corresponding returns for the *manufacturing* sector were 9.1 and 7.8; the return in the UK airports' industry falls neatly between the two (Table 6). Competition appears to be a most effective regulator[23].

7. CONCLUSIONS

On the basis of the foregoing evidence, the author would argue that a competitive framework is an achievable objective for a national airports policy. It is by no means evident that the industry is inherently a natural monopoly industry and thus requires regulation of prices or financial returns. On the contrary, the UK illustrates the ability of an airports industry to evolve a competitive structure whereby competition is an effective regulator of what the airport can charge the airline. Where there have been problems it is because of the failure to break up the state enterprise, the British Airports Authority, when it was privatised in the mid-1980s, so that proximate airports in two UK regions, London and Scotland, continue in common ownership. The lesson to be drawn is clearly apparent.

And yet, in those countries where privatisation or corporatisation of the airports industry is on the policy agenda, as is currently the case in Spain and Portugal, it appears that economic regulation is considered the natural adjunct of such a policy, a necessary appendage[24]. The alternative approach, of restructuring ownership to provide a less concentrated, more competitive industry structure and then allowing competition to drive the industry forward, does not appear on the radar screen. It is suspected that one of the reasons for this is that unless the national administrations are familiar with the processes, the fundamental problems associated with even well-designed economic regulation[25] will not be fully appreciated (and there will be an army of advisers with a vested interest in a regulated solution; the consulting industry, for example, does well out of offering solutions to regulatory problems).

The most important of these perceived problems is that the price control approach could discourage investment, the so-called “hold-up” problem, and encourage the under-supply of service quality. In the former case, because the regulator can commit to a regulatory settlement for only a limited period of time (usually five years) but investments are amortized over much longer periods, the regulated firm is faced with the risk that (future) regulators might renege on the regulatory settlement, thus reducing incentives to invest[26]. In the case of service quality, the price-regulated firm can save costs and increase its return by skimping on quality but the regulator finds the problem difficult to address because of the difficulty of judging an optimal level of service quality.

And yet the irony of this situation is that, as we have seen, the unregulated airports industry reaches its own solution to these problems: it establishes long-term vertical supply contracts with its airline customers. The long-term nature of the contract provides the security that the airport needs to sink costs in additional infrastructure, thus avoiding the hold-up problem, and the terms of the contract stipulate the quality of service that the airline expects from the airport. It is, after all, the way in which similar issues are resolved in much of the market economy[27]. In contrast, the effect of regulation can be to crowd out the efficient solution[28].

It would be better, therefore, if policymakers when undertaking industry reviews, instead of reaching first for the regulatory tool-box, pose the question: is the structure of the industry such that a reasonably competitive outcome is likely? If not, can the industry be restructured to make it more competitive? For the UK’s airport industry, as the author has tried to show, competition appears to have worked well and led to a dynamic industry, free of subsidy[29], yet profitable for both small and large airports, with an overall level of profit similar to that for the non-financial sector of the UK economy: a most satisfactory state of affairs.

NOTES

1. For a recent excellent general overview of the UK industry, see Graham (2008).

2. At www.caa.co.uk/airportstatistics.

3. For UK airports with under £30mn turnover (n=13), total passenger numbers explained twothirds of the variance in turnover.

4. BAA is owned by Airport Development and Investment Limited (ADI), in turn a wholly owned subsidiary of SGP Topco Limited, in which Groupo Ferrrovial SA holds 61.06% of the ordinary shares through two of its subsidiaries. The other two shareholders are Airport Infrastructure Fund LP, which is managed by Caisse de Dépôt et Placement du Québec, which has 28.9% of the ordinary shares and Baker Street Investment PTE Limited, a subsidiary of GIC Special Investments PTE Limited, which holds the remaining 10%.

5. Some have been written with 20-year terms.

6. For a review of similar arrangements in the electricity supply industry, see Littlechild (2007).

7. This description of contract terms is based on those in two contracts, details of which are known to the author.

8. Note that the airline is not necessarily dependent upon the existence of a potentially competing airport in the same region. It is to be stressed again that the airline will be looking for the best return on its airline capital across a wider European market.

9. It is also one of the UK's major centres for air freight.

10. Competition Commission, 2002, Appendix 7.5.

11. This group is referred to as "non-legacy" airlines rather than LCC's because only easyJet and Ryanair maintain the essential characteristics that define the original LCC brand.

12. For London Stansted the figure was about 80% but closer to 90% in the case of London Luton and London Gatwick. This difference between Stansted and the two other airports might reflect the fact that Stansted is dominated by Ryanair, which has a lower average fare yield than the low cost airlines that are relatively more important at Gatwick and Luton; thus passengers might be driving longer distances to benefit from lower fares.

13. One of the UK's two competition agencies, the Office of Fair Trading (OFT), conducted in 2005-6 an investigation of UK airports (OFT, 2006). This led to a referral to the second agency, the Competition Commission, with the request that it carry out a market investigation into the supply

of airport services by BAA, the dominant airport operator in two regions of the UK, with a view to increasing competition in this part of the market. This inquiry is ongoing but in April of this year the Commission published its *Emerging Thinking* report[13]. The Commission plans to publish its interim conclusions in August 2008 and its final report in March 2009.

14. Cardiff International is the only significant airport in Wales.

15. The sunk costs associated with the specialised facilities required for freight operations are also protected in a number of cases by long-term contracts.

16. In this part of the market, London Heathrow competes with Mainland European hubs.

17. The most recent examples are FR17 and FR 21.

18. Also included in the series, but in aggregate form only, are the results for the Highland and Island group of airports, controlled by the Scottish Executive. Because of the aggregation, these are excluded from this analysis.

19. Manchester was de-designated in 2008, thus removing price controls.

20. Blackpool's operating loss and net loss were virtually identical, recording no movement on the tax account and virtually zero movement on the interest account.

21. Cardiff's net loss is the result of an exceptionally large tax charge.

22. Humberside's net loss is the result of a large interest payment.

23. It is perhaps useful to note that a survey by SH&E (2006) of 50 European airports, most of which were in the public sector, found that the average return on capital was 4.6%.

24. For a very good overview of the European industry, see Gillen and Niemeier, 2008.

25. In the case of the UK, utility industries has taken the form of the price control model "RPI-/+X", developed during the 1980s and, because this model provides incentives for economic efficiency (particularly because of its forward looking approach), it is generally considered to be superior to rate base (rate of return) regulation which preceded it. The generic model has a number of key features: a periodic review process, a building blocks approach focused around a Regulatory Assets Base (RAB) which integrates (depreciated) past and planned investments, and a process for deciding upon an allowable return on the RAB: the RAB, allowable return and efficient operating costs then form the basis for determining future allowable prices, usually for a period of five years, benchmarked against the Retail (Consumer) Price Index, hence the RPI-/+X formula. There are different variants of the approach based on this core, with a different emphasis given to different components at different times and according to the industry concerned, (for example, applied to the airports' industry, there can be commercial revenues from retailing to take into account).

26. There are counter arguments that suggest that price-controlled airports might over-invest. Furthermore, there is also the issue of a suitable cost of capital. It is argued that the standard

approach, deriving the weighted average cost of capital (WACC) with reference to a partly debt-financed RAB and an equity-based capital expenditure programme, does not provide enough incentive for equity capital (particularly in circumstances where there are, as is probably the case with large airports like Heathrow, decreasing returns to scale).

27. By coincidence, at the time of writing this paper, the following example appeared in the *Financial Times* (3rd July 2008): "*Scottish Coal has agreed to sell about 2 million tonnes of coal a year – half its current output – to Scottish Power to feed its two coal-fired power stations… . The coal will be sold at an undisclosed fixed price, which Scottish coal said gave both parties the certainty they need to invest in new mines and power generation equipment*."

28. London Luton Airport provides an interesting footnote on this point. EasyJet, an important customer of Luton, attempted in its earlier days at the airport, to get the airport subject to price control. It failed to do so, but it then reached a negotiated long-term contract with the airport which, when judged against the published tariff, was on terms most favourable to the airline.

29. The exceptions are the Highland and Island airports, subsidized by the Scottish Executive for social reasons.

TABLES AND FIGURES

Table 1. **Selected Financial and Operating Data for UK Airports, 2005-06**

	Turnover (£000)	**ATMs**[a]	**Other movements**[b]
London Heathrow	1 195 400	472 954	5 981
London Gatwick	361 500	254 004	9 058
Manchester	290 553	217 396	16 421
London Stansted	176 500	180 729	15 465
Birmingham	111 109	113 668	9 731
Glasgow	82 615	97 610	13 296
Edinburgh	77 381	117 312	9 808
London Luton	77 021	87 690	20 203
Newcastle	51 360	55 164	23 798
Nottingham East Midlands	50 566	56 224	24 490
Bristol	49 619	59 854	20 670
London City	40 180	61 179	9 733
Aberdeen	33 954	94 665	17 851
Belfast International	31 206	43 780	37 093
Liverpool	2 8 799	43 312	37 347
Cardiff	22 103	20 689	22 337
Southampton	22 022	45 109	13 351
Leeds Bradford	21 023	36 330	31 641
Exeter	17 707	14 481	40 572
Bournemouth	14 440	14 041	69 600
Coventry	14 123	13 951	54 134
Norwich	12 089	20 894	30 145
Humberside	10 934	11 342	25 996
Durham Tees Valley	10 834	53 532	52
London Biggin Hill	6 892	4 834	62 666
Blackpool	6 333	13 028	61 985
Southend	4 973	1 548	47 798

Source: Centre for Regulated Industries, *Airport Statistics 2005/6*, Appendices D1 and B2.

a Movements of aircraft engaged in the transport of passengers, cargo or mail on commercial terms.
b Includes test and training flights, aero club movements, military movements and private flights.

Table 2. **Ownership Patterns at Main Airports in the United Kingdom, 2007**

	Present ownership	Private interest (%)	Privatization	
			Date	Re-sales[a]
Aberdeen	ADI (BAA)	100	1987	1
Belfast City	Ferrovial	100	n.a.	1
Belfast International	ACDL	100	1994	2
Birmingham	Local authorities/Dublin Airport Authority/ Macquarie Airports/ Employees	51	1997	
Bristol	Ferrovial / Macquarie Airports	100	1997	
Cardiff	ACDL	100	1995	1
Edinburgh	ADI (BAA)	100	1987	
Glasgow	ADI (BAA)	100	1987	2
Leeds Bradford	Bridgepoint	100	2007	
Liverpool	Peel Holdings	100	1990	
London City	AIG / GE / Credit Suisse	100	n.a.	2
London Gatwick	ADI (BAA)	100	1987	1
London Heathrow	ADI (BAA)	100	1987	1
London Luton[b]	ACDL	100	1998	1
London Stansted	ADI (BAA)	100	1987	1
Manchester	Local authorities	0	n.a.	
Newcastle	Copenhagen Airport	49	2001	
Nottingham East Midlands	Manchester Airport Group	0	1993	1
Prestwick	Infratil Ltd	100	1987	2
Southampton	ADI (BAA)	100	1961	2

Source: Adapted from Graham, 2008. All airports in the United Kingdom with more than one million annual passengers in 2005.

n.a. = Not applicable.

a "Re-sales" indicates the number of changes of owner since the first privatization or initial sale in the case of Belfast City and London City.

b 30-year concession contract. Ownership remains with the local authorities.

Table 3. **UK Operating Bases for Four Non-Legacy Airlines, Summer 2008**

	easyJet	Flybe	Ryanair	Jet 2
Belfast:				
– Belfast City		●	●	
– Belfast International	●			●
Birmingham		●	●	
Blackpool				●
Bournemouth			●	
Bristol	●		●	
Edinburgh	●		●	●
Exeter		●		
Glasgow:				
– Prestwick			●	
– Renfrew	●			
Leeds Bradford				●
Liverpool	●		●	
London:				
– Gatwick	●			
– Luton	●		●	
– Stansted	●		●	
Manchester	●	●		●
Newcastle	●			●
Nottingham East Midlands	●		●	
Southampton		●		

Table 4. **Driving Times between Adjacent Airports** (hours.minutes)

	BHX	BLK	BOH	BRS	CWL	DSA	EMA	EXT	HUY	LBA	LCY	LGW	LHR	LPL	LTN	MAN	MME	NCL	NWI	SOU	STN
BHX							0.48								1.26	1.34					
BLK										1.44				1.14		1.01					
BOH																				0.42	
BRS					1.23			1.17													
CWL				1.23																	
DSA							1.22		0.48	1.20						1.44					
EMA	0.48					1.22															
EXT				1.17																	
HUY						0.48				1.32											
LBA		1.44				1.20			1.32							1.06	1.29				
LCY												1.01	0.44								0.47
LGW											1.01		0.44		1.14					1.28	1.19
LHR											0.44	0.44			0.40					1.08	1.09
LPL		1.14														0.44					
LTN	1.26											1.14	0.40							1.37	1.01
MAN	1.34	1.01				1.44				1.06				0.44							
MME										1.29								1.04			
NCL																	1.04				
NWI																					2.12
SOU			0.42									1.28	1.08		1.37						
STN											0.47	1.19	1.09		1.01				2.12		

BHX: Birmingham	BLK: Blackpool	BOH: Bournemouth	BRS: Bristol	CWL: Cardiff	DSA: Doncaster	EMA: Nottingham
EXT: Exeter	HUY: Humberside	LBA: Leeds Bradford	LCY: London City	LGW: Gatwick	LHR: Heathrow	LPL: Liverpool
LTN: Luton	MAN: Manchester	MME: Durham Tees Valley	NCL: Newcastle	NWI: Norwich	SOU: Southampton	STN: Stansted

Table 5. **Financial Data for the Smaller UK Airports, 2005–06**

	Turnover (£000)	Operating profit/loss (£000)	Net profit/loss (£000)	Operating profit as % of turnover	Operating profit as % of fixed assets
Birmingham	111 109	35 477	19 458	31.9	9.9
Glasgow	82 615	25 789	15 153	31.2	10.0
Edinburgh	77 381	31 381	18 335	40.6	12.1
London Luton	77 021	12 878	5 643	16.7	13.5
Newcastle	51 360	19 072	15 309	37.1	10.9
Nottingham East Midlands	50 566	15 804	7 433	31.3	25.8
Bristol	49 619	25 344	23 465	51.1	33.7
London City	40 180	7 587	6 024	18.9	164.8
Aberdeen	33 954	10 944	8 715	32.2	11.1
Belfast International	31 206	9 436	4 700	30.2	7.9
Liverpool	28 799	18 336	20 606	63.7	17.7
Cardiff	22 103	5 953	-2 188	26.9	7.8
Southampton	22 022	8 791	5 941	39.9	9.6
Leeds Bradford	21 023	1 357	571	6.5	2.9
Exeter	17 707	1 019	32	5.8	6.1
Bournemouth	14 440	2 951	1 513	20.4	5.6
Coventry	14 123	-1 739	1 415	-12.3	N.A.
Norwich	12 089	563	71	4.7	2.3
Humberside	10 934	642	-751	5.9	2.2
Durham Tees Valley	10 834	-2 715	-1 242	-25.1	-9.8
London Biggin Hill	6 892	391	246	5.7	32.1
Blackpool	6 333	-2 953	-2 952	-46.6	-46.4
Southend	4 973	137	118	2.8	7.1

Source: Centre for Regulated Industries, *Airport Statistics 2005/6*, Appendix D.

N.A. = Not available.

Note: There is some variability in depreciation policies which might have an effect on the figures for operating profits as a percentage of fixed assets.

Table 6. **Net Return (%), Airports and UK Private Non-Financial Sector, 2005–06**

	2005–06	
Airports[a]	15.2 (10.9[b])	
	2005	**2006**
Non-financial service sector	17.9	19.5
Manufacturing sector	9.1	7.8
All private, non-financial corporations	14.0	14.5

Source: National Statistics and author's calculations.

[a] Airports listed in Table 5.
[b] Excluding outliers.

Figure 1. **Competition and Catchment Areas**

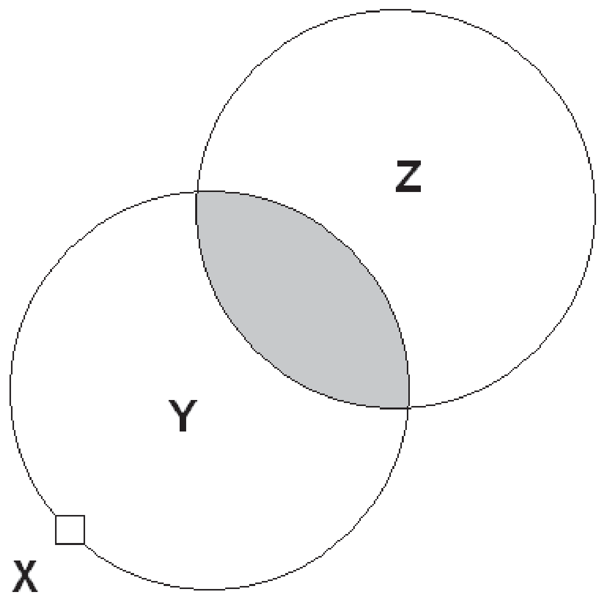
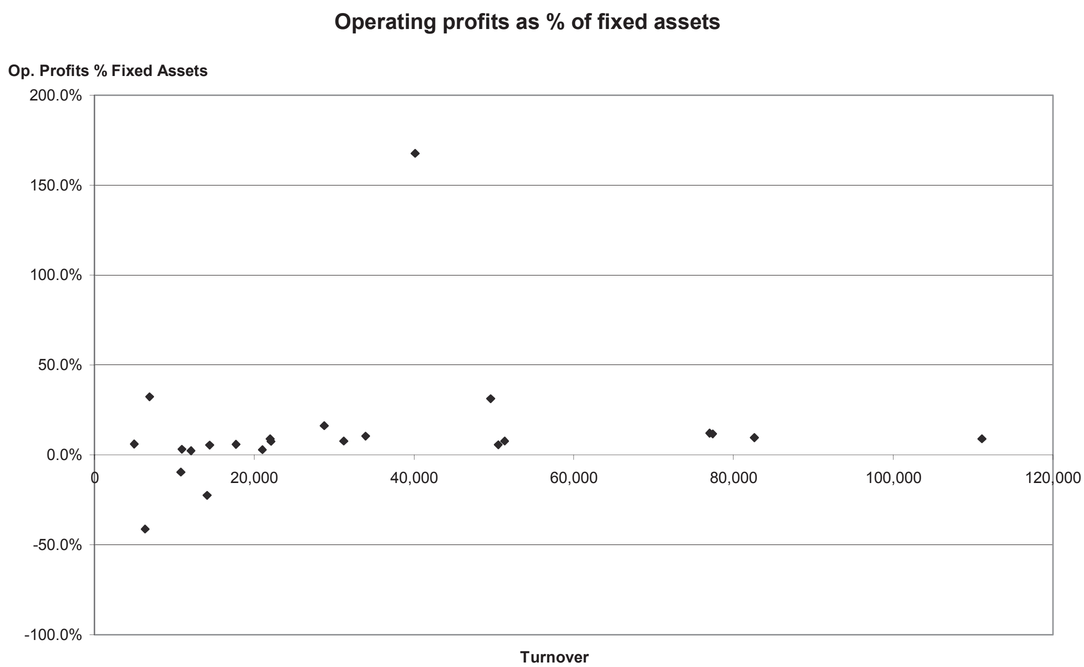


Figure 2. **Operating Profit as % of Fixed Assets *vs.* Turnover** (£000)



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THE IMPACT OF CLIMATE CHANGE POLICY ON COMPETITION IN THE AIR TRANSPORT INDUSTRY

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SUMMARY

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ABSTRACT

This paper examines how climate change policy can impact on competition, prices and profitability in the air transport industry. It begins with an outline of the climate change policies that have been suggested, and it gives particular attention to the inclusion of air transport in an emissions trading scheme (ETS).This is likely to prove an important policy direction, with the EU, Australia and New Zealand all planning to include air transport in their ETSs. The scope for airlines to reduce their emissions intensity in the short and long run is examined – it is concluded that the scope in the short run is quite limited. After this, the application of the emissions trading schemes of the EU, Australia and New Zealand to air transport is discussed, and the possible impacts on airfares are assessed. Allowance is made for the cost of permits for both direct and indirect emissions.

The impacts of climate change policies, such as carbon taxes or requirements to purchase emissions permits, on airline competition, prices and profitability are analysed next. Impacts differ according to market structure – whether airline city pair markets are competitive, monopolistic or oligopolistic. They also depend on the time scale – airlines are unlikely to be able to pass on the full cost of their permits to their passengers in the short run, though in the long run, it is likely that airlines will exit from some city pairs, and this will enable the remaining airlines to raise their fares and restore their profitability. This may not occur in markets constrained by airport slots or capacity limits imposed in air services agreements on international routes, though the airlines' problems are not likely to be as severe as has been suggested.

If permits are provided free of charge to airlines, fares should still rise in the long run, assuming that airlines are profit maximisers and they factor in the opportunity cost of the permits they obtain free. However, even if airlines do this, there can be cases where fares do not rise by as much as they would if permits had to be purchased, because the operation of the ETS may discourage exit from markets. If airlines do not act as profit maximisers, air fare increases will be limited, and airlines will have the scope to cross-subsidize less profitable routes. The limited evidence on airlines' use of free inputs (such as airport slots) is examined, to obtain insights into whether airlines do indeed maximise their profits – this evidence is inconclusive. Finally, the application of an ETS to international air transport is considered – this can give rise to issues of competitive non-neutrality, even when permits are sold.

1. INTRODUCTION

Several countries are introducing climate-change mitigation policies, and many of these are intending to apply them to air transport. While there are several ad hoc policies that countries are implementing which are loosely justified in terms of climate change benefits, there are some comprehensive policies, such as carbon taxes and emissions trading schemes (ETSs), which are specifically designed to reduce greenhouse gas (GHG) emissions.

This paper explores how these systematic policies will impact on air transport costs, competition, fares and profits. Taxes, or the requirement to purchase emissions permits, will add to airlines' costs, and they will seek to pass these costs on to their passengers. The extent to which they will be able to do this, in the short and long run, and whether the ability to do so depends on market structures, are examined. One issue that arises is whether higher costs will induce some airlines to exit from route markets, and whether this will assist the remaining airlines to maintain their profitability.

The impacts on competition and airfares are more uncertain if airlines are provided with free permits. One issue is whether there are any situations in which the impacts of free permits are the same as when permits have to be paid for, if airlines are profit maximisers. Another issue is whether the method of allocation of free permits could affect competition and fares, by encouraging airlines to stay in marginal markets or by altering their cost structures, even when airlines are profit maximisers. In such situations, some of the value of the free permits may be passed on to passengers. There is also a possibility that airlines will not maximise profits, and will not recognise the full value of the free permits they obtain when making decisions – will airlines keep fares low and try to gain market share, and will they use profits on one route to cross-subsidize other routes? These issues are relevant to the question of whether the introduction of climate change policies will impact on competitive neutrality on international markets.

The paper begins with a review of climate-change mitigation policies that have been suggested for air transport, and pays particular attention to the workings of ETSs. It also examines the ability of airlines to reduce their emissions in the short and long run. There is a brief review of ETSs proposed for air transport, and an assessment of their possible impact on fares. Next, the paper analyses how carbon taxes or permits which have to be paid for will impact on competition in unconstrained and capacity constrained markets. After this, the impacts of free permits on competition and fares are considered. How these policies might impact on competition in international markets, not necessarily directly included in the policies, is briefly considered. Finally, some conclusions based on the analysis are drawn.

2. CLIMATE CHANGE MITIGATION POLICIES AND AVIATION: AN OUTLINE

There is quite a wide range of policies that might be imposed on air transport operators, airlines and airports, to induce reductions in GHG emissions. Some of these are very general policies, such as carbon taxes, while others are specific. Some are intended to work though reducing air travel, while others are intended to work more directly, though reducing the use of fuel and thereby reducing emissions. Two aspects of these policies that are of relevance are:

- How closely or directly are the policies related to fuel use or emissions?;
- Will the policy promote leakage, by encouraging those affected to switch their behaviour and substitute goods and services which create emissions elsewhere?

In general, it is likely that policies directly related to emissions or fuel use will be more cost effective in reducing emissions, since the closer a control is to the externality, the better it will work. There will be incentives to reduce fuel use or emissions per passenger as well as to reduce passenger numbers. Many of the policies noted here also face some risk of a leakage effect – they may reduce emissions from the traffic that is directly targeted, but emissions from substitutes will increase. Thus, a tax on aviation could lead to an increase in emissions from ground transport. The likely leakage effect needs to be taken into account when assessing the effectiveness of a policy.

While many policies have been suggested, some are likely to be much more relevant than others. Thus, some countries are moving to include air transport in their emissions trading schemes, and doing so will amount to a major policy shift with significant impacts. Attention here will be focussed on these core policies. Other policy options are worth noting, though they are given less attention.

2.1. Policy options

Specific aviation levies

Several countries are now imposing taxes on aviation that are ostensibly intended to reduce GHG emissions. The UK has the Air Passenger Duty (APD) (IATA, 2006b), and other countries such as the Netherlands have similar taxes. Others have called for specific taxes on aviation to reduce emissions (Macintosh and Downie, 2007). These are taxes levied on passengers when they take flights – they may depend on the length of the flight and be higher for higher class travel. These would only reduce emissions through their effect on air travel demand, and they would give rise to some leakage effects.

Travel restrictions

There have been suggestions for limiting the number and duration of flights that residents of specific countries might be permitted to take. While such measures could be effective in reducing emissions, they are draconian and would be very difficult to implement.

Mandatory emissions standards

Countries have considered setting emissions standards for aircraft that use their airports. These could work in a way similar to noise standards – noisy aircraft are prohibited from some airports. While such approaches may work for localised externalities such as noise, they will not work well for global externalities, since there is a strong likelihood of leakage. High emissions will shift to other airports and still generate emissions.

Tax incentives

Tax incentives can be used to induce airlines to reduce their emissions. Thus corporate tax treatment of depreciation can be changed to make it more attractive to airlines to have newer fleets. Since newer aircraft are less emissions intensive, this would have the effect of reducing emissions.

Air traffic control reforms

Considerable emissions are generated through ATC delays and less direct flight paths (Hodgkinson, Coram and Garner, 2007). Both institutional (Single European Sky) and technological improvements have the scope to reduce these. These options should not lead to carbon leakage, since they may well be accompanied by cost reductions, encouraging greater utilisation of the air space subject to the reforms.

Airport reforms

Many airports, especially in the US, are subject to considerable delays, on the ground and in the air, and thus emissions are higher than need be. Delays and emissions can be reduced by more efficient use of airport capacity, through the introduction or improvement of slot management schemes (see Forsyth and Niemeier, 2008), or through pricing. Again, there should be no leakage, since reductions in the costs of using airports which institute reforms will encourage less use of non-reformed airports.

Airport emissions charges

It is feasible for airports to impose emissions charges in the same way that they do for noise. Some airports, such as Zurich, impose emissions-related charges to lessen locally damaging emissions. Since airport use is not likely to be closely related to the total emissions from flights, which may be of long or short duration, this is not likely to be an effective means of controlling a global externality such as GHG emissions. There is also a strong likelihood of leakage.

Controls on airport development

Limits to airport expansion are frequently used as a means of lessening externalities associated with their use, such as noise. Restrictions on airport development (e.g. in London) are now being advocated as a means of limiting GHG emissions. Granted that airport use is only weakly related to emissions, and that the leakage effect is likely to be substantial (passengers will travel by car to more distant airports), this would not be a cost-effective means of reducing aviation emissions.

Aviation fuel taxes

Aviation often does not pay much by way of fuel taxes, even on domestic services – this contrasts with high fuel taxes often levied on land transport modes such as private motor vehicles. Aviation fuel taxes would be closely related to emissions, and thus could be cost effective. They would work in a manner similar to a carbon tax, which is the more general policy instrument. There is an issue of leakage if substitute modes are not subjected to similar taxation.

Carbon taxes

Carbon taxes are comprehensive taxes on the generation of CO_2 emissions levied across all or several industries. While many countries prefer to go down the ETS route, some countries, such as the US, could introduce carbon taxes instead. In the case of aviation, a carbon tax would most likely be implemented through a tax on fuel, related to its CO_2 content. The comprehensive nature of carbon taxes implies that substitute modes, such as land transport, would be similarly treated, and there is no risk of leakage to them. There remains some risk of leakage to other jurisdictions that do not impose comprehensive emissions policies – tourists are encouraged to visit countries which do not impose carbon policies rather than those which do.

Emissions trading schemes

Emissions trading schemes (ETSs) are shaping up to be the core policy instrument preferred by many countries to achieve reductions in GHG emissions (for discussion of this, see Frontier Economics, 2006; IATA, 2006a; Sentance, 2007; Thompson, 2007; Hodgkinson, Coram and Garner, 2007). The European Union, Australia, New Zealand and several US states are implementing ETSs, and all air transport is to be included in the EU scheme, while domestic air transport is to be included in the Australian and the New Zealand schemes.

ETSs normally have a cap and trade structure. An overall limit is set on emissions – this limit may be one which is agreed with international partners. While targets for particular years will be set, it will also be necessary to set trajectories from the start of the scheme to the years for which specific targets must be met. With the overall limit being set for a particular year, permits to emit up to this limit can be issued. Firms which emit are required to have a permit to emit. Permits can be traded, and a market price for them will be established. Market prices will depend on how tight the cap is, and on how easy it is for firms to achieve emissions reductions – over time, the cost of achieving a given target will fall as new technical options become available. Granted that the costs of achieving reductions in the earlier years will be higher than in later years, governments may set easier targets for the earlier years. In some schemes, there may be scope to save or borrow permits from year to year.

Granted the broad structure of the ETS, there are a number of issues that will need to be settled when applying one to aviation.

2.2. Air transport in an ETS

An air transport specific ETS?

A country might impose an ETS on its air transport industry – this could operate alongside a general ETS for the rest of the economy, or it could be imposed only on air transport. Such a scheme would have the effect, if implemented effectively, of achieving a specific target level of total emissions from air transport. This property is seen by some as desirable.

However, an air transport-specific ETS would be an inefficient means of achieving a country’s targets. An ETS will work most efficiently if there is a single price for carbon for all industries, since this would encourage the greatest reduction being achieved in the industries that face the least cost in reducing emissions. If the objective is to achieve a country's overall target at least cost, specific industry targets are counterproductive. It is possible that, under an ETS, the reductions in emissions (compared to a business-as-usual case) in some industries such as aviation may be quite small, because they do not have much scope to reduce. If the ETS is working overall, there is no problem if aviation does not achieve much reduction in emissions.

It might be objected that aviation emissions are more damaging than other emissions (see discussion below). If this is the case, it can be handled most efficiently through adjustment factors for aviation in the ETS (e.g. requiring airlines to have more permits per unit of fuel purchased) or by supplementary schemes, such as emissions trading for other gases. Such approaches address the issues directly rather than indirectly.

Substitute industries

If efficiency in transport choices is to be achieved, it is desirable that substitute industries for air transport, including land transport, be also included in the ETS. If this is not the case, including air transport in the ETS will encourage switching from air to land transport, at some cost in terms of overall efficiency, and lessening the impact on GHG emissions reductions.

This will be the case if each mode is efficiently priced other than for its GHG emissions. In practice, some modes (e.g. motor vehicles) may be more heavily taxed than air transport, and this tax need not be optimally set. Other modes, such as rail, may be subsidized. Imposing an ETS on an economy that already faces many tax distortions needs special consideration.

Direct or indirect permits

An ETS may operate with all firms that produce emissions being required to have permits. Alternatively, it may operate with only a small number of firms being required to have permits directly, but with other firms that purchase inputs, the use of which generates emissions, paying indirectly for permits through the upstream suppliers being required to have permits. Thus, the suppliers of aviation fuel might be required to have permits for their sales, but airlines might not be required to have permits. The indirect system simplifies administration, though it does rule out some options or makes them more complex – for example, if airlines do not use permits directly it is difficult to allocate them free permits.

Free or sold permits

ETS permits can either be sold, or issued free. Relatively few issues arise if the permits are sold, for example, by auction. If permits are given away free, to whom are they to be provided? Incumbents will receive permits, but new entrants may not qualify. The criteria for allocation between airlines pose an issue, since the allocation process can impact on competition and market outcomes (see Morrell, 2006; CE Delft, 2007a; CE Delft, 2007b).

Permits for foreign firms

Some jurisdictions, such as the EU, are planning to extend their ETSs to include international air services operated by foreign airlines. This poses the question of whether these airlines will qualify for permits on the same basis as home country airlines – if not, there is a problem of lack of competitive neutrality. Even if foreign airlines are granted free permits, there remains an issue of who bears the costs of reducing emissions, since foreign passengers will still be paying higher air fares as a result of the implementation of the policy.

Carbon leakages

The carbon leakage problem is a well-recognised one for ETSs. Higher airfares to a country that is including air transport in its ETS will encourage visitors to go to other countries that are not imposing such policies. Airlines in the home country will have an incentive to replace their fleets with newer, lower emissions aircraft, selling their older aircraft to other countries. Their reduction in emissions is partly achieved by shifting emissions offshore.

The role of supplementary measures

While a country may adopt a core major policy to address GHG emissions, there is often a call for supplementary policies. The intention is often to increase the effect; for example, to increase the reduction in GHG emissions achieved. Thus, a carbon tax might be imposed but, in addition, airlines might be given tax incentives to renew their fleets – this would result in reductions in emissions beyond those achieved by the carbon tax. It is recognised that the response of aviation to carbon taxes or an ETS would not be large, and there have been calls for additional measures, such as aviation specific taxes, or accelerated depreciation allowances. However, if general policies such as carbon taxes are set at the right level, there should be no need to increase GHG emissions reduction from aviation – it is efficient that some industries reduce emissions less than others.

There is a further consideration that is relevant in the case of an ETS applied to air transport. In some respects, the ways an ETS works are very different from the ways carbon taxes work. Since the overall amount of GHG emissions is set by the policy, supplementary measures will have no effect on overall emissions. Thus, for example, if air transport is subjected to an additional tax, it will contract, and produce fewer emissions. However, this will free up permits, which airlines will sell to other industries, which will use them. Overall emissions will remain unchanged. Even if the reduction in aviation emissions is considered too small, supplementary measures, such as air transport taxes, will not help by achieving further emissions reductions.

In the situation where air transport is subject to an ETS, and this ETS is working effectively, there is little to be achieved by imposing further supplementary measures. It does make sense to correct distortions that are in place – for example, if corporate tax arrangements are discouraging efficient investments in new fleets or to reform air traffic control arrangements. However, other measures, such as restrictions on airport development or additional air transport taxes, impose an efficiency cost while doing nothing to reduce GHG emissions. Once the EU ETS is applied to aviation, the UK Air Passenger Duty will be both costly and ineffective. If additional measures are to be taken, they need to be justified in terms of other benefits, not in terms of reductions in GHG emissions.

2.3. Aviation emissions – the complexities

Aviation emissions pose a number of complexities that need to be recognised when policies are being set. In addition, the science of aviation emissions and the damage they cause is not settled.

Aviation produces CO_2, but there is evidence to suggest that the damage done by aviation emissions is greater than that done by equivalent terrestrial emissions. Like some other processes, aviation also produces a number of other emissions, including sulphur dioxide and nitrous oxides, which contribute to global warming and thus climate change costs. The condensation trails of aircraft also affect cloud formation and can have an impact on global warming. The impacts of these emissions are not straightforward, and will depend on where they occur. While various multiples have been suggested, it may not be accurate to state that the damage and cost of a tonne of CO_2 emissions is some simple multiple of the damage and cost of a tonne of terrestrial emissions: sometimes the impact might be larger, sometimes smaller.

In addition to this, there can be tradeoffs between different types of emission. Aircraft engines can be designed to reduce their CO_2 emissions, but at the expense of increasing their nitrous oxide emissions. While CO_2 emissions can be monitored moderately accurately through fuel use, other emissions may be less easy to monitor, and the damage created by the emissions of all kinds will be more difficult to monitor. Even where there is no uncertainty about effects, it would be difficult to design policies that accurately internalised the externalities.

Most current proposals involve a simple charge for CO_2 emissions, either through a tax or requirement for a permit. Moving from a zero to a positive price is probably welfare improving. If it becomes clear that CO_2 emissions from aviation are more damaging than terrestrial emissions, it would be efficient to adjust the charge upwards, by levying a higher carbon tax on aviation, or by requiring more permits to be purchased for a tonne of CO_2 from aviation. If only this is done, problems could develop in the longer term if engine manufacturers lower CO_2 emissions by increasing other emissions. If so, charges for these emissions may be needed, if feasible.

3. EMISSIONS REDUCTIONS OPTIONS

Airlines, and their suppliers such as aircraft manufacturers, have a range of options available to them to reduce GHG emissions. Most of the more effective options are likely to only be available in the longer term as a result of technological change. Short-term options are mostly likely to be of limited effectiveness.

3.1. Reductions options

Voluntary offsets

An airline can offset the emissions it creates by investing in schemes that reduce emissions, such as forestation schemes. There has been some questioning about how genuine some of these schemes are and whether they really reduce emissions. An airline can choose to offset all its emissions, and offer its passengers no choice. Such an airline will have higher costs than comparable airlines that do not offer offsets, and it will have to charge higher fares, thus risking its competitiveness. Some small airlines have chosen this path. The more common option is for airlines to offer their passengers the option of offsetting their emissions, at a price. Normally, only a small proportion of passengers are willing to pay extra for a carbon offset, but there are some airlines, such as the budget carrier Jetstar in Australia, that claim an over 10% take-up rate.

Flight path and network optimisation

With higher fuel prices, airlines have been reviewing their flight paths and networks. A network that is optimal with a low fuel price may not be so with a high fuel price. Airlines may be able to save fuel by altering flight paths (when permitted to do so by air traffic control authorities). Airlines have more direct control over their networks, and they have options to save fuel, perhaps by offering more direct flights that lessen the distance travelled by passengers, and perhaps by consolidating loads. These changes have the effect of reducing emissions. Airlines are likely to respond in the same way if GHG emissions mitigation policies are imposed – policies that increase the price of fuel will have the same effect as any other cause of higher fuel prices.

Fleet renewal

Individual airlines have the scope to renew their fleets and rely more on less emissions intensive aircraft. Newer aircraft have lower emissions per passenger kilometre than older aircraft. If there is a downturn in traffic, they will retire or mothball the high fuel and emissions intensive aircraft first. While an individual airline can respond quickly, and reduce the emissions from its fleet by buying newer aircraft, this is not an option for the whole industry. Fleet renewal will depend on how quickly manufacturers can supply new, more fuel efficient aircraft, and whether the airlines are willing to pay a large cost to turn over their aircraft more quickly. This suggests that fleet renewal will be associated with a considerable leakage problem. Airlines in countries with tough emissions policies, which impose high emissions charges, will seek to replace their fleets faster, but they will release high emissions aircraft that will be economical for the countries with weak or no emissions reductions policies to use. The gradual renewal of fleets over time will result in emissions reductions of around 1% per annum per passenger-kilometre, but emissions reductions policies are unlikely to speed up this process by much. It is likely that emissions reductions policies will have a positive, though quite small, impact on global emissions through fleet renewal.

Airport operational savings

There is some scope for aircraft to use less fuel on the ground at airports, for example, by greater use of tugs. The scope for this is greatest at airports that experience long on-ground delays.

Alternative fuels

There will be some scope for aviation emissions reductions in the medium term from the use of alternative fuels, such as biofuels. Airlines are currently experimenting with these. There does not seem much likelihood of a revolution in fuels in the medium term. There are questions about the availability and cost of alternative fuels.

Engine developments

In the long term, in two or more decade’s time, there may be significant changes in engine design, which will enable significantly lower emissions per passenger-kilometre, through achieving improvements in fuel efficiency. Over the very long term, there is the possibility of new methods of propulsion, such as hydrogen fuel cells, which produce no GHG emissions.

3.2. Responses to policy

Unlike other industries, such as electricity, air transport is not likely to be able to respond quickly to GHG emissions reduction policies. Emissions may be reduced by reducing air travel, or by reducing the emissions intensity of that travel. With technology being relatively locked in, there is only limited scope to reduce the emissions intensity of air travel in the short term. There is a gradual reduction in emissions intensity, and there are few options present that can accelerate this process by very much. It is unlikely that there will be technological options available for significant reductions in emissions intensity, except in the very long term.

Emissions reduction policies will increase airline costs, and in the long run, subject to the qualifications below, these will mostly be passed on to passengers as higher fares. This will have an effect on demand, as air travel is moderately price elastic. In some markets, where there are good substitutes for air travel, long-run demand elasticities are distinctly higher than short-run elasticities, and in these markets, demand reductions will be greater. Emissions reduction policies will be imposed on an industry with a strong and consistent growth rate, and their effects, even if carbon prices are high, will be to lower the growth rate of air travel and emissions from this travel, rather than reduce it.

4. CLIMATE CHANGE POLICIES AND THEIR IMPACTS

As noted above, the most comprehensive climate change policies that countries are adopting are ETSs. While there are several ad hoc policies directed towards reducing GHG emission from air transport, and there are some taxes which appear to be revenue-raising measures, justified in terms of reducing GHG emissions, most countries or jurisdictions which are making a substantial effort to reduce emissions are employing an ETS. Some countries could take the carbon tax route, which should have similar quantitative impacts on air transport even though it will work rather differently.

Three jurisdictions are planning to apply an ETS to aviation in the near future. The situation is summarised in Table 1.

Table 1. **Applying Emissions Trading to Aviation**

Jurisdiction	Aviation Sector	Time of Introduction	Comments	Allocation of Permits
EU	Intra EU	2012	Partial ETS: Motor vehicle transport excluded	Free, limited
EU	Beyond EU	2012	Partial ETS: Motor vehicle transport excluded	Free, Limited
Australia	Domestic	2010	Comprehensive ETS	Auctioned to Fuel Suppliers
Australia	International	Excluded	Comprehensive ETS	N A
New Zealand	Domestic	2009	Comprehensive ETS	Auctioned to Fuel Suppliers-possible free allocation
New Zealand	International	Excluded	Comprehensive ETS	N A

Source: Compiled from Commission of the European Communities (2008), Australia Department of Climate Change (2008), New Zealand, Ministry for the Environment (2007).

As Table 1 shows, the EU, Australia and New Zealand have advanced plans to apply their ETSs to air transport. Within the EU, international flights are to be included, but the intention is to also apply the ETS to flights beyond the EU, using both EU and non-EU airlines. At this stage, Australia and New Zealand intend to exclude international aviation for the time being, though it could be included later. While at least some of the permits in the EU will be supplied free of charge to airlines, there will be no free permits in Australia and New Zealand, at least initially (though New Zealand has indicated that this could change). In both Australia and New Zealand, airlines will not be direct participants in the ETS – rather they will be covered by permits being required at the upstream level, through the sale of fuel. In Australia and New Zealand there is an intention to introduce a comprehensive ETS which covers most of the economy – in Australia's case, it will cover all industries except for agriculture and forestry, as well as international shipping and aviation. The EU ETS is less comprehensive, and does not cover motor vehicle use at this stage. There is also no coverage of emissions from imported goods and services in these ETSs.

With an ETS in place, airlines will be affected both directly and indirectly. Airlines directly create GHG emissions when they use fuel. When permits are required, they will face higher fuel prices. By far the most attention that has been paid to aviation's HG emissions has concentrated on direct emissions. However, indirect emissions, which come about through the production of goods and services that are used as inputs, are also significant, though smaller than the direct emissions. Some estimates of the indirect emissions associated with Australian airlines international services are presented in Table 2.

Table 2. **Indirect GHG Emissions: Australian Airlines' International Services**

Source	**Emissions (Mt)**	**% of Direct Emissions**
From Home Production	0.848	18.0
From Imports	0.438	9.3
Total Indirect	1.286	27.4
Direct Emissions	4.700	100.0

Source: Calculations based on data in Forsyth *et al.* (2008).

These estimates were derived using data on the pattern of air transport industry purchases, along with the input-output structure of the Australian economy, as embedded in a computable general equilibrium model (Adams, Horridge and Wittwer, 2003). This model also relates CO_2 equivalent emissions from each industry to its output, enabling an estimate to be made of the CO_2 emissions indirectly associated with air transport. It indicates that indirect production of inputs in the home country generates about 18% of direct emissions, and that emissions from imported inputs account for about 9% of direct inputs. These results are for Australia, a country which relies heavily on coal, and which is a relatively carbon-intensive economy. On the other hand, Australian stage lengths are long, and goods and services inputs per passenger-kilometre (and thus indirect GHG emissions) would be relatively low.

Indirect emissions are of importance, but have different impacts from direct emissions. Airlines based in a country with a comprehensive ETS will be paying for indirect emissions as well as direct emissions – this will be true for international well as domestic flights.

The possible impacts of an ETS on fares are illustrated in Table 3. Five cases are considered: three short- to medium-haul types of flight (averages for three airlines) and two medium- to long-haul flights, as operated by Qantas. Estimates of the GHG emissions for a passenger flight are presented – these depend on the nature of the flight and the equipment used. In the case of the London-Sydney flight, older, less fuel-efficient aircraft are used. A price of €20 per tonne of CO_2 equivalent is assumed, as well as full pass-through of permit costs. To allow for total emissions from home sources (subject to the ETS – imports are assumed not to be subject to a country's ETS), direct emissions are multiplied by 1.2. The impacts on European flights would be less than this because the European ETS is not comprehensive.

Table 3. **CO2 Emissions and Impacts on Fares: Various Flights**

Airline:	**Ryanair**	**Lufthansa Passage**	**Condor**	**Qantas Hong Kong Sydney**	**Qantas London-Sydney**
Aircraft:	**New 737/A320**	**New 737/A320**	**New 737/A320**	**747 400**	**A330**
Average ticket price €	44	136	90	341	644
CO_2 per pax	0.088	0.107	0.163	0.470	1.600
Cost of permits €	1.76	2.14	3.25	9.40	32.00
% of ticket price	4.0	1.6	3.6	2.8	5.0
Cost of permits for direct and indirect emissions €	2.11	2.57	3.90	11.28	38.4
% of ticket price	4.8	1.9	4.3	3.4	6.0

Source: Calculations based on data in Scheelhaase and Grimme, (2007) and Forsyth *et al.* (2007).

This table gives a rough order of magnitude of the impact that an ETS might have on air fares in the earlier years, before airlines have been able to reduce emissions per passenger-kilometre significantly. The percentage change in fares ranges from 1.6 to 5, when only direct emissions are considered, and from 1.9 to 6 when direct and indirect emissions are included. Short-haul and long-haul flights are affected to about the same extent. If permit prices were higher, impacts would be proportionately higher. As can be seen, the cost imposition on airlines is significant, though smaller than that as a result of the rise in fuel prices over recent years.

5. IMPACTS OF POLICIES ON AIRLINE COMPETITION, FARES AND PROFITS

Suppose that airlines are faced with a carbon tax or an ETS in which they are required to purchase permits, either directly or indirectly, through their purchases from upstream suppliers. The case of free permits is considered later. The tax or permit requirement might be levied on fuel or on emissions though, most likely, fuel will be used as a proxy for emissions. It will result in a cost increase to the airline, initially for a flight. This will mean that the cost per passenger or unit of freight will increase. The impact on competition and on prices will depend on several factors:

1. Whether the short run or the long run is being considered;
2. The market structure of the market in question; and
3. Whether there are constraints on operation, such as slots at airports or on capacity permitted on routes (mainly through international regulation through air services agreements).

Three possibilities for market structures are competition, monopoly and oligopoly. It is probably best to analyse market structure at the route level, while recognising that some routes are imperfect substitutes for each other. At the route level, there may be competition, monopoly or oligopoly.

Some busy routes could be considered competitive, since there are moderately large numbers of airlines serving the route. Some North Atlantic routes or groups of routes, such as that between South East England and North East USA, could be regarded as competitive. There are several airlines which operate between the London and New York airports, along with others which serve nearby cities. Some routes between major hubs in Europe and Asia may also be competitive. Airlines in these markets can be regarded as price-takers, and have little scope to employ oligopolistic strategies.

At the other end of the scale, routes could be monopolistic. There are many routes around the world which have only one airline serving – these are typically thin, low-density routes. While monopolistic, meaning that the airline has some discretion over pricing, these routes will often be marginal, not highly profitable, and airlines may face competition from surface transport.

Perhaps the most common market structure is oligopoly – there are many routes with around two to four airlines. These airlines possess some market power, and recognise their interdependence. In most, though not all cases, there will be free entry and exit. This tendency to oligopoly might be explained by fixed costs of operating a route, or by the requirements of operating an adequate frequency in order to appeal to the passengers and make one's presence evident. Hence, even though there may be many potential entrants, a market may remain dominated by a few airlines.

5.1. Market power and profitability – the airline paradox

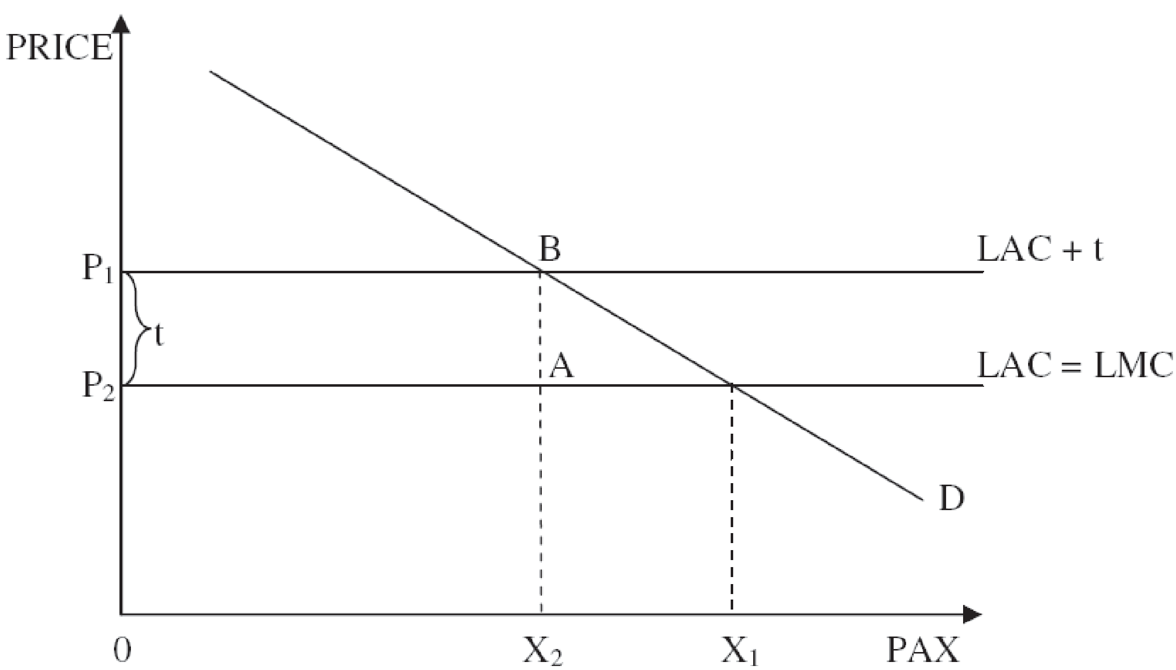
As suggested, some airline markets can be regarded as competitive, but most markets are best regarded as either oligopolistic or monopolistic. In short, airlines possess market power. If this is the case, one would expect them to be making profits over the longer term. In fact, the airline industry is hardly very profitable, struggling to earn the cost of its capital taking one year with another. Profitability is more typical of that which would be achieved in strongly competitive markets, rather than oligopolistic and monopoly markets. In addition, the industry has had to face several shocks on the cost side. These have led to short-run reductions in profitability, but in the longer term profitability has been restored. Again, this result is more characteristic of competitive markets rather than oligopolistic or monopolistic markets. The paradox is explained below. The monopoly power on most routes is weak, and routes are not necessarily highly profitable. On oligopoly routes, there is free entry and exit, and this results in profits being eliminated by entry and maintained by exit.

5.2. Impacts in non-constrained markets

Competition

In the short run, in a competitive market, a tax increase will impose a loss on firms in the market. As long as the price exceeds average variable cost, all airlines will stay in the market, offering the same amount of capacity. Prices will remain the same, and airlines will incur losses. While airlines may be able to reduce capacity on the market fairly quickly (and exit quickly if they choose to do so), it is likely that the values of their fleets will decline, if a large number of routes are affected by the imposition of the tax. While capacity on a route can be reduced quickly, that of all the affected airlines will not be. Profitability evaluated at the new lower opportunity cost of the aircraft can be restored quickly, but the profitability of the airlines which operate the route will not be restored to such a level as can return the cost of capital until the excess capacity in the industry is eliminated. In a growing industry such as air transport, this will happen when growth catches up with actual capacity again.

Figure 1

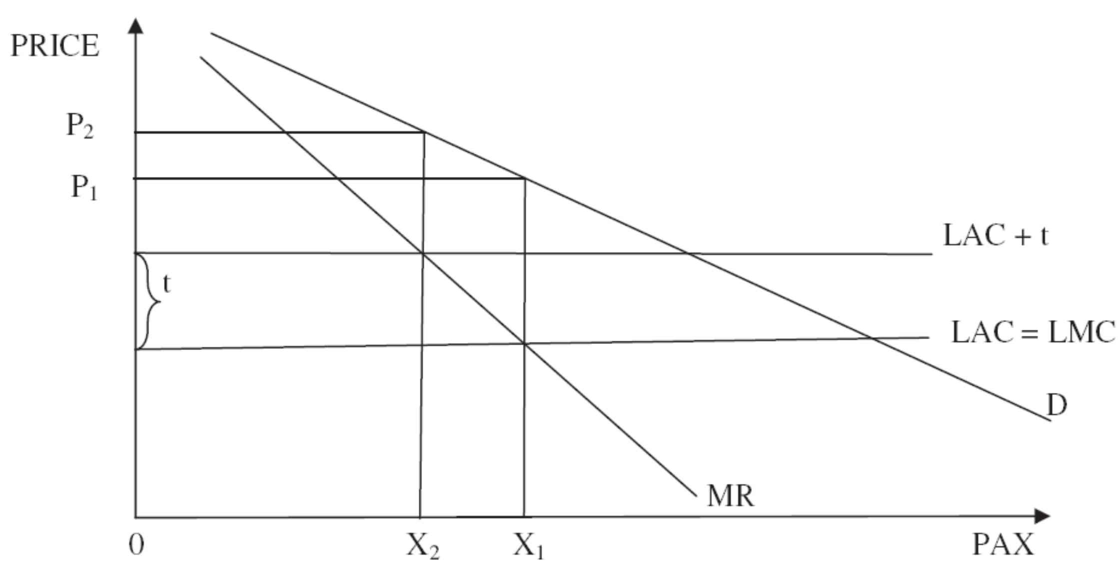


The long-run case is illustrated in Figure 1. The long-run average and marginal cost curves are assumed to be straight and horizontal (no scale economies). The initial equilibrium is one of price P_1 and output X_1 The imposition of a carbon tax (or permit price) of t raises the cost airline to LAC+t, and the new price P_2, will cover this. Output falls to X_2. There is full pass-through of the carbon tax to the passengers, and the reduction in output will depend on the elasticity of demand for flights. Airlines neither gain nor lose from the implementation of the carbon tax in the long run. The impact on the number of firms will depend on the cost structure of the airlines. The higher costs and prices in the market are likely to be accompanied by fewer firms of about the same scale.

Monopoly

Not all airline routes are competitive – at the extreme, some may be monopolies. The case of monopoly is shown in Figure 2. With monopoly, there is little difference between the short- and long-run cases. Suppose that a carbon tax of t is levied. This raises the marginal cost of the monopoly by t. However, it does not raise the price to the passengers by this amount – the rise in price is from P_1 to P_2, less than the amount of the carbon tax. The exact amount that prices rise will depend on the elasticity of demand and on the form of the marginal cost function. With the smaller price increase, the impact on output will be smaller than under competition. The monopoly is unable to pass on the full carbon tax. The airline will face an unambiguous reduction in profit. This could lead to the route becoming unprofitable in the short and long run. If prices are less than average variable cost, the airline will exit the route in the short run, and if they are less than average cost, the airline will exit in the long run. As noted in the discussion of competition, the opportunity cost of aircraft will fall if the cost increase is faced across the industry, and airlines may continue to serve the market even though they are earning insufficient revenue to cover the cost of the capital they have invested. When demand grows enough to eliminate the excess capacity in the industry, the airline may drop more marginal routes (redeploying capacity to more profitable routes).

Figure 2



Oligopolistic airline markets

The distinction between short and long run is important in the oligopoly case, because the number of firms in the market is fixed in the short run, but variable in the long run. In oligopoly, firms may employ different strategies, such as Bertrand or Cournot strategies, and these will affect outcomes.

If the airlines on a route indulge in Bertrand competition, they will compete prices down. When faced by a cost increase, they will initially be unable to increase prices, and they will face losses. (Again, they will exit if prices fall below average variable cost). In the long run, they will only continue to serve the market if they are covering their costs. If this is not feasible, firms will exit, allowing prices to rise. The long-run outcome of the imposition of the carbon tax or permit requirement will be that the costs will be passed on to passengers, and the profitability of the airlines will be maintained, though there could be fewer firms competing in the market.

In the Cournot case, prices can be set above marginal and average costs. If there are very few firms, prices will be below, though close to monopoly prices, while if there are several firms, prices will be closer to competitive levels. In the short run, with a fixed number of firms, a cost increase will lead firms to increase prices, though the per unit price increase will be smaller than the per unit cost increase. The burden of the carbon tax or permit price will be shared by the airlines and their passengers.

However, this is not the end of the story, since the number of airlines serving the market can change. If there is free entry, then airlines will enter up to the point that the marginal firm covers its costs (see Suzumura and Kiyono, 1987). More firms and more competition mean lower prices, and they also mean higher overall costs, since each firm faces a fixed cost of participating in the market. While the market is oligopolistic and the firms technically possess market power, free entry keeps prices and profits down, though profits are not necessarily reduced to zero. If prices and profits are low, the imposition of a tax or permit price raises costs, and this can render the airlines unprofitable in the long run. If so, an airline will drop out. This leads to a saving in costs, as airlines gain from greater scale, and also to less competition and higher prices, and profitability is restored.

This process involves an indivisibility, granted the small number of firms. In some cases, the number of firms remains the same. In these cases, the airlines were moderately profitable, and they remain profitable in spite of the cost increase. Prices increase, but not to the extent of the cost increase – airlines and passengers share the tax. In other cases, where profitability before the tax imposition is low, a firm will exit, enabling the remaining firms to increase prices and profitability. The result will be less competition, higher profits than before, and passengers paying more than the tax increase.

Overall, in airline markets, there will be examples of each of these cases. As costs increase, some more profitable markets will become less profitable, but the number of firms will not change; in other markets, firms will drop out, and markets will become less competitive, enabling higher prices and profitability. Overall, airlines will be able to pass on cost increases, such as those due to a carbon tax or permit price, to their passengers, and thus maintain their (low) profitability.

Summary

The effects of imposing a GHG emissions reduction policy on airlines, such as a carbon tax or requiring the purchase of permits, will depend on whether a short- or long-run perspective is taken.

In the short run, there is not likely to be much reduction in competition on markets, as measured by the numbers of airlines serving them. Prices will not be able to rise to the extent of the cost increase, and thus airline profitability will be reduced. This will be true regardless of the market structure – it will be so for competitive, monopolistic and oligopolistic markets. In this case, the short run will last as long as overall aircraft capacity exceeds its desired level.

In the long run, there will be some exits from markets. In oligopolistic markets, these will be significant, and they will enable airlines to restore their profitability overall, though the patterns of profitability of different markets will alter. There will be some exits from competitive markets, though these will not be sufficient to affect the intensity of competition. Some marginal monopoly routes will be dropped. Profitability of airlines will be restored, helped by exits from some markets. The cost increases occasioned by the policy will ultimately be passed on to passengers.

This picture is consistent with the long-run experience of the airline industry. The industry is not very profitable and it does not have much scope to absorb cost increases. It has had to face sudden cost increases, such as those resulting from fuel price shocks. In the short term, it has been unable to pass all of the higher costs on to its passengers for several years, and it has experienced periods of unprofitability. Airlines have had to rationalise their services. Ultimately, with demand growth, profitability has been restored.

Thus, the airlines will have a short-run problem resulting from imposition of carbon taxes or selling of permits, and they will face an adjustment problem. The short-run problem could be quite significant. In the long run, profitability will be maintained. The view that these policies will lead to chronic loss of profits, suggested by consultant reports, is not supported (e.g. Ernst and Young/York Aviation, 2007). At least in the long run, the view that airlines will be able to pass cost increases on to their passengers, as suggested by the EC (European Commission, 2006), is supported.

5.3. Impacts in slot- or capacity-constrained markets

Homogeneous airlines and taxes

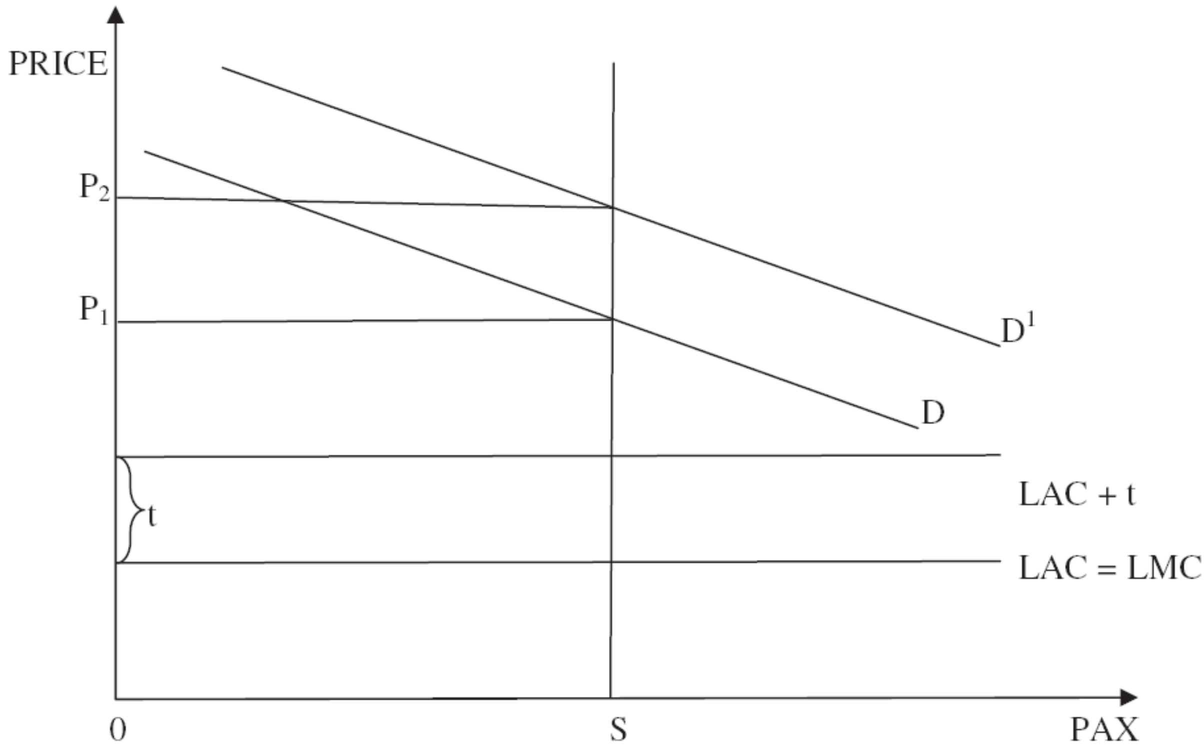
Many airline routes, especially in Europe and some parts of Asia, use airports which are slot constrained. Most of the major airports in Europe are slot constrained at least for part of the day. To schedule a flight into such an airport, the airline must have a slot. This may have been allocated to it earlier, or it may be able to gain a slot through trading with other airlines. Granted that there is excess demand for the airports, these slots are valuable. For present purposes, it is necessary to note that there is an overall limit on the number of flights into and out of slot-constrained airports.

This situation is illustrated in Figure 3. The demand by flights to use the airport is shown as D, and the available capacity is shown as S. Slots ration demand to S, and the market clearing price is P_1. Given that LMC lies below P_1, there is excess demand, and slots command a premium.

If a carbon tax is levied at the rate t, the average and marginal costs to the airlines rise to LAC+t. The price to the passengers, P_1, cannot change, since it is set by the balance of demand to slot capacity. In this situation, the airline is unable to pass on any of the carbon tax, and there is no reduction in output. Airline profits fall by the amount of the carbon tax levied on them. The value of a slot falls by the amount of the carbon tax (Oxera, 2003).

This suggests that for a substantial proportion of air traffic – that which uses slot-constrained airports – carbon taxes will have no effect on emissions through reducing airline demand. Taxes levied on emissions will have some effect on emissions through inducing airlines to use less GGE-intensive aircraft, though this is not likely to be a large effect except in the very long run.

Figure 3



However, this is not the whole story – there is a situation in which airlines may be able to pass on some of the costs of a carbon tax. Suppose that some airlines, such as British Airways, operate short-haul flights from a slot-constrained airport such as London Heathrow, while others, such as easyJet, operate competing short-haul flights from non-constrained airports, such as Luton and London Stansted. If carbon taxes are imposed on all airlines, the fares which easyJet charges will rise, though in the first instance, BA fares will not. However, since the fare premium for using London Heathrow has fallen, and since BA flights and easyJet flights are imperfect substitutes, the demand for BA flights will increase, as will the demand for use of London Heathrow Airport. This is shown in Figure 3 – the demand curve shifts upwards somewhat, to D'. Fares on short-haul flights using the airport will rise to P_2. The value of a slot at London Heathrow will be higher, though it will be lower than the value before the imposition of the carbon tax. In this situation, the airline loses less as a result of the imposition of the carbon tax than in the case where the demand curve does not shift.

A similar situation can occur when airports are competing for hub traffic. Suppose some of these airports are slot constrained (London Heathrow, Frankfurt) while others are not as subject to slot limits (Amsterdam, Paris Charles de Gaulle) or not significantly subject to limits (Munich). If air fares in flights through the non-constrained airports rise, then demand for the constrained hubs will increase, enabling fare increases for airlines using these hubs.

In each of these cases, passengers have a choice as to which airport they use. The slot premium does not come about as a result of an absolute lack of capacity relative to demand. Rather, it is a result of limited capacity at a preferred airport. Passengers are prepared to pay a premium to use Heathrow rather than Stansted. When costs increase at both of these airports by the same amount, there is no reason to expect the premium which passengers are willing to pay to use the preferred airport to fall. In such a situation, the airlines would be able to increase fares at the slot-controlled airport by the same amount as for flights from the unconstrained airport. In practice, imperfect substitutability may mean that the price increase will be less at the slot-constrained airport. In addition, in cases where there are no effective competitors for slot-constrained airports, airlines will not be able to pass on any of the cost increase – as discussed above.

Another context in which airlines will not be able to pass on cost increases caused by carbon taxes or sold permits arises on international routes. Some routes are still subject to capacity controls, and governments have regulated capacity such that it is insufficient to cater for demand at competitive fare levels, and market fares are sufficient to enable airlines to earn economic profits. Since fares are market determined, airlines will not be able to increase fares when costs increase – thus, they will be forced to absorb them. This is not likely to be a long-run problem for the airlines, since capacity is a policy variable chosen by governments. As demand grows, fares will increase, and governments are unlikely to increase capacity on the route if their airlines are not achieving (the government's) desired level of profitability.

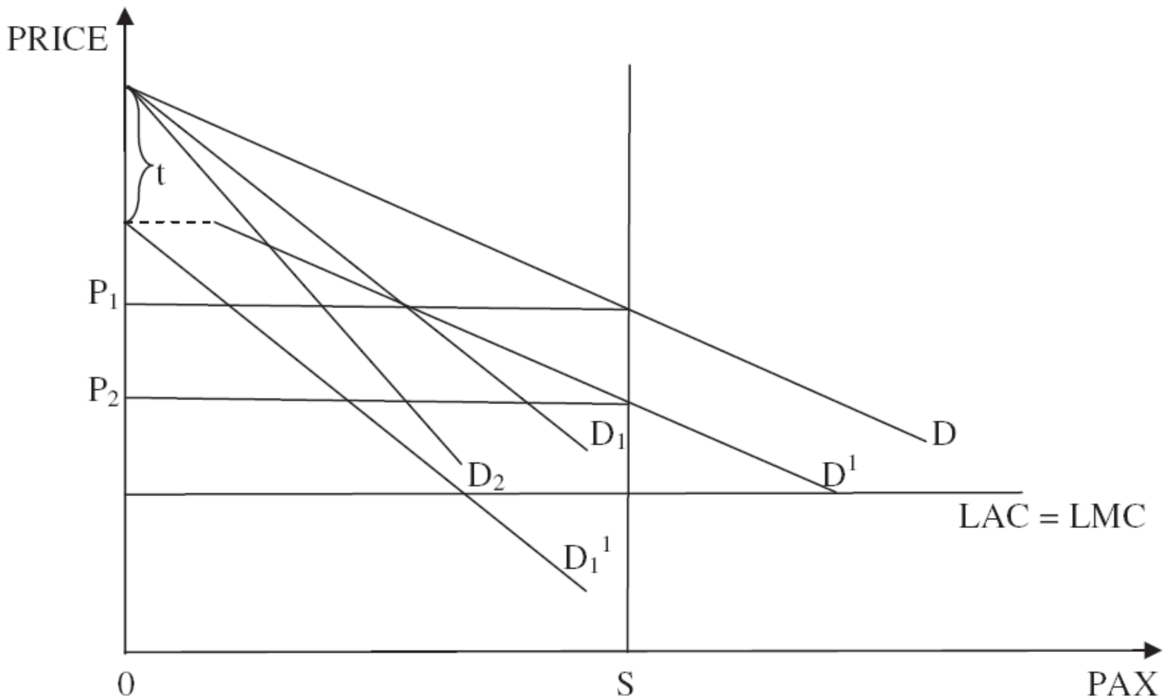
Capacity restrictions, due to slot limits at airports or air services agreements on international routes, result in fares being market determined, though competition between airports can result in fare increases at one airport leading to fare increases at the slot-constrained airport. In both cases, airlines will be unable to raise fares enough to cover the tax or permit costs imposed on them (at least in the short run with international routes) – thus, they will experience a reduction in profits.

Differential taxes on slot-constrained routes

It is quite likely that different users of slot-constrained airports will be paying different carbon taxes. For example, long-haul flights are likely to have to pay higher carbon taxes per flight than short-haul flights. This will affect the outcome in terms of prices and slot values.

This is illustrated in Figure 4. Suppose that there are two types of flight, with demand curves D_1 and D_2. Airline markets are competitive. The aggregate demand for the use of the airport is shown as D and the price is set at P_1. A carbon tax t is levied only on flights of type 1, and this can be shown as a downward shift in the demand curve to D_1^1. The new overall demand curve is shown as D^1. The shift downwards is less than t, and the new market clearing price is P_2. The value of a slot falls, but by less than the carbon tax. The price of type 1 flights will rise, and the price of type 2 flights will fall. More type 2 flights will use the airport, and fewer type 1 flights. Because slot values and prices have fallen, passengers of type 2 airlines will gain, but the airlines will lose, even though they have not been subjected to the tax. By contrast, passengers on the type 1 flights will lose, and airlines will limit their losses by being able to pass on some of the carbon tax. Another way of looking at this is the fall in the slot value is smaller than the carbon tax imposed.

Figure 4



This case may be a realistic one in Europe. Long-haul flights are likely to be subjected to higher carbon taxes than short-haul, intra-European flights. The legacy carriers, such as British Airways and Lufthansa, tend to have slots at, and use extensively, the tightly slot constrained airports, such as London Heathrow and Frankfurt. Their low-cost carrier (LCC) competitors tend to use less constrained airports. When carbon taxes are levied on the LCCs, they will pass them on to their passengers in full. When carbon taxes are levied on the long- and short-haul flights using the slot constrained airports, slot prices will fall by more than the amount of the taxes levied on the short-haul flights. The premium for using preferred airports will fall. Thus, the costs faced by short-haul flights operated by legacy carriers will fall, and in a competitive market, these cost savings will be passed on. While the airlines themselves will be worse off as a result of a fall in slot values, legacy airlines' prices will fall, while the prices of their LCC competitors will rise.

6. IMPACTS OF FREE PERMITS ON COMPETITION, FARES AND PROFITS

6.1. Profit-maximising airlines

If airlines are granted free permits in an ETS, the impacts on competition prices and profits could be much the same as before, if airlines operate as profit maximisers. Since permits will be valuable and can be bought and sold, the airlines could be expected to factor the market price of permits into their decisions. The critical requirement is that the processes of allocation of the free permits should not have any effect on the airlines' cost structures or behaviour. If permits were allocated permanently on the basis of past output, and there is nothing that the airlines can do to affect their future entitlements, this would be so.

In the long run, air fares will rise, and airline profits will rise to the extent that they gain free permits in the cases of competitive and oligopolistic markets. The situation will be different in the case of monopolistic markets since, in these, the airlines will be unable to raise fares by as much as the value of the permits. Even if an airline on a monopoly route is granted all the permits it needs free of charge, it will be worse off than in the pre-permit days. When it recognises the market value of the permit, it will make a price/quantity choice which it had rejected before – it must therefore be gaining lower profits than before. The difference between competitive and oligopolistic markets on the one hand, and monopolistic markets on the other, is that in the former, the imposition of the permit requirement enables airlines to increase their fares – something which they normally cannot do under competition. By contrast, the monopoly is able to choose its fares, whether or not it requires permits.

This result depends upon the airlines being unable to affect their allocation of future permits. This might not be the case. One possibility is that permits are conditional on actually participating in the specific route market. Permits might be allocated on a year-by-year basis, to airlines active in the market. If permits are allocated on a permanent basis, then an airline that is considering exiting a market will be able to take advantage of its free permits when it exits by selling them, or using them in other markets. However, if permits are allocated on a year-by-year basis, an airline might earn a profit if it stays in the market, with permit rents exceeding operational losses. If it exits, it would lose the rents from the free permits – thus it will stay in the market, even though an identical airline that had to pay for its permits would exit. This lock-in effect is actually being planned to be used in some jurisdictions to prevent export industries moving offshore when an ETS comes into operation (Australia Department of Climate Change, 2008).

The lock-in effect would dissuade marginal firms in oligopoly markets from exiting. As a result, competition will be stronger, and prices will be lower, than if the airlines had to pay for their permits. Airlines would be, in effect, forced to share some of the rents from the permits with their passengers. This effect could also be present in the competitive case in the long run. Free permits can result in lower air fares, even when all airlines are profit maximisers.

A situation in which eligibility for free permits is conditional on operating in a specific airline route market is a possibility, especially where an airline operates on only one of a few markets to a foreign country with an ETS. However, most allocation systems will make eligibility dependent on total output of airlines, not their presence in a specific market (though withdrawing from a market could reduce the airline's total output and subsequent entitlement to free permits). In this scenario, there is a lock-in effect, which encourages an airline to stay in the industry.

If the airlines' entitlement to future free permits depends on their actual outputs, this will alter their effective cost functions. Suppose that the airlines' marginal costs are LAC, as in Figure 1, and marginal costs including the opportunity cost of permits are LMC+ t. If by producing more output the airlines qualify for more free permits, the value of these permits needs to be deducted from marginal cost to obtain an effective marginal cost. Thus the effect marginal cost will lie between LMC and LMC+t, in Figure 1. In competitive markets, the airlines will charge fares less than LMC+t, and the airlines' passengers will share some of the benefits of the free permits. In the case of oligopoly markets, lower marginal and average costs of the airlines in the market will make remaining in the market more attractive for the marginal firm. There is less likelihood of an airline exiting, and competition will be more intense, leading to lower fares and profits.

Incumbents versus entrants

One possible scenario is that incumbents, either in the industry or on a route, obtain free permits, whereas entrants do not. If airlines are profit maximisers and not capital-constrained, this should pose no problems for competition between incumbents and entrants – entrants will be less profitable than incumbents, but all will face the same input prices. The free permits will be like a lump sum subsidy to the incumbents. However, again, the way in which permits are allocated can influence competitive outcomes. Suppose that permits are only allocated if the airline stays in the market. This can induce the incumbent to remain longer in the market than would otherwise be profitable for it to do so. If an entrant appears, the incumbent may be unable to make a profit, and it should exit – the lump sum subsidy will induce it to stay. Competition will be stronger and fares lower than if permits were not free.

Excessive competition can also come about if the entrants are granted free permits, on condition that they actually serve a market. In this situation, an entrant might be induced to enter even if it would otherwise not be able to make a profit, since it can gain access to a subsidy by doing so. Subsidies can encourage excessive entry into oligopolistic markets.

If free permits are allocated for a number of years, airlines will not need to be competing in a market to gain free permits – thus an airline would be willing to exit a market and sell its permits. The lock-in effect or the entry encouragement effect will be lessened if permits for multiple years can be sold.

These results will come about even if all airlines are maximising their profits. In addition, if incumbents are granted free permits while entrants are not, they will have the ability to cross-subsidize marginally unprofitable routes. Entrants will know this, and will be less willing to enter markets even when they would be viable competitors.

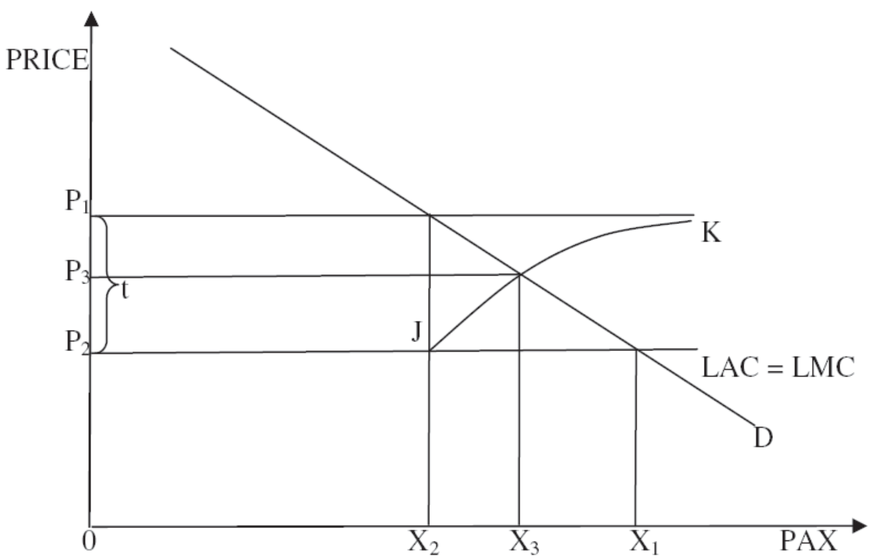
6.2. Non-profit-maximising airlines: average cost pricing

The analysis so far has assumed that firms maximise profits. It is possible that airlines will not act in a profit-maximising manner. They may not value the permits, and factor in their opportunity cost, when making decisions about routes to fly and pricing. Airlines might seek to cover their costs, and not seek to profit from their free permits. Thus, they might keep prices down on routes which are incorporated in the ETS. Alternatively, they might price to market on routes covered by the ETS, earn profits on these, and use the profits to cross-subsidize other routes.

One possibility is that airlines will simply seek to recover the average cost of their flights from passengers on a route covered by the ETS. This cost will be made up of operating costs plus the cost of any permits they need to buy – airlines may not obtain all of the permits they need free of charge. The implications of this approach are considered in Scheelhaase and Grimme (2007). The case of competitive airlines using non-slot-constrained airports is considered here.

The case is illustrated in Figure 5. Suppose that a scheme of carbon permits is introduced, and that the value of the permits is P_2-P_1. Consider a representative airline in a competitive industry. Suppose that this airline is granted OX_2 permits. The profit-maximising price would be P_2, and this would induce an output of X_2. The airline would be profitable. Alternatively, it could choose to set prices at average cost. If it goes beyond an output of X_2, it will experience increasing average costs, since it would need to purchase more permits as output increases. The average cost will begin to rise at J and will asymptote to the price P_2. By setting prices equal to P_3, and allowing an output of X_3, the airline will just achieve cost recovery.

Figure 5



Thus the impact on prices will be smaller than under profit maximisation, and the reduction in output will be smaller. In fact, output will be inefficiently large, since the social marginal cost can be regarded as P_2 (if the level of carbon credits has been set optimally), and the actual price is less than this. If the benefits from carbon permits are passed on to the passengers, they will be relatively inefficient as a GHG emissions mitigation strategy. Carbon taxes or sold permits would be preferable on this ground, since automatically they would be passed on to passengers.

The extent to which airlines behave as profit maximisers or implement average cost pricing (thereby being sales maximisers) is an important empirical issue for determining the likely impact of including airlines in an emissions trading scheme. The difference between fares under profit and sales maximisation will be very substantial. Quite high carbon prices can be consistent with very low changes in average costs (Morrell, 2006; Scheelhaase and Grimme, 2007). Thus the impacts on GGEs will also differ markedly.

6.3. Airline behaviour with free permits

Airlines are used to dealing in resources that they obtain at less than market prices. Airport slots are an obvious example – airlines have obtained most of these free, through grandfathering. In addition, many airlines are currently paying much less than market price for their fuel, as a result of hedging contracts. These do not represent a free or subsidized resource in the long run, and hedging has to be paid for. Nevertheless, many airlines are now paying much less than market price for their fuel. Airlines' behaviour with respect to these resources may give clues as to their likely treatment of free emissions permits.

If airlines are maximising profits, one would expect that their decisions and pricing would reflect the market prices of the resources. Consider airport slots first. Airlines, such as British Airways, BMI and Lufthansa, with many slots at the very slot-constrained airports, such as London Heathrow and Frankfurt, could be expected to be earning very high profits. While slots at Frankfurt are not extensively or freely traded, slots at Heathrow are very valuable, with recent sales at £25m per daily slot pair.

What happens to the slot rents that airlines enjoy is never adequately explained. Given slot values at Heathrow, one would expect higher profits for airlines such as BMI than are achieved. BMI has 11% of the slots at Heathrow, yet its profits in 2007, at £15.5m, were less than the value of a single slot pair. Even its record profit, of £29.7m in 2006, is only slightly above the value of a slot pair. It is possible that airlines are not fully factoring in the opportunity cost of slots they possess when determining whether to operate flights into Heathrow and that many Heathrow flights are not covering the cost of their slots. Alternatively, it could be that profits being earned on Heathrow routes are being used to cross-subsidize routes elsewhere.

Airlines' responses to fuel prices also should provide a test of their behaviour. Fuel price hedging gives some airlines a short-term advantage. Some airlines have very valuable hedging contracts, enabling them to purchase, currently, much of their fuel needs at well below market prices. On the one hand, airlines are likely to have difficulties in passing on the full amount of fuel price increases to their passengers in the short run, for the reasons discussed in the context of cost increases due to climate change policies. Thus, airlines without hedging could well be unprofitable – many are. On the other hand, airlines with low hedged prices should be able to earn profits if they are able to increase their fares by more than warranted by the actual price they are paying for fuel (though this will be lower than the fares warranted by the market price of fuel). Some airlines that have been strongly hedged, such as Qantas, have been earning record profits in spite of the current downturn.

It is not possible to determine if airlines are all turning the values of their hedges fully into profits. Some airlines with good hedging may be choosing to use their advantage to increase market share – though whether this is a profitable strategy remains to be seen. It is not possible, without more detailed analysis, to determine whether airlines with good hedging are making the maximum profit out of their position (it is moreover possible that the well-hedged airlines are also the more profit-oriented). Analysis of the pricing and profitability of airlines, with allowance for hedging, in the context of recent fuel price rises, should provide useful information on both the ability of airlines to pass on costs in the short run, and on how profitably they make use of windfalls such as those that have come about from hedging.

6.4. Summary: free permits and airline pricing

If permits are free to airlines, there is some chance that their full value will not be passed on to passengers. Airlines may be profit maximisers, but the allocation of permits may create incentives for more airlines than is efficient to remain in markets, thereby lowering fares. In addition, airlines may not be profit maximisers, and pass on some of the value of their free permits to passengers, keeping prices lower in pursuit of market share. If this happens, prices will be less than marginal social costs, including the externality costs of the emissions. While the ETS will face airlines with the marginal cost of their emissions, and give them an incentive to reduce emissions, it will not face passengers with the marginal costs of their travel. The ETS will be less effective and efficient than it would be if permits were not free.

7. COMPETITION AND INTERNATIONAL MARKETS

Carbon taxes or ETSs are most likely to be applied to domestic markets or intra-jurisdictional markets (e.g. to international flights within the EU), though they may be applied to all markets to and from a country or jurisdiction. How the policy is implemented might have implications for competition in air transport in international markets. There are several possibilities.

7.1. Taxes or sold permits with international markets excluded

Countries such as Australia and New Zealand are planning to impose an ETS with purchased permits on domestic, but not international aviation. This is likely due to their airlines earning lower profits in domestic markets in the short run, though they should recover their profitability in the long run. If the airlines are profit maximisers and not capital-constrained, this should not have any implication for competition on international markets. If the airlines were not making profits on some routes before, international or domestic, then the profits squeeze might lead them to cut back on unprofitable routes. This could lead to slightly less completion on both domestic and international routes. There is not likely to be any major effect in the long run, however.

7.2. Free permits with international markets excluded

Free permits will enhance the profitability of home country airlines, the more so in the longer term as fares rise. If airlines are profit maximisers which face no capital constraints; this should have no impact on international markets. Airlines will have the scope to cross-subsidize domestic and international routes, if they choose to do so (at the expense of their overall profitability). If initially capital-constrained, they will be less so. Thus, if they wish to continue to operate on marginally unprofitable routes, or make a gamble on new routes, they will be able to do so. Thus, competition in international routes could be more intense, and this would put some pressure on fares and profitability of airlines from other countries flying on the home country's international routes.

7.3. Taxes or sold permits on all markets

A country could impose taxes on all flights, by home and foreign airlines, to and from its gateways as well as on its domestic markets. This policy would transfer income from foreign passengers and airlines to the home country, and it is not likely to meet with a country's air service partners. International agreements may limit its ability to do this – for present purposes, suppose that it is possible. If a country does this, there should be no implications for competition on international markets, since all airlines would be treated equally. Depending on how the policy works, there could be problems for neutrality between flights that take different routings. If the permits required are based on the kilometres flown on the first stage from the home country, indirect routings will be advantaged relative to direct routings. Thus, a flight from Singapore to Paris via Dubai will pay less than a direct flight from Singapore to Paris.

7.4. Free permits for all markets

A country may be able to secure the agreement of its partners if it provides free permits to home and foreign airlines operating on international routes. Foreign airlines would gain, though foreign passengers would lose. Again, since foreign and home airlines are being treated equally, there should not be any problems of competitive neutrality. Some flights would be affected more than others. Airlines would gain more from longer direct flights for which they gain more free permits, while passengers would prefer indirect routings for which fares would not rise as much – this could have implications for competition in these markets. Free permits would pose many practical problems for allocation – for example, if an airline changes its routing to or from a destination, will this affect its allocation of permits?

7.5. Competitive neutrality and indirect emissions

Whether or not international air transport is included in an ETS, there will be an impact on competition between home and foreign airlines as a result of the ways in which indirect emissions are treated. Suppose that a country imposes a comprehensive ETS. An airline based in that country will then have to pay higher prices for its inputs, since the emissions it creates indirectly will require permits. Even if permits are free, its input prices will rise. Its foreign competitors will only be marginally affected, since they will not purchase many of their inputs in the country imposing the ETS. Thus, the home country airlines will be at a competitive disadvantage, though the size of this disadvantage is not likely to be large (around 0.5% to 1.0% with a €20 per tonne permit price, as indicated above).

An ETS will make all of a country's exports less competitive on international markets, and thus it will lead to some reduction of its exchange rate. This will counteract the negative effect noted above, though how strong this effect will be is unclear. However, if countries seek to shield their export industries from the effects of their ETSs, as Australia is seeking to do (Australia Department of Climate Change, 2008), the exchange rate offset will be weak.

8. CONCLUSIONS

Countries are moving to implement climate change mitigation policies that include air transport. Most of these, especially carbon taxes and ETSs, will have the effect of raising costs to airlines, though the effects of ETSs with free allocation of permits will have ambiguous effects on costs.

With carbon taxes or requirements to purchase permits, airline costs will rise and the airlines will seek to preserve their profitability by passing the higher costs on to their passengers. The extent to which they are able to do this will depend on how they affect competition. In the short run, in all market structures, it is likely that competition (and firm numbers) will not be much affected, and fares will not rise enough to cover increases in costs – thus, the airlines' profitability will be reduced. In the long run, in competitive and oligopoly markets, there is the possibility of some airline exits from route markets, and this lessening of competition will enable the remaining airlines to raise fares and restore profitability. In short, full or nearly full pass-through of the cost increase will be possible. This will not be the case in markets affected by airport slot constraints or capacity constraints under air services agreements, though even in these markets the airlines are likely to have more scope to increase fares than has been recognised.

The possibility of free permits poses interesting questions for airline competition. The rules for the allocation of the permits will have implications for the competitive process. If the airlines are profit maximisers, and the allocation process is neutral and does not affect airline behaviour, free permits will work like permits that have to be purchased, and fares will rise and airlines will enjoy profits as a result of them. However, depending on the allocation rules, free permits may create incentives for airlines to remain in markets, to enter markets, and may alter airlines' costs structures. If this is the case, competition is likely to be more intense than if permits are purchased, fares will be lower, and some of the value of the free permits will be passed on to passengers, even though the airlines are maximising their profits. In addition, prices and profits are likely to be lower if airlines do not factor in the full opportunity cost of permits into their decisions, and choose to use the profits they gain to cross-subsidize unprofitable routes. If free allocation of permits has these effects, airline prices will be less than marginal social costs and the ETS will be less efficient than it would be if permits were not free.

The introduction of a carbon tax or ETS, whether permits are free or not, could have implications for competition on international markets. These markets might be affected, even if they are excluded from the policy directly. These policies could affect the competitive balance between international airlines, though the effects are not likely to be large.

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THE ROLE OF ACCESSIBILITY IN PASSENGERS' CHOICE OF AIRPORTS

Marco KOUWENHOVEN

Significance
The Hague
Netherlands

SUMMARY

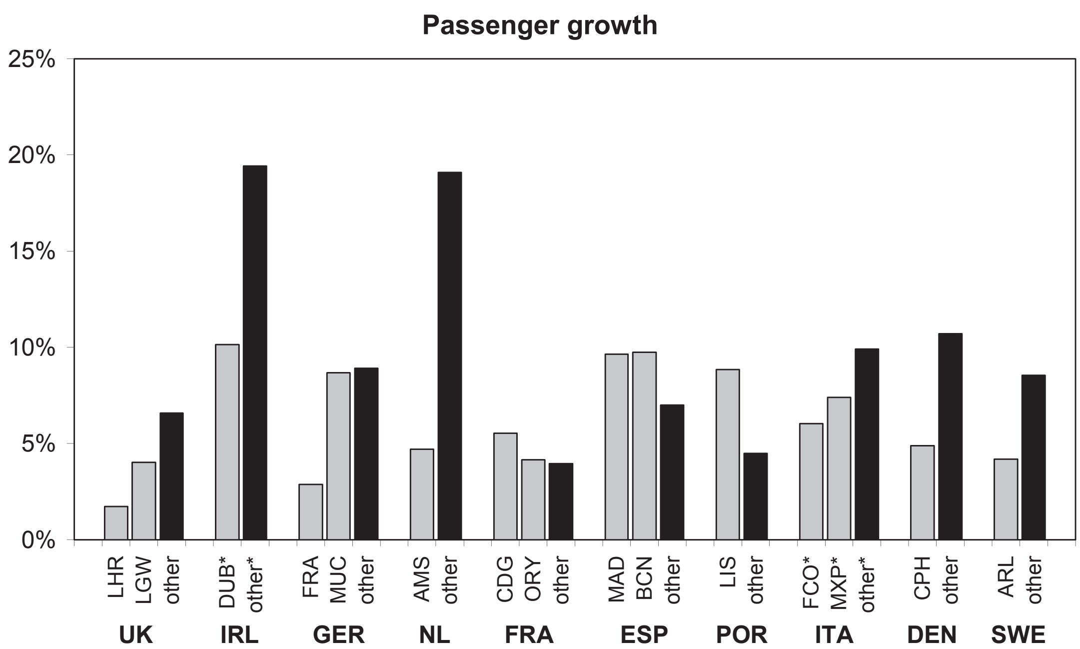
The Hague, August 2008

1. INTRODUCTION

1.1. Growth of regional airports

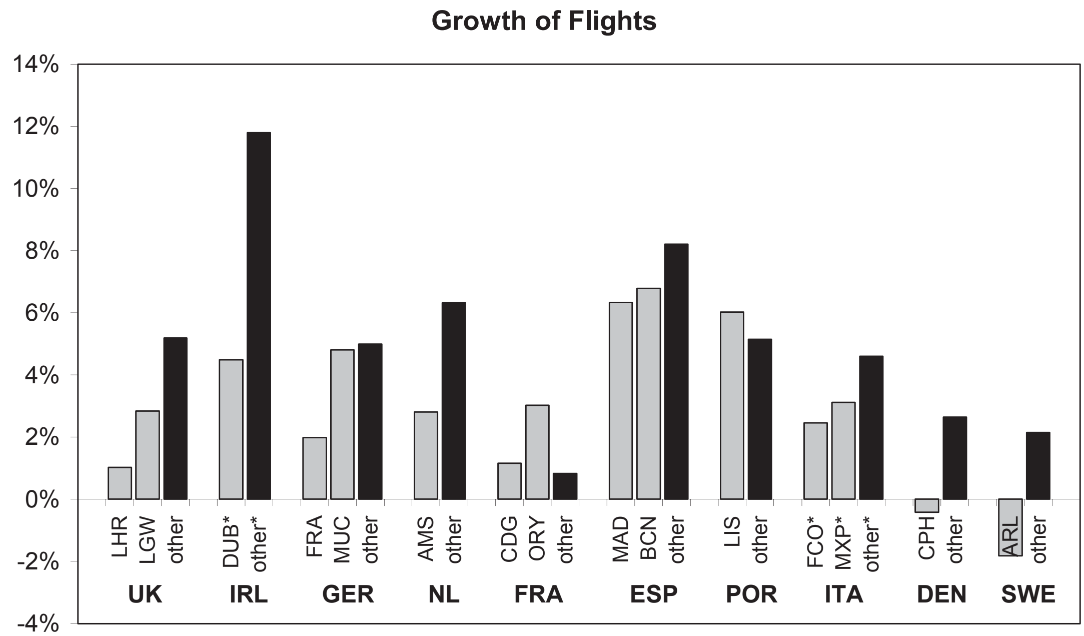
Until about two decades ago, the choice of airport was relatively easy for travellers. Within acceptable travel distances, usually only one airport provided flights to the preferred destination. However, nowadays people can choose between multiple airports when arranging a trip. Regional airports have grown very fast over the last decade(s) and are now providing flights to many destinations. The growth rates (both in terms of passengers and in number of flights) at the "smaller" airports in north-western European countries are usually larger than at the largest airports in those countries (see Figure 1 and 2 for the average growth rates in the last five years).

Figure 1. **Annual growth rate of the total number of passengers (averaged between 2003 and 2007) at the major airport(s) in a selection of western European countries, compared to the same growth rate at the other airports in those countries**
Data points indicated with *: averaged between 2003 and 2006



Sources: Eurostat 2008. Data from United Kingdom: London Heathrow (LHR) and London Gatwick (LGW); from Ireland: Dublin (DUB); from Germany: Frankfurt (FRA) and Munich (MUN); from the Netherlands: Amsterdam (AMS); from France: Paris Charles de Gaulle (CDG) and Paris Orly (ORY); from Spain: Madrid (MAD) and Barcelona (BCN); from Portugal: Lisbon (LIS); from Italy: Rome (FCO) and Milan Malpensa (MXP); from Denmark: Copenhagen (CPB) and from Sweden: Stockholm Arlanda (ARL).

Figure 2. **Annual growth rate of the total number of passenger flights (averaged between 2003 and 2007) at the major airport(s) in a selection of western European countries, compared to the same growth rate at the other airports in those countries**
Data points indicated with *: averaged between 2003 and 2006



Source: Eurostat 2008, see Figure 1 for explanation of the abbreviations.

An obvious reason for this enhanced growth at regional airports is the rise of low-cost airlines that have concentrated their business at particularly those airports. Though these airports might be further away from their departure address, the cheaper ticket fares are an incentive for people to travel from these airports (similarly for the arrival airport).

The development of the Internet also contributed to the growth of low-cost airlines and hence, of regional airports. People can now book trips from their home and search for alternative travel themselves, instead of choosing the most obvious alternative. Websites that search for cheap flights also list alternative departure airports. Yet another development is the increase of capacity problems at airports. This stimulates both airlines and airports to outplace part of their services to other airports; and more reasons can be thought of (new airports, conversion of military airports into civil airports, increase of car ownership, ground transport capacity around larger airports becoming increasingly constrained as growth outstrips ground transport capacity improvements, etc.)

1.2. Implications for policymakers

From a policy point of view, passengers' choice of airport has become an important issue. Several airports in Europe are approaching their capacity limits (either physical limitations in terms of runway or handling capacity or environmental limitations in terms of amount of noise produced or amount of gases or particles emitted). Policymakers can respond to this situation in several ways by:

- doing nothing;
- reducing demand for air transport (e.g. by stimulating the use of alternative modes);
- stimulating more effective use of existing capacity; and
- expanding physical capacities (i.e. building more runways and/or terminals) or changing the limitations on emissions.

However, since building new runways and/or terminals is a major investment and the physical space is not always available, alternative solutions are also considered. These include:

- Building a new airport at another location;
- Aattracting more traffic to existing airports in the neighbourhood, either by attracting (new) airlines to these airports, by collaboration between the aiports, or by (actively) outplacing flights to these other airports; and
- Making alternative airports more accessible (extra roads, better public transport, new high-speed rail connection).

Understanding the choice process of air travellers is key in understanding the effectiveness of these policy options.

The accessibility itself is another important issue from a policy point of view. Most airports are located close to large cities or metropolitan areas. As a result of the increase in ground traffic, congestion is becoming a major issue, as is, therefore, the accessibility (and the competitive position) of the airport. Improving the accessibility of the airport (by improving current infrastructure, or by introducing new access modes such as high-speed rail connections) could be an option for policymakers. Again, understanding the choice process of the traveller is important in this respect.

1.3. Objective of this paper

This paper aims to give an overview of what is known about the role of accessibility in passenger choices. Particularly, it will look at the question of to what extent passenger volumes might change if the accessibility of an airport changes. Obviously, two factors are important:

1. The passenger choice between the (available) modes; and
2. The passenger choice between the (available) airports.

The paper focuses on these two choices. Section 2 starts with a general discussion on the concept of accessibility. The passenger access mode choice is discussed in Section 3. The passenger choice between airports is dealt with in Section 4. Section 5 discusses the effects of the introduction of new access modes on the access mode choice, while Section 6 discusses a case study on the effect of a local tax on the airport choice. Finally, conclusions are drawn in Section 7.

In general, air trips can be divided into direct and indirect trips and in the case of indirect trips, travellers have a choice of transfer airport (e.g. for a trip between Germany and the United States, travellers can transfer at Frankfurt, Paris, London, Amsterdam, etc.). This choice is not discussed here, since land-side accessibility does not influence that choice.

Several sections in this paper focus on access to airports and do not discuss egress. Generally, it is easier to collect data when travellers are departing from an airport (and have just made an access trip) than after arrival, and therefore more information is known about airport access behaviour. However, since many travellers use the same mode for access and egress, many statements are true for egress as well.

2. DEFINITIONS OF ACCESSIBILITY

Most people have an intuitive feeling for the concept of accessibility. However, it is not trivial to quantify this variable. Definitions abound, some simple, others more complex. We mention here three categories of definition:

1. Accessibility measures that only take travel time into account. Examples of such definitions are:
   - the time to an airport;
   - the area of all locations from where one can travel to the airport within a certain time.

   However, these simple definitions only take part of the accessibility into account;

2. Accessibility measures that also take other characteristics into account, such as travel costs, parking costs, reliability of travel times, service level. In these measures, the characteristics are usually monetised using a value of travel time, value of reliability, value of service level, etc. In this way, all components are converted in monetary values and can then be added together. The sum of all these values is called the "generalised travel costs".
3. Accessibility measures that take multiple modes into account. The measures mentioned above only take a single travel mode into consideration, usually the car-mode. Accessibility measures that take multiple modes (car, train, bus, etc.) into account have to weigh the accessibility of the individual modes. This can be done by using the so-called LogSum as an accessibility measure (see e.g. Ben-Akiva and Lerman, 1985):

$$LogSum = \log\left(\sum_{i=\text{mode}} e^{-\beta \cdot GenCost(i)+X}\right) \qquad (1),$$

   where the sum is taken over all available modes. In this equation, X indicates all other factors included in the utility function.

This LogSum is a kind of inverted travel impedance: the more options you have to travel, the higher the LogSum value (and the better the accessibility). Cheaper and faster options contribute more than slow and expensive options. The advantage of such a measure is that it is very good for relative comparisons (i.e. comparison of the accessibilities of different locations) and it is a useful tool for the calculation of the consumer surplus changes for cost-benefit analyses of transport projects (de Jong *et al.,* 2007). A disadvantage, however, is that the absolute value by itself does not have an intuitive meaning.

3. ACCESS MODE CHOICE

3.1. Observed access mode shares

In order to explore the passenger choice of access mode, we start with a very simple observation on chosen modes for a selection of major airports.

Table 1 provides access mode shares for the selection of airports. This table shows that car, taxi, rail and bus are important modes of access for all these airports. The selected airports are all international, in the neighbourhood of large cities and metropolitan areas, and can therefore not be representative for all airports. However, the wide range of market shares of each mode already indicates that the choice behaviour of air passengers is very different between airports.

Car shares within this selection range from 7.5% for Hong-Kong (due to a general policy to discourage car use, heavy congestion and the presence of toll roads) to 79% (including taxi) for Chicago O'Hare (due to cheap parking and a general low public transport modal share). Rail shares range from 4% for the CTA Blue Line (metro) in Chicago to 40% for the combined rail services in Tokyo (due to road congestion, limited parking and high taxi costs) and 41% for the successful high-speed Flytoget service in Oslo. Taxi shares range from 6% in Oslo (due to the long distance to the airport and corresponding high prices) to 27% for Paris Orly, while bus shares range from 6% in Frankfurt to 47% in Hong Kong.

Access mode shares do not only differ widely between airports, they also differ significantly between travel segments within one airport. Figure 3 displays the access mode distribution for London Heathrow in 2001 for four segments, split by location of residence (inside/outside UK) and by trip purpose (business and leisure). Non-residents have a much lower car share, which is logical, since they usually cannot use their own private car and hence they use public transport more intensively. Business travellers generally have a stronger preference for taxi, since they are willing to pay for this more expensive mode in order to save access travel time and prevent transfers.

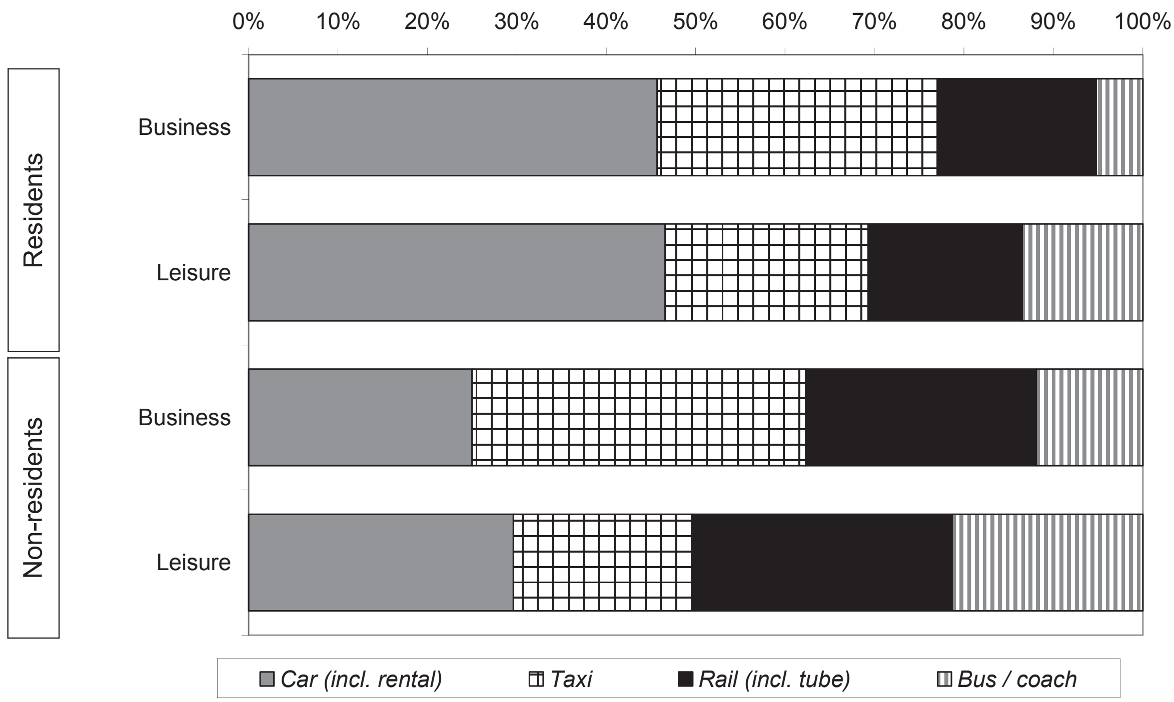
Similar preferences can be observed in Amsterdam (Figure 4). In this figure, business trips are also split between short (less than three days) and long trips (more than three days). Residents have a strong preference to use their own car when going on a short business trip, but for long business trips the share of this mode is clearly lower, and travelling as car passenger (kiss-and-ride) is the preferred alternative. For non-residents, the difference in access mode shares between short and long business trips is small.

Table 1. **Access mode shares for a selection of airports**

	Hong-Kong Intern. **HKG** (2004)	Tokyo Narita **NRT** (2003)	Oslo Gardermoen **OSL** (2005)	Stockholm Arlanda **ARL** (2003)	London Heathrow **LHR** (2004)	Paris Orly **ORY** (2002)	Amsterdam Schiphol **AMS** (2002)	Frankfurt **FRA** (2002)	London Gatwick **LGW** (2004)	New York JFK **JFK** (2004)	Chicago O'Hare **ORD** (1998)
Car	7.5%	17.6% (car and taxi)	34%	35%	37.8%	43%	45.3%	46%	53.8%	56.2%	79% (car and taxi)
private			*32%*		*35.0%*			*41%*	*51.4%*		
rental			*2%*		*2.8%*			*5%*	*2.4%*		
Taxi	12.9%		6%	21%	25.9%	27%	9.3%	19%	14.6%	20.7%	
Rail	23.4%	40.8%	40%	19%	23.5%	13%	34.7%	27%	24.6%	12.1%	4%
high-speed	*23.4%*		*33%*	*19%*	*9.3%*			*8%*			
regional			*7%*					*8%*			
local					*14.2%*			*12%*			
Bus	47.4%	41.6%	19%	19%	12.4%	16%	8.9%	6%	6.8%	10.9%	17%
Other			*2%*	4%	0.3%		1.8%	2%	0.2%		

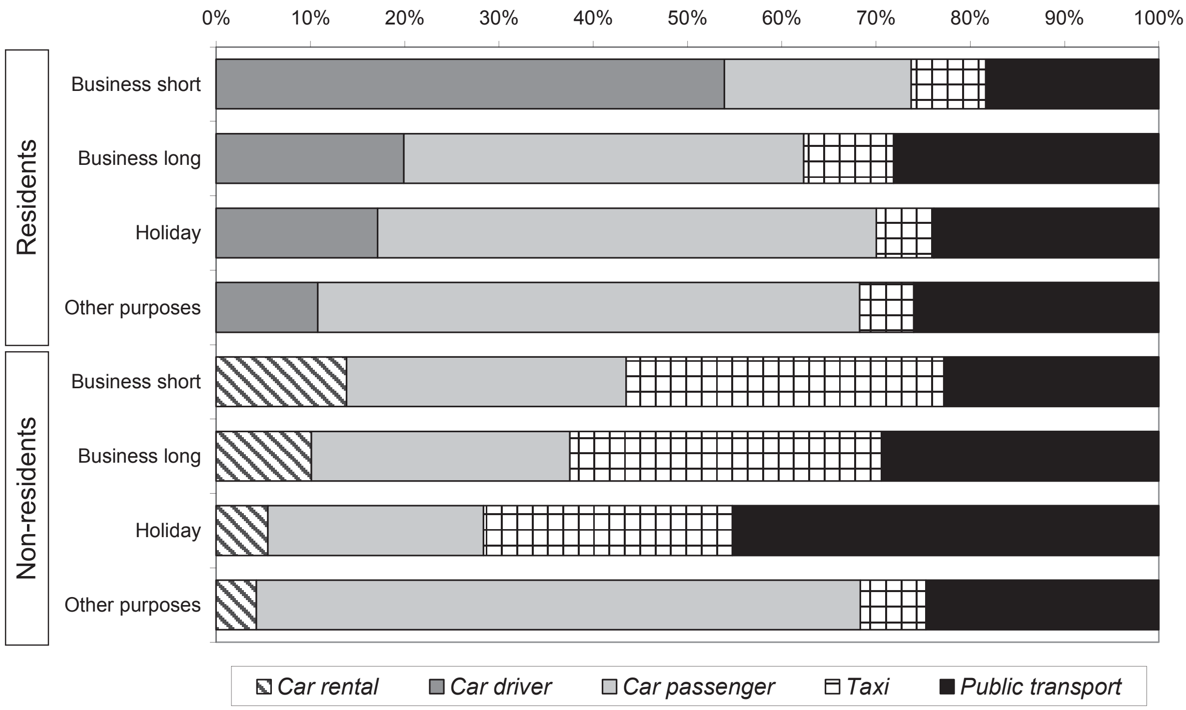
Sources: HKG:Tam *et al.* (2004)
NRT: Hirota (2004)
OSL: Avinor (2006), TOI (2005)
ARL: Luftfartsverket (2006)
LHR:Civil Aviation Authority (2006), LeBlond (1999)
ORY: Air Transport Action Group (ATAG) data, as published in RPB (2005)
AMS:Mott MacDonald (2003)
FRA: Scherz (2000)
LGW: Civil Aviation Authority (2006)
JFK: Port Authority of NY & NJ (2006)
ORD: TCRP (2000).

Figure 3. **Access mode distribution for travellers (split by segment) departing from London Heathrow (2001)**



Source: Mott McDonald 2003.

Figure 4. **Access mode distribution for travellers (split by segment) departing from Amsterdam Schiphol (1991)**



Source: Hague Consulting Group 1998.

3.2. Factors influencing access mode choice behaviour

The previous subsection demonstrated the large differences in access mode choice between travellers and airports. This subsection and the following one try to build a more fundamental understanding of the underlying reasons for the choice of access mode.

First, we make an educated guess about which factors might play a role in the choice of access mode. In the next subsection, we check these assumptions with choice behaviour as reported in the literature.

Factors that might play a role in access mode choice are:

– Availability: which access modes are available? Does the traveller own a car? Does he have relatives or friends that are willing to bring him to the airport? Is public transport available for his departure, is it available when he returns?

– Access time: how long does it take to reach the airport? This also includes any time needed to find a parking space (if applicable) and to travel from the parking location to the airport terminal.

- Access cost: how much does it cost to reach the airport? This also includes any parking costs if applicable.
- Frequency (for public transport alternatives): how often is the service provided? How much will the travel time increase if you just miss your bus or train?
- Comfort (for public transport alternatives): how easy is it to travel? How often do you have to make a transfer? What is the probability of having a seat? Can you check-in your luggage already at the station? Are extra luggage facilities available?
- Reliability: how reliable is your travel time? How reliable are the transfers (for the public transport alternative)? How much earlier do you need to depart in order to be (reasonably) certain that you will not miss your flight?

3.3. Modelling access mode choice behaviour

Gosling (2008) provides a review of the airport ground-access mode choice models that are currently available. This review is based on a comprehensive review of relevant literature, supplemented by findings from an extensive survey of airport authorities, metropolitan planning organisations, consulting firms, research organisations and other relevant government agencies. He identified nine (recent) air passenger mode choice models (Atlanta, Boston, Chicago, Miami, Oakland, Portland, San José, Toronto, UK South East and East of England). These models are based on either observed access mode choices (so-called revealed preference data) or on hypothetical mode choices (so-called stated preference data, which is collected by giving respondents two or more hypothetical mode alternatives and asking them which option they would choose in a certain situation) or on both.

Besides availability, all models indeed use access time and access cost as explanatory variables. Time variables are usually split into components (in-vehicle time, split by mode; waiting time, walking time, etc.). Public transfer frequency variables are included by means of average waiting times. Some models include terms that refer to the number of transfers (interchange penalties, etc.) and others include variables referring to luggage services. None of the models has explicit variables that refer to the travel time reliability of the modes.

Available modes usually differ both in travel time and travel cost. Some travellers prefer a more expensive but faster mode, while others choose a cheaper but slower mode. A common indicator to describe this choice behaviour is the value of time (or value of travel time savings). Technically, this is the ratio of the travel time coefficient to the cost coefficient from the access mode model. This ratio describes the (maximum) costs that an average traveller is willing to make to save, e.g., one hour of travel time. However, the values of time derived from the models differed widely: from about 10 USD/hour for Atlanta to 78 USD/hour for Miami (averaged over all traveller segments).

Gosling (2008) concluded that no clear consensus has yet emerged on which explanatory variables should be included or how the various modes and sub-modes should be nested in the model. A number of issues are still open, including how to treat rental car use and what the influence of traveller income is. Because of this, he believes that it is not possible to transfer these models to other airports for which they were not specifically developed.

4. AIRPORT CHOICE

4.1. Factors influencing airport choice behaviour

Again, we first make an educated guess about which factors might play a role in the choice of airport. In the next subsection, we check these assumptions with choice behaviour as reported in the literature.

Factors that might play a role in departure airport choice are:

Relating to flights and airlines

- Availability of flights towards a certain destination;
- Availability of flights from a certain preferred airline (frequent flyer memberships);
- The frequency of flights (a higher frequency results in a wider choice of departure and arrival times);
- Ticket price;
- Flight time (indirect flights result in longer travel times. Furthermore, an indirect flight implies a transfer at a certain airport, which results in extra waiting time and the possibility of missing connections. All these factors result in a negative valuation of transfers by travellers);
- Quality of available flights (on-board service, punctuality).

Relating to the airport

- Check-in facilities (including: time taken between arrival at the airport and arrival at the gate);
- Shopping/lounge/restaurant facilities;
- Baggage/customs/immigration facilities;
- Accessibility of the airport (access time, access costs, and all other factors discussed in the previous section, but also the possibility to park a car at an acceptable location (in terms of parking cost, distance to the airport, security, etc.).

4.2. Modelling airport choice behaviour

One of the first models by Skinner (1976) was used for the Baltimore-Washington, D.C. area (three airports) and had significant coefficients for flight frequency and accessibility. Windle and Dresner (1995) found significant effects for flight frequency and airport access time, but they also found a significant inertia term: the more often a traveller uses a certain airport in a year, the more likely he is to choose the same airport again.

Innes and Doucet (1990) derived a model for airport choice in Canada and they found that the type of aircraft can also play a role: travellers prefer jet services to turboprop services. Thomson and Caves (1993) studied airport choice in England and found a significant effect for the number of seats on the aircraft (a possible reflection of comfort).

Studies using revealed preference commonly do not find significant coefficients for ticket price. The revealed preference data is not always complete, since it usually lacks information on which other airport alternatives have been considered by the travellers, and especially the ticket price of alternative options (at the time of buying the ticket) are not available. Stated preference surveys usually find significant ticket price coefficients [e.g. Bradley (1998)], see discussion below).

However, these stated preference surveys generally do not capture the complexity of the real choice process by air travellers. Collins *et al.* (2007) are experimenting with a new SP survey design that presents the choice questions in a format similar to online air travel booking websites. Respondents are given a more realistic choice situation in this way, providing them with much larger choice sets and attribute levels.

Little is known about the impact of the airline service quality (on-board service, punctuality, etc.). At best, this is part of a standard airline-specific constant. Likewise, the general quality of the airport (check-in facilities, shopping facilities, etc.) is usually included in an airport-specific constant. In this way, it is not (yet) possible to isolate the effect of these factors on passenger choice behaviour.

4.2.1 Example of a study based on SP data: Amsterdam Schiphol

Bradley (1998) collected about 12 000 binary SP choices from 1 000 respondents. He found significant coefficients for the fare, frequency, access time and transfer time and a significanct transfer constant. A model specification with a logarithm of the fare was statistically better than a model with a linear fare term, indicating that people are less sensitive to a small fare change at high fare levels than at low fare levels. Also, a logarithmic frequency term outperformed a linear frequency term. This is in agreement with other models that use the frequency of flights as a logarithmic "attraction variable".

Bradley found some indications for airport "loyalty": the resistance to switching to an alternative airport increased with the number of flights made by the respondent in the previous year. However, this could also be interpreted as loyalty to specific airlines associated with those airports. Students, pensioners and part-time workers are slightly more price-sensitive than full-time workers. Tourist class users are more price-sensitive than travellers in First or Business Class.

4.2.2 Examples of studies of the best choice model structure: San Francisco Bay area

The San Francisco Bay area is served by three major airports: San Francisco International (SFO, about 15 million passengers per annum), San Jose Municipal (SJC, about 4 mppa) and Oakland International (OAK, about 8 mppa). Airport choice in this area has been studied by several researchers, mainly thanks to the availability of good data. This data not only allows for studies on which factors play a role in the airport choice, but also allows for studies into which model structure describes the passenger choice behaviour best [e.g., a multinomial logit model (MNL), a nested logit model (NL), etc.].

Harvey (1987) used a MNL model for airport choice and found significant coefficients for both flight frequency and access time. Both factors were added to the utility function in a non-linear way to indicate the diminishing marginal utility.

It should also be recognised that passengers not only choose an access mode choice and an airport, but also choose an airline. Pels *et al.* (2001) used NL models for airport and airline choice. They concluded that both business and leisure travellers choose the departure airport and airline sequentially (first airport, then airline). This implies that travellers are more likely to switch between airlines than between airports.

Hess and Polak (2005a,b) have investigated whether there was any evidence of random taste heterogeneity in the traveller choice behaviour. They found significant heterogeneity for the in-vehicle access time coefficient, the access cost coefficient and the flight frequency coefficient. Accounting for heterogeneity prevented a bias in the trade-off ratios that are found when using fixed coefficients for all passengers: the values of time decreased and the trade-off ratio between flight frequency and in-vehicle access time increased.

5. CASE STUDY: THE EFFECTS OF THE INTRODUCTION OF NEW RAIL MODES

5.1. Introduction

Airport rail links are increasingly seen as a means of providing high-capacity, fast and convenient access to airports from the conurbations they serve. Of the 150 largest airports by passenger numbers[1] some 58 (39%) have a rail link connecting directly to the airport while another 18 (12%) are at an advanced stage of planning or constructing a rail link (data collected in 2006 from airport and rail authority websites by the author and colleagues).

As shown in Table 2, European airports have been very actively pursuing airport rail links, with 64% of European airports in the top 150 already having a rail link and another 9% actively pursuing such a link. By comparison, in North America only 22% of airports have rail links. Within regions, there are also significant differences by country. For example, in Japan all eight airports that are in the top 150 globally have rail links, while in China only one (Shanghai Pudong) has a rail link of eight airports in the list (excluding Hong Kong). It is notable, however, that another three Chinese airports are currently constructing airport rail links.

The types of rail link vary significantly, from fast dedicated links, such as to Stockholm Arlanda and Oslo Gardermoen, to regional links that form an extension of the suburban rail network (for example, Sydney and Minneapolis/St Paul) and part of the metro system (for example, Frankfurt Main and Chicago O'Hare). As shown in Table 3, regional rail connections are the most common type of connection. However, fast dedicated systems are increasingly being developed across Europe and Asia in particular. None of these fast dedicated systems existed in their current form 10 years ago, and most (such as Stockholm Arlanda, Oslo Gardermoen and Shanghai Pudong) have involved major new infrastructure and rolling stock.

1 Passenger numbers include transit movements as a single movement, although they do not contribute to ground transport movements. Data is from 2004; the top 150 airports representing all airports with passenger numbers above 6.4 mppa.

Table 2. **Airport rail links by continent (top 150 airports by passenger numbers)**

Continent	Existing		Proposed		No. of Airports	
Oceania	2	(40.0%)	0	(0.0%)	5	(3.3%)
Asia	14	(40.0%)	8	(22.9%)	35	(23.3%)
Europe	29	(64.4%)	4	(8.9%)	45	(30.0%)
North America	12	(20.3%)	6	(10.2%)	59	(39.3%)
South America	0	(0.0%)	0	(0.0%)	4	(2.7%)
Africa	0	(0.0%)	0	(0.0%)	2	(1.3%)
Total	58	(38.7%)	18	(12.0%)	150	(100.0%)

Source: Data collected in 2006 from airport and rail authority websites by the author and colleagues.

Table 3. **Breakdown of rail links by type and continent**

Continent	Fast dedicated		Regional		Metro	
Oceania	0	(0.0%)	2	(5.6%)	0	(0.0%)
Asia	2	(28.6%)	6	(16.7%)	5	(35.7%)
Europe	5	(71.4%)	20	(55.6%)	5	(35.7%)
North America	0	(0.0%)	8	(22.2%)	4	(28.6%)
South America	0	(0.0%)	0	(0.0%)	0	(0.0%)
Africa	0	(0.0%)	0	(0.0%)	0	(0.0%)
Total	7	(100.0%)	36	(100.0%)	14	(100.0%)

Source: Data collected in 2006 from airport and rail authority websites by the author and colleagues.

In the remainder of this section, we will concentrate on four rail links that have been introduced or upgraded recently. The objective of this case study is to assess the impact of a new or improved access mode on the access mode choice behaviour: what mode share might such a mode attract and which are the success factors? Ideally, we would also like to discuss the effect on airport choice behaviour. However, no information is available on this.

5.2. London Heathrow – Heathrow Express

London Heathrow Airport is the largest of the five London airports with 67.7 million passengers per annum (2005). The first rail service to Heathrow Airport was the Piccadilly line extension to Terminals 1/2/3, completed in 1977. This was followed by a loop under the airport to Terminal 4, opened in 1986. While this service proved convenient and well-patronised by airport employees and passengers alike, a number of studies had indicated the need for a faster express service. Approval was given for the construction of what had become known as Heathrow Express in 1993, which opened in 1998. The line follows the existing fast Great Western mainline rail alignment from London

Paddington for 18 km before branching into the airport for a further 7 km of newly built track (much of it in tunnel) that loops under the airport.

Heathrow Express is heavily marketed as a premium service, offering a fast, reliable and comfortable journey between central London and Heathrow Airport. The trains are of a high internal standard and emphasize the branding around the station terminals. The express service operates every 15 minutes for a 15-minute journey time (to Terminals 1/2/3, 22 minutes to Terminal 4). The Piccadilly line of the London Underground runs standard "tube" rolling stock, but with extra provision on trains for large baggage near doors, as well as information on which terminal flights depart from. The service runs every five minutes throughout the day, taking some 49 minutes to central London.

That the price of the Heathrow Express is much higher than the underground (£14.50 versus £3.50 in 2006 prices) does not seem to act as a substantial deterrent when the journey time saving is at least 30 minutes. This journey time saving alone, however, does not appear to explain the service's success. It is likely that the lack of crowding (compared with the underground) and more dedicated luggage space on the Heathrow Express are additional attractions.

The Civil Aviation Authority (CAA) undertakes continuous surveys of departing air passengers to Heathrow Airport, which include recording the last three modes of access to the airport. Data up until 2004 (the most recently available year) are given in Table 4, along with mode split information reported by Le Blond from 1996 and the forecast for 2003 made by BAA prior to the opening of the Heathrow Express in 1998.

Table 4. **Mode shares to Heathrow Airport (percentages)**

Mode	**1996**	**2001**	**2002**	**2003**		**2004**
				Forecast	**Actual**	
Private car	43	35.0	36.0	*44*	35.9	35.0
Rental car		3.2	3.2		3.1	2.8
Taxi/minicab	24	26.5	26.1	*16*	25.3	25.9
Underground	16	13.1	13.3	*10*	14.0	14.2
Heathrow Express	-	8.4	8.8	*19*	8.9	9.3
Bus/coach	17	13.1	12.3	*11*	12.6	12.4
Other	-	0.7	0.3	-	0.3	0.3
Total	100	100.0	100.0	*100*	100.0	100.0

Source: CAA surveys and le Blond (1999).

The forecasts for 2003, provided by BAA prior to the opening of the scheme, assumed a substantially higher car mode share (44% *versus* 36%) than actually occurred, but – more critically – assumed that the Heathrow Express would capture 19% of the market, as opposed to the 8.9% it had actually captured by 2003. This is a very substantial shortfall, but not unique – the Arlanda Express service similarly experienced market penetration far below forecasts. Comparing the actual and forecast mode splits, it appears the forecasts overestimated the time sensitivity (and underestimated the cost sensitivity) for underground passengers, who did not shift to the Heathrow Express in the numbers predicted. Equally, the capture of taxi journeys was not as great as had been predicted, perhaps because of underestimating the penalty associated with getting to Paddington with luggage against a taxi journey, direct from anywhere in London to the airport. This latter effect suggests that taxi users are not overly price or time sensitive, but rather value the convenience of a direct service over connecting in London. For groups of 2-3 people, the taxi can be more cost effective as well.

5.3. London Gatwick – Gatwick Express

London Gatwick Airport is the second largest of the London airports after Heathrow (32.7 mppa in 2005). A rail link was first established at Gatwick Airport in 1959, the airport being located directly along the busy north-south line linking Brighton on the south coast with London. A service under the name of Gatwick Express was first established in 1984. During 2000-01, the by then very dated rolling stock was replaced with new rolling stock, much stronger branding was introduced both on the trains, at the airport and at London Victoria Station, and a substantial investment was made in marketing the service to air passengers. The system has thus been given an identity similar to the Heathrow Express as a fast, premium service.

Determining the proportion of the rail mode share that is attributable to each of the rail services, and particularly to Gatwick Express, is difficult. Based on information from CAA (2006) and BAA (2005), we estimate that, of the 24.6% mode share of all rail services to Gatwick in 2004, around 15% would be attributable to the Gatwick Express.

This new Gatwick Express service is recognised as one of the more successful airport rail links. The Gatwick Express service is competing with slower, commuter rail services. The commuter rail services, however, do not start at the airport, but rather further south from London and so they can be very busy in the morning peak period by the time they reach the airport on their journey into London. That this is a disincentive to air passengers is clear, given the 80% rail share that the Gatwick Express service has to London's West End, despite charging 50% more than the Southern service and being only three minutes faster.

The advantages of the Gatwick Express link are the following:

- Strong branding and high-quality rolling stock;
- Availability of a train on the airport platform at most times (avoiding the need for passengers to wait on the platform);
- Dedicated rolling stock with ample baggage storage;
- No crowding over most of the day.

The main disadvantage of the service is that it does not offer any substantial journey time improvement over the competing rail services (although all rail services are very substantially faster than competing road-based modes). This is due to the lack of dedicated high-speed track and the need to fit with existing stopping services on an alignment that is operating at and beyond capacity. Should the Gatwick Express service be upgraded to offer a shorter journey time than competing rail modes, it may reasonably be expected that the service's rail share would increase. To what extent this would happen, and to the detriment of which modes, is uncertain. Given the already high public transport share to London (greater than 70%) and the existing time advantage of rail, it is possible that a faster service would serve only to extract journeys from the competing rail modes.

5.4. Oslo Gardermoen – Flytoget

Oslo Gardermoen Airport was opened in October 1998, to serve as a replacement for Fornebu, which was operating at capacity and could not be expanded further due to its suburban location. The Flytoget is a dedicated high-speed rail link operating between central Oslo and the new airport, some 50 km northeast of central Oslo. The service operates dedicated high-speed rolling stock, which operates every ten minutes during much of the day for a journey time of 19 minutes. The fare is 160 NOK (€20) one way from central Oslo.

Flytoget has maintained a very high modal split since Gardermoen opened, although it has decreased somewhat with time (Table 5). Since 2001, Flytoget's mode share has been stable between 31-35%, suggesting the very high mode split in the opening year was due to a number of external factors related to the opening of both the airport and rail link.

Table 5. **Mode shares to Oslo Gardermoen**

Mode	1999	2005	Change
Taxi	4	6	+2
Rental car	2	2	0
Private car – parking	14	18	+4
Private car – Meet & Greet / Kiss & Fly	7	14	+7
Bus	21	19	-2
Flytoget	41	33	-8
Other train (NSB)	5	7	+2
Other	7	2	-5
Total	100.0	100.0	0

Source: Avinor (2006) and TOI (2005).

The Flytoget service has one of the highest mode shares for an airport rail link anywhere in the world, this being attributable to a number of factors:

- The location of the airport some distance from the city, making a high-speed rail connection inherently more viable (allowing for very substantial improvements in journey time compared to competing modes);
- High-frequency, highly reliable and very fast service between the airport and Oslo city centre (almost twice as fast as any other mode);
- Pricing strategy for the product, that while not the cheapest, is not much more expensive than the bus alternative;
- Extensive marketing and branding of product, resulting in a perception of a premium product. Significant expenditure has been allocated by Flytoget AS to promote the rail service, it being positioned as the highest-quality, fastest and most reliable means of getting from Oslo to the airport. Ongoing marketing campaigns have been supported by rolling

market research of passengers to quantify various service attributes. The Flytoget brand is one of the most widely recognised and highly regarded in Norway. Onboard passenger surveys have indicated that 94% of passengers agree with the statement that Flytoget is the "fastest, easiest and most effective way of getting to and from Oslo Airport" (Flytoget AS, 2005).

5.5. Stockholm Arlanda – Arlanda Express

Four commercial airports serve the Stockholm area; Arlanda is the major airport, serving the majority of domestic and international flights. This airport was built some 43 km north of Stockholm on a greenfield site about two-thirds of the way between Stockholm and Sweden's fourth largest city, Uppsala. The Arlanda Express is a high-speed rail link, operating between central Stockholm and the airport.

Patronage and modal split of the Arlanda Express service has fallen very considerably below forecasts. Actual patronage in 2004 was 2.865 mppa, while the forecast demand for 2005 was 5.10 mppa.

A number of factors may serve to explain, at least in part, why patronage has been so far below forecast. Firstly, the downturn in global aviation following 9/11, the SARS outbreak and more recent terrorist incidents have all had an adverse impact on air passenger growth at Arlanda. In addition, increased competition from other airports in the region – primarily Oslo Gardermoen and Copenhagen Kastrup – and from low-cost carriers operating from other Stockholm regional airports have further suppressed passenger growth. Other factors that have resulted in much lower patronge may include the pricing strategy, which positions the rail service at a much higher price than the alternatives, particularly the "Flybussarna" bus alternative, which has similar service frequencies, twice the journey time but half the cost.

The Arlanda Express link shares many commonalities with the Oslo Flytoget service in that they are both high-speed rail services operating on largely dedicated lines to airports some 40-50 km from the cities they serve. Differences emerge, however, when comparing the mode shares of rail (31% at Oslo, 19% at Stockholm), the financing (Oslo was and remains wholly government-owned) and profitability (the Oslo system has returned an operating profit in all but one year of operations).

The lessons learned from the Arlanda Express can then be contrasted with the comparative successes of the Oslo Flytoget system:

- A high-quality, fast rail service is not in itself sufficient to ensure profitability, nor a very high mode share;
- Rather, the cost relative to competing modes is an important determinant of demand, particularly for leisure travellers. While it is true that business travellers remain a core part of the market for such services (and essential to profitability), the additional volumes that leisure travellers bring (at little marginal cost) seem an important determinant of profitability.
- Pricing differentiation is not always effective, particularly when the perception amongst potential users is that the service is expensive – and thus they fail to even consider the rail alternative. The Oslo ticket structure is very simple and has not changed significantly since inauguration, whereas the Arlanda service has many ticket types that are continually changing.

– Integration into the wider transport network becomes more difficult in a PPP such as Arlanda Express, where the rail network to the airport is effectively vertically integrated in the hands of the private sector provider.

5.6. Conclusions

The above cases have made it clear that a substantial mode share can be attracted by a new rail mode (up to more than 30% as achieved by the Oslo Flytoget service). The success or failure of the rail systems is dependent on a number of factors. The following characteristics are the most important, roughly in decreasing order of importance:

– *Journey time advantage over other modes*
This, along with journey time reliability of rail and/or competing modes, appears to be a very significant factor, as air passengers have high time values;

– *Direct access to the city centre*
Avoiding the need to interchange;

– *Size of the catchment area with direct rail access*
Direct services from the airport catchment are critical;

– *Product positioning*
Critical, both to building brand awareness and sustaining market share, while charging a substantial premium over competing modes. All of the rail links with high mode shares actively marketing their systems as a premium product, have dedicated branding and spend significant sums on marketing their product;

– *Composition of airport passengers*
Particularly the proportion of business travellers (who are more likely to be prepared to pay for a premium, high-speed service) and local passengers (who are more likely to have a car available or be able to obtain a lift to or from the airport);

– *Fare*
There is clear evidence from a number of systems that air passengers are less price-sensitive than passengers for other journeys. However, a price premium over other modes must be combined with superior journey times and product positioning. There is evidence that there is an upper limit to what price can be charged. For example, Oslo charges a premium over other modes that is some 30% above the bus fare and which still achieves a very high mode share. By comparison, the Arlanda and Heathrow services cost more than twice the cheapest modes (bus and underground, respectively) and, as a consequence of this, they lose price-sensitive passengers to competing modes;

– *Terminal access*
The importance of integrating the airport rail station/s into the airport terminal/s is widely recognised.

A number of other relevant factors exist that have not been mentioned explicitly above. One of them is *information provision*. This is clearly very important, particularly when service delays occur. The premium services tend to be more proficient at service provision and customer service in general, as would be expected of their product positioning. While this is undoubtedly important, the requirement for remote *baggage check-in* facilities does not appear to be seen as so important by passengers. While most of the premium rail links have offered baggage check-in facilities at their city termini in the past, most have subsequently removed the service on the basis that the take-up was poor for a service that was costly in terms of labour and space utilisation at the station. The Oslo Flytoget has never offered baggage check-in at the city stations but instead has focussed on providing ample luggage space on trains, luggage trolleys and accessible platforms at both the city and airport stations.

6. CASE STUDY: TICKET TAX IN THE NETHERLANDS

6.1. Introduction

In 2007, the current Dutch Government decided on the introduction of a tax on air tickets. This tax measure should generate €350 million annually, but the exact implementation was still under discussion: it was not yet specified which travellers would pay and which would be exempt from this tax. Sixteen different implementation variants were suggested. The effects of each of those on passenger volumes have been calculated with the AEOLUS model. In this section, we discuss five of these alternative implementations. The objective of this case study is to assess the impact of a change in accessibility (the ticket tax) on passengers' choice of airports.

6.2. AEOLUS model

Dutch government policy allows the continuing growth of air traffic within strict safety and environmental limits. In order to assess the impacts of new policies on the development of Schiphol airport, a model to forecast demand for air travel under a wide range of scenarios was developed for the Ministry of Transport, Public Works and Water Management. This model was developed between 2004 and 2007, and was originally named ACCM – Airport Catchment area and Competition Model, see Kouwenhoven *et al.*, 2006). In 2008, several improvements were implemented and the model was renamed AEOLUS, after the Greek god of the wind.

The model considers worldwide traffic flows from, to and through the airports within the catchment area of Schiphol Airport (the Netherlands, Belgium, northern part of France, western part of Germany, see Figure 5). The model considers traffic flows to/from 56 zones in the world. These zones are relatively small within the catchment area of Schiphol Airport, more aggregated in the rest of Europe and very large in the rest of the world.

The architecture of the simulation system consists of two modules: a module to forecast traveller choices and one to forecast choice of airlines (see Figure 6).

Figure 5**. Relevant airports in the catchment area of Schiphol Airport**

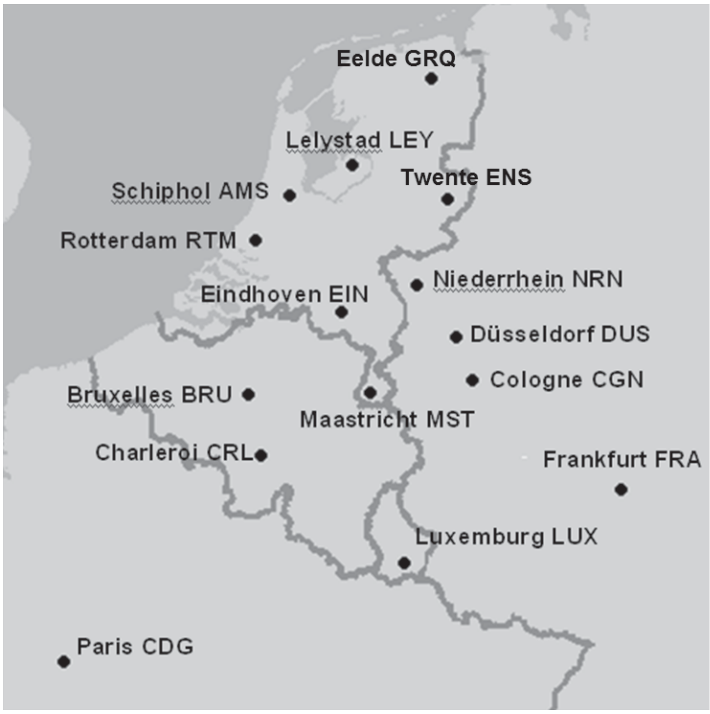
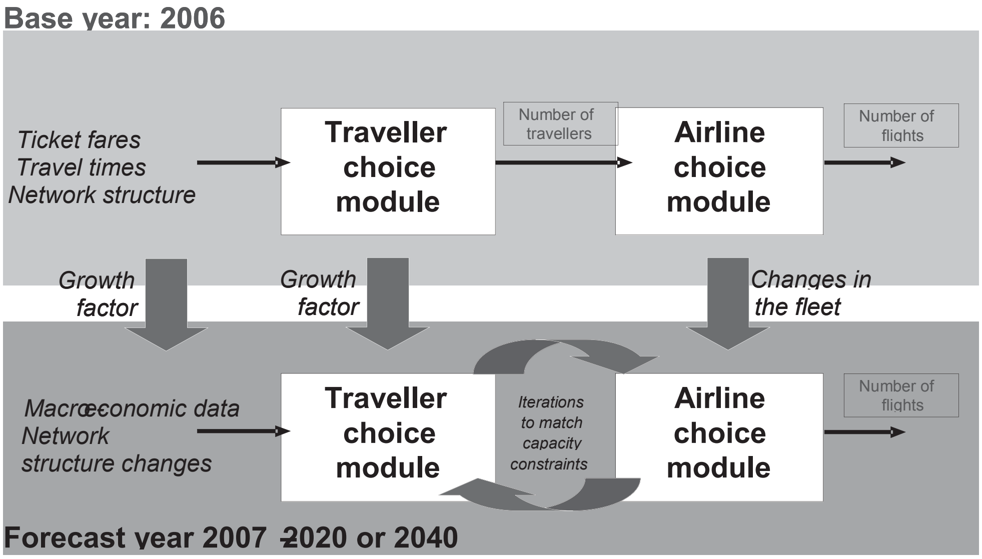
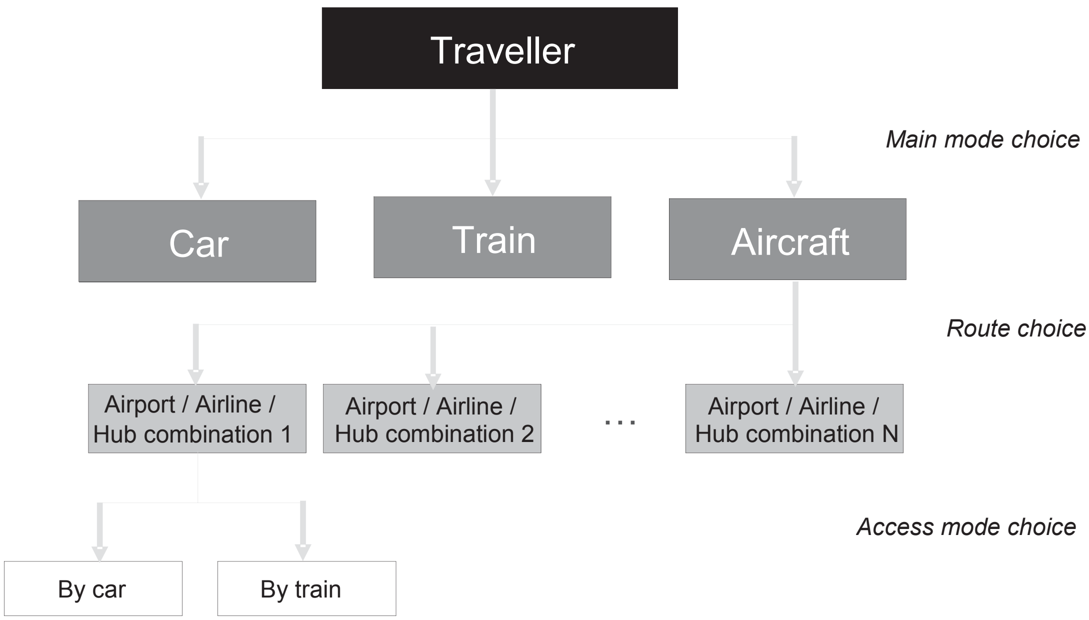


Figure 6. **Structure of the AEOLUS model**



In the first step of a model run, all traffic flows in the base year (i.e. 2006) are simulated. The traveller choice module calculates the number of (one-way) trips that travellers make between an origin and a destination zone in a certain year, and it calculates the distribution of these trips over the available alternatives. The market shares of the available travel alternatives are determined by simulating traveller choices at one to three levels (Figure 7): choice between main modes (car, train or aircraft), choice between available routes [specified by departure airport, airline and route (direct flight or indirect via a hub)], and choice between access modes to the airport (car or train). We use random utility models of the logit type to define traveller choices (Ben-Akiva & Lerman, 1985). Travel and transfer times, travel costs and service frequencies are the main determinants for the utility functions. The module requires current passenger counts and level-of-services for calculating travellers' preferences for the available alternatives in the base year (see Kroes *et al.* (2005) for more details on how a complete OD-matrix was derived from a partially observed database).

Figure 7**. Structure of traveller choice module**



The airline choice module converts the passenger numbers into number of yearly flights per type of aircraft and per period of the day. Calibration factors were determined so that the calculated number of passengers and number of flights match the observed numbers.

For each traffic flow, the number of travellers in the base year is extrapolated towards the forecast year (up to 2040), using a growth factor that depends on economic and price developments. The distribution over the available alternatives in the forecast year is calculated again in the travellers' choice module using a level-of-service for the forecast year. If the capacity constraints are exceeded, scarcity costs are added (both for passengers and airlines) in an iterative loop in order to reduce the demand and redistribute the passenger flows so that the total number of flights and the amount of noise produced does not exceed the limitations.

6.2.1 Access mode choice

There are two alternatives: car and train. Generalised costs for the car mode are determined by fuel cost, parking cost and travel time. Travel times are converted into generalised cost by means of multiplication by an assumed value-of-time, depending on the travel purpose (business or non-business). Generalised costs for the train mode are determined by the train fare and generalised train travel time. Travel fares and times are taken from an input file with level-of-service information.

The same model is used to model the egress mode in case the destination of the trip is in the catchment area.

6.2.2 Route choice

Alternatives are defined by airline (Skyteam, Star Alliance, OneWorld, low-cost airlines, other airlines), by hub (direct flight, or one of 64 international hub options), and by access/egress airport (only if origin or destination is in the catchment area). The utility of each alternative is the sum of the logarithm of the number of flights per week, a generalised cost term [determined by an assumed ticket fare and flight time (with an extra penalty for an indirect flight)] and an accessibility term for the airport (only in the catchment area). This accessibility term is the LogSum of the access mode choice model.

6.2.3 Main mode choice

Main mode choice is only included if the origin is in the catchment area of Schiphol and the destination is somewhere else in Europe (or *vice-versa*). There are three alternatives: car, train and aircraft. The utilities for the first two modes are determined by travel cost (fuel or train fare) and travel time; the utility of the air alternative is determined by the LogSum of the route choice model.

6.3. Simulation of a ticket tax

Sixteen alternative versions of the ticket tax have been studied. These versions differed in the amount of tax that each of the segments (departing passengers, transferring passengers, freight) had to pay. In all versions, the total amount of tax collected per year was €350 million. In the remainder of this section, we discuss five of these versions. Since this paper concentrates on passenger choices, we have only selected versions with no tax on freight (Table 6). The names of the versions correspond to the names in the original report (Significance & SEO, 2007). The simulations have been carried out with the third version of the ACCM model (ACCM-III) in 2007. The results have been confirmed with new simulations performed with the AEOLUS model.

The AEOLUS model simulates the effects of the ticket tax by increasing the fare of air travel, starting from the year of introduction of the tax (i.e. 2008), for each of four macroeconomic scenarios. These scenarios were developed by the Netherlands Bureau for Economic Policy Analysis (de Mooij and Tang, 2005) and they differ in the amount of economic growth (slow to fast) and in the focus on globalisation (small to high).

For the discussion on the effects of the ticket tax, we distinguish between departing and transferring passengers. Arriving passengers do not pay a tax. However, since most passengers buy a round trip ticket, we assume that half of the tax applies to the outward journey and half of it applies to the return journey. Therefore, the effects on arriving passengers are in the model identical to the effects on departing passengers. Note that a transfer passenger has to pay the tax twice per journey, since he makes a transfer both during the outward trip and the return trip.

6.3.1 Version 1: tax on departing passengers only

Each passenger departing from a Dutch airport (except transfer passengers) has to pay a tax of €23. As a result, fewer travellers will use a Dutch airport as their departure airport. The number of departing passengers at Schiphol Airport decreases by 10 to 12% in 2011 (depending on the macroeconomic scenario, see Table 6). As a result, the number of flights will go down. This affects transfer passengers, since they will have fewer options to travel via Amsterdam, and results in a decrease in transfer passengers of between 5 to 8%.

Table 6. **Effect of ticket tax (2011)**

	Version 1	***Version 1E***	***Version 1E-B***	***Version 2***	***Version 2E***
Tax per departure					
European destinations	€23.00	€16.67	€12.50	€13.75	€9.50
Intercontinental destinations	€23.00	€37.50	€47.50	€13.75	€21.38
Tax per transfer					
Europe – Europe	-	-	-	€13.75	€9.50
Europe – ICA	-	-	-	€13.75	€15.44
ICA – ICA	-	-	-	€13.75	€21.38
Schiphol					
Total passengers	-10 to -12%	-8 to -11%	-8 to -10%	-19 to -22%	-20 to -26%
- departing total	*-13 to -14%*	*-11 to -12%*	*-10 to -11%*	*about -10%*	*about -9%*
- departing Europe	*-15 to -16%*	*about -12%*	*-9 to -10%*	*-11 to -12%*	*about -9%*
- departing intercont.	*-8 to -9%*	*-11 to -14%*	*-14 to -18%*	*-6 to -7%*	*-9 to -10%*
- transferring	*-5 to -8%*	*-5 to -7%*	*-4 to -8%*	*-37 to -39%*	*-44 to -48%*
Total flights	-9 to -12%	-8 to -9%	-8 to -9%	-17 to -20%	-17 to -23%
Dutch regional airports					
Departing passengers	-18 to -20%	-14 to -16%	-11 to -13%	-13 to -15%	-9 to -12%
Emissions (Schiphol)					
Noise (dBA)	about -0.3	-0.2 to -0.3	-0.2 to -0.3	-0.7 to -0.8	-0.9 to -1.0
Particles	-5 to -10%	-5 to -9%	-3 to -9%	-14 to -19%	-17 to -23%

For European destinations, the relative increase in air fare is larger than for intercontinental destinations. Hence, the decrease in the number of travellers that depart from Schiphol for a European destination is larger than for intercontinental (15-16% *versus* 8-9%). Since the Dutch regional airports offer mainly European flights and do not serve the segment of transfer passengers that is exempted from the tax, regional airports are affected more than Schiphol Airport (a decrease in the total number of passengers of between 18 to 20% for regional airports *versus* a decrease of 10 to 12% for Schiphol).

6.3.2 Version 1E: differentiation between European and intercontinental destinations

In this version of the ticket tax, departing passengers with a European destination have to pay a tax of €16.67, while passengers with an intercontinental destination have to pay a tax of €37.50. As a result, the decrease of the European market at Schiphol is similar to the decrease of the intercontinental market (about 12%).

6.3.3 Version 1E-B: further differentiation between European and intercontinental destinations

In this version of the ticket tax, departing passengers with a European destination have to pay a tax of €12.50, while passengers with an intercontinental destination have to pay a tax of €47.50. As a result, the decrease of the European market at Schiphol is less than the decrease of the intercontinental market (9-10% *versus* 14-18%). Regional airports are less affected than in versions 1 and 1E: the decrease in the total number of passengers for the Dutch regional airports is about the same as for Schiphol Airport (11-13% for regional airports versus 8-10% for Schiphol).

6.3.4 Version 2: tax on departing and transferring passengers

Transfer passengers pay the same amount of tax (per transfer) as departing passengers. In order to raise €350 million per year, the tax is €13.75. This results in a very strong decrease in the number of transfer passengers (37-39%). This is due to the fact that these passengers have to pay the tax twice per round journey, since they will make a transfer both during the outward and the return trip. Furthermore, these passengers have very good alternatives, because most of them can also choose to make a transfer at London Heathrow, Frankfurt or Paris Charles de Gaulle without paying extra tax or having to make a detour.

6.3.5 Version 2E: differentiation between European and intercontinental destinations

This version is similar to version 2, but the amount of tax depends on the destination (tax for intercontinental destinations is about 2.25 as high as for Europeans destinations). This has an even larger effect on transferring passengers (that are predominantly passengers with a intercontinental origin or destination. The decrease of the total number of passengers at Schiphol Airport is 20-26%, while the decrease at regional airports is limited to between 9 to 12%.

6.4. Effects by segment

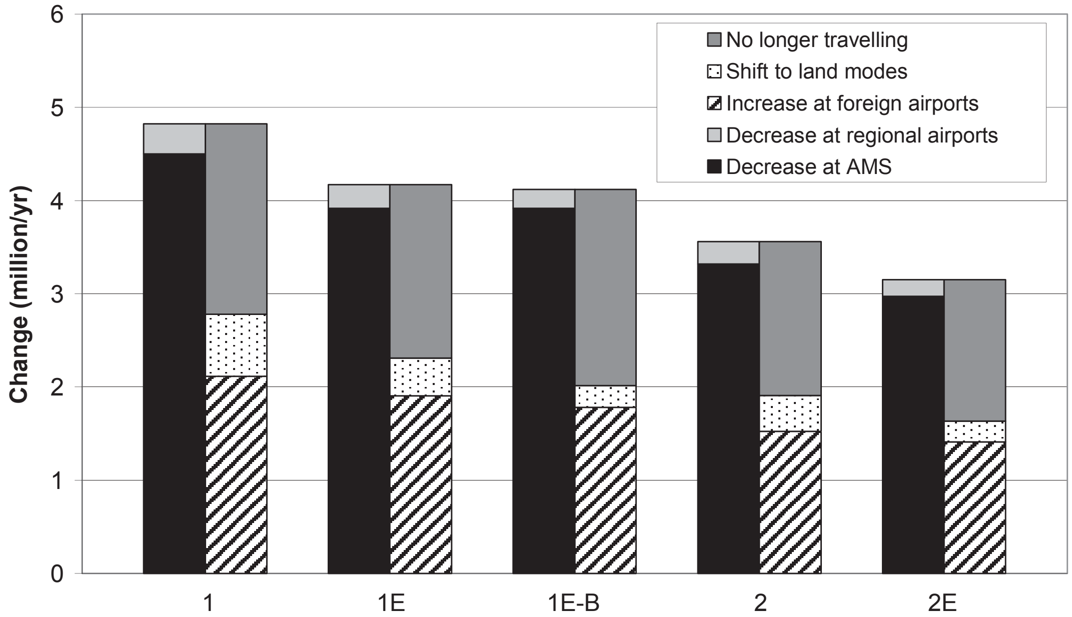
6.4.1 Departing passengers

In all versions, the number of passengers departing from Dutch airports will decrease. Instead, they will:

– depart from a foreign airport, where they do not have to pay the ticket tax;
– travel using another mode (either train or car). This is only an alternative for travel within Europe;
– not make the trip.

Figure 8 displays the number of passengers (absolute number of passengers, as determined after averaging over the four macro-economic scenarios), that change their travel behaviour for each version of the ticket tax (departing and arriving together). The total number of passengers that no longer depart from/arrive at a Dutch airport (either Amsterdam Schiphol, or at one of the regional airports) is equal to the number of passengers that either shift their departure/arrival to a foreign airport (about 45%), or shift to a different mode (about 10%), or no longer travel (about 45%).

Figure 8**. Effect of ticket tax on passengers departing/arriving at Dutch airports (2011)**



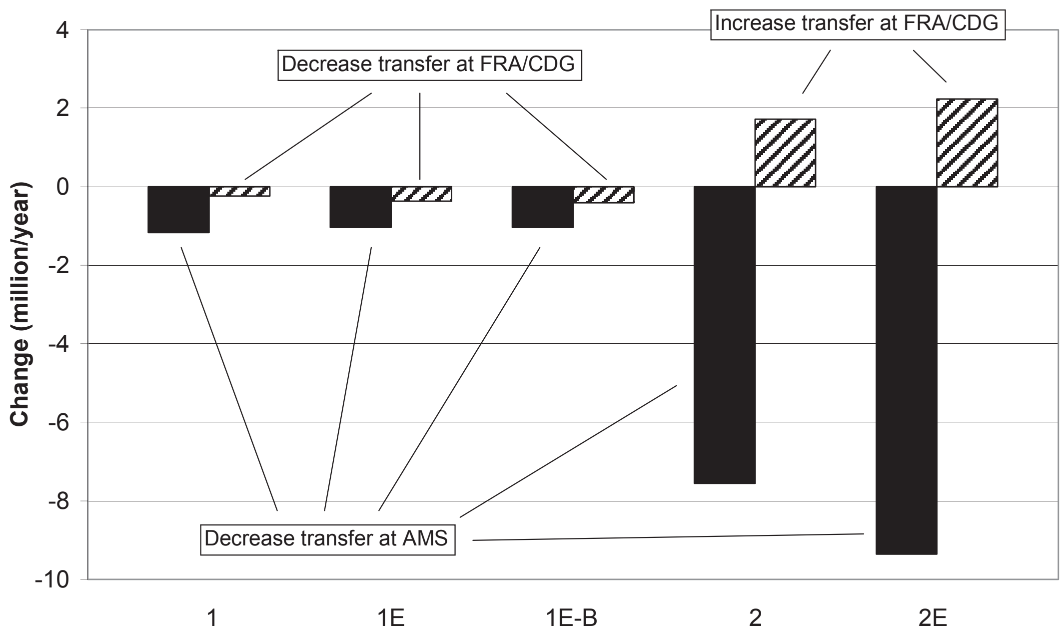
6.4.2 Transfer passengers

Travellers that stop transferring at Schiphol Airport as a result of the introduction of the ticket tax will instead:

– transfer at another airport;
– shift to a direct flight;
– not make the trip.

Figure 9 displays the effect on the number of transfer passengers at Schiphol, Frankfurt and Paris Charles de Gaulle. In versions 1, 1E and 1E-B, the number of transfer passengers at Frankfurt and Charles de Gaulle reduces as well. These are travellers that would have departed from a Dutch airport and would have transferred at FRA or CDG if there would not have been a ticket tax. In versions 2 and 2E, the number of transfer passengers at Frankfurt and Charles de Gaulle increases. These are travellers that have diverted their route due to the ticket tax at Schiphol Airport.

Figure 9**. Effect of ticket tax on passengers transferring at Amsterdam Schiphol Airport (2011)**



6.5. Final implementation

In order to mitigate the effects of the ticket tax on the airlines and airports (particularly on Dutch regional airports), the government decided to implement a version that is very similar to version 1E-B. It was decided that the tax would be €11.25 for all destinations within 2 500 kilometres, including all EU Member countries) and €45 for other destinations. An exception is made for countries with destinations on both sides of the 2 500 km border. The low tax of €11.25 also applies for other destinations in those countries, provided that they are not further away than 3 500 km.

This tax took effect on 1 July 2008, and its consequences are already noticeable. The number of passengers departing from foreign airports is increasing, according to travel agencies. One of these agencies (D-reizen) reports an increase in this number of 350% (Volkskrant, 2008a). Schiphol Airport expects that passenger growth will stagnate (NRC, 2008). KLM expects to lose half a million to a million passengers in 2008 (Volkskrant, 2008b).

6.6. Conclusion

A change in the accessibility of a single airport (or a group of airports) can have major effects on passengers' choice of airports, especially if good alternatives are available. In this specific situation, the average ticket price for journeys departing from/arriving at a Dutch airport increases by about 5%. Since the reduction in the number of passengers departing/arriving at Dutch airports is about 10%, the elasticity of demand is about -2 (of which about half is attributed to a switch to a foreign airport, while the other half is attributed to travellers that cancel the trip).

7. CONCLUSIONS

Understanding the choice process of air travellers is a key element in understanding the effectiveness of policy options regarding airport development. Two important factors in this choice process are the access mode choice and the airport choice.

Access mode choice has been studied extensively and several models are around. However, no clear consensus has yet emerged on which explanatory variables should be included or how the various modes and sub-modes should be nested in the model (Gosling, 2008). Because of this, it is not possible to transfer these models to other airports for which they were not specifically developed.

A change in the attributes of an access mode can have large impacts on passengers' access mode choice. The most important attributes that determine the mode choice are access travel time and access cost. Some travellers prefer a cheaper but slower mode, while others (especially business travellers) choose a more expensive but faster mode. Other factors that may also be important, such as the reliability of travel times/predictability of arrival times, have not been studied in depth so far.

Introducing a new access mode (e.g. a fast rail connection) can substantially change the access mode shares. Factors that determine the success of such a scheme include that the journey time should clearly be shorter than that of competing modes, and the fare should be in accordance with the travel time savings and the positioning of the product.

A relative change in accessibility of one airport to another can have large impacts on passenger airport choice behaviour. The case study on the introduction of a ticket tax in the Netherlands demonstrated both a high total demand elasticity and a high elasticity for airport switching. The total demand elasticity (at all airports) in the case study was shown to be about –1 (i.e. a 1% increase in ticket price results in a 1% reduction in the number of departing/arriving passengers). In addition, the airport switch elasticity was also shown to be about –1 (in case of a 1% increase in ticket price, an additional 1% of travellers will switch airports).

Though very little research has been done into this, it is likely that a deterioration of car accessibility resulting from increasing congestion, can have a large impact on airport choice behaviour. This not only results in longer access times, but also in a decrease of reliability (i.e. a decrease of predictability of arrival times). Especially in multi-airport regions, this might result in a substantial switch in airport market shares. But other factors impacting airport market shares can be thought of, especially fast, easy and cheap parking, fast and easy travel within the terminal, etc. Again, very little research into the impact of these factors has been carried out.

Further quantitative research remains necessary to really understand the choices that air travellers are making. Given the large investments made to improve accessibility to airports and to increase their capacity, objective analysis is essential. New, stated-preference design techniques make it possible to provide respondents with realistic choice situations. This will improve the quality of the results. Other factors not yet researched, such as reliability and the impact of congestion around airports, also need to be included in these studies.

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THE ECONOMIC EFFECTS OF HIGH SPEED RAIL INVESTMENT

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SUMMARY

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ABSTRACT

The allocation of traffic between different transport modes follows transport user decisions which depend on the generalised cost of travel in the available alternatives. High-Speed Rail (HSR) investment is a government decision with significant effects on the generalised cost of rail transport; and therefore on the modal split in corridors where private operators compete for traffic and charge prices close to total producer costs (infrastructure included).

The rationale for HSR investment is not different to any other public investment decision. Public funds should be allocated to this mode of transport if its net expected social benefit is higher than in the next best alternative. The examination of data on costs and demand shows that the case for investing in HSR is strongly dependent on: the existing volume of traffic where new lines are built; the expected time savings and generated traffic; the average willingness to pay of potential users; the release of capacity on congested roads, in airports or on conventional rail lines; and the net reduction of external effects.

This paper discusses, within a cost-benefit analysis framework, under what conditions the expected benefits from deviated traffic (plus generated traffic) and other alleged external effects and indirect benefits, justify the investment in HSR projects. It pays special attention to intermodal effects and pricing.

Keywords: Cost-benefit analysis, infrastructure investment, high-speed rail, intermodal competition.

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1. INTRODUCTION

Investing in high-speed rail is a central planning decision. The government decides the introduction of a new rail technology which allows trains running at a speed of 300-350 kilometres per hour (although the average commercial speed is substantially below the technically feasible speed). At the beginning of 2008, there were about 10 000 km of new high-speed lines in operation around the world and, in total (including upgraded conventional tracks), more than 20 000 km of the worldwide rail network was devoted to providing high-speed services (Campos *et al*., 2006).

This railway technology is particularly popular in the European Union. High-Speed Rail (HSR) investment projects of European member countries are financially supported by the European Commission. Revitalising the railways (European Commission, 2001a) is the new motto in European transport policy, meaning both introducing competition in the railway industry and giving priority to public investment in the rail network[1].

Investing in HSR is on the front line of action to revitalise the railways. The ultimate objective is to change modal split in passenger transport with the aim of reducing congestion, accidents and environmental externalities. HSR investment is seen as a second-best policy, with the aim of changing modal split to the benefit of the railways[2].

High-speed trains require high-speed infrastructure, meaning that new dedicated tracks need to be built at a cost substantially higher than the conventional rail line. Infrastructure maintenance costs are comparable with conventional rail but the building costs and the acquisition, operation and maintenance costs of specific rolling stock make this transport alternative an expensive option. In any case, the cost of HSR is not the point. The economic problem is whether the social benefits are high enough to compensate the infrastructure and operating costs of the new transport alternative. Even this being the case, other relevant alternatives should be examined and compared with the investment in HSR.

HSR competes with air and road transport within some very specific distances and is also considered as a substitute for feeder air services to main hub airports (Banister and Givoni, 2006). In any case, spending public money on the construction of HSR lines has been defended as a socially desirable public investment, producing several types of benefits: passenger time savings; increase in comfort; generation of new trips; reduction in congestion and delays for roads and airports; reduction in accidents; reduction in environmental externalities; release of needed capacity for airports and conventional rail lines; as well as wider economic benefits, including the development of the less developed regions.

To enumerate the list of social benefits generated by HSR is as irrelevant as showing how expensive the new technology is. In economic terms, the net balance is what really matters, and this net result cannot be obtained without due consideration of the base case, compared with different "projects" available for the solution of the "transport problem" under evaluation. HSR is one alternative whose net benefits have to be compared with those resulting from, e.g., the construction or upgrading of a conventional railway line, the construction of new airports or road capacity, or the introduction of congestion pricing, alone or combined with different investment plans.

HSR social profitability is obviously very sensitive to the full price that passengers incur when choosing between different transport alternatives. Modal split is in equilibrium when users have compared the generalised costs of travel for different options available to them and have chosen according to those costs and their willingness to pay. Before HSR is introduced, travellers use road and air transport in proportions clearly determined by distance. HSR investment alters the existing equilibrium, competing with car in distances up to 300 km and with air particularly in the range 300-600 km. These distances are coarse references as the particular conditions of accessibility (access and egress time, parking conditions, security control, etc.) are frequently more determinant than the travel time itself.

The average fare to be charged is an important component of the generalised cost of travel. Producer costs (infrastructure and operation) are basically included in the general cost of using the car or the airline. This is not always the case with HSR. Railways are far from being cost-recovering when infrastructure costs are included. Therefore, the decision on which kind of pricing principle is going to be followed for the calculation of railway fares is really critical. Given the high proportion of fixed costs associated with the HSR option, the decision on charging according to short-term marginal cost or something closer to average cost could radically change the volume of demand for railways in the forecasted modal split, and this unavoidable fact has obviously a profound effect on the expected net benefit of the whole investment.

This paper discusses, within a basic cost-benefit analysis framework, under what conditions the expected benefits from deviated traffic (plus generated traffic) and other external and indirect benefits, justify the investment in HSR. The case for the HSR is strongly dependent on the volume of traffic where the new lines are built, the time savings and generated traffic and the average willingness to pay of passengers, the release of capacity in congested roads, airports or conventional rail lines and the reductions of external effects. The magnitude of the traffic volumes and shifts depends heavily on whether infrastructure costs are included in rail fares or financed by taxes. If rail infrastructure charges are based on short-run marginal cost, intermodal substitution will be dramatically affected by HSR public investment decisions. In this case, *ex ante* cost-benefit analysis of HSR investment is, more than ever, a key element of transport policy.

The economic evaluation of HSR investment has been covered from different perspectives. A general assessment can be found in Nash (1991), Vickerman (1997), Martin (1997) and de Rus and Nombela (2007). For the cost-benefit analysis of existing or projected lines, see: de Rus and Inglada (1993, 1997), Beria (2008) for the HSR Madrid-Seville; Levinson *et al.* (1997) for Los Angeles-San Francisco; Steer Davies Gleave (2004), Atkins (2004) for the UK; de Rus and Nombela (2007), de Rus and Nash (2007) for the European Union. For the regional effects of HSR investment: Vickerman (1995, 2006), Blum, Haynes and Karlsson (1997), Plassard (1994), Haynes (1997), Preston and Wall (2007) and, in a broader context, Puga (2002).

This paper tries to shed some light on the economic dimension of HSR investment decisions, which not only affects the transport sector but has significant effects on the allocation of resources. The European Commission has opted enthusiastically for this technology; meanwhile countries like the UK or the USA have been reluctant in the recent past to finance the construction of a high-speed rail network with public funds, which is a priority in the European Union. Why are some countries such as France or Spain allocating a high proportion of public money to the construction of new lines while others maintain their conventional railway lines? HSR is quite effective in deviating passengers from other modes of transport, but the relevant question is whether the sum of the discounted net social benefits during the life of the infrastructure justifies the investment cost.

The description of the costs and benefits of HSR lines is covered in section 2, where some figures on the average fixed and variable costs per passenger on a standard line are presented for comparison with the alternatives. The source of the benefits of HSR is also discussed. The economic analysis of the investment in HSR is contained in section 3, where a simple model is presented to evaluate the social value of this public investment. In section 4, the intermodal effects are covered from the perspective of deviated traffic and the impact on secondary markets. Pricing is a key element in explaining the economic results of the HSR. Price determines demand volume, social benefits and the financial outcome. In section 5, the economic consequences of pricing HSR services according to different economic principles are discussed, as well as some long-term effects.

2. THE COSTS AND BENEFITS OF A NEW HSR LINE

2.1. Total costs of building and operating an HSR line

The total social costs of building and operating an HSR line include the producer costs, the user and the external costs. *Producer costs* involve two major types of cost: infrastructure and operating costs. *User costs* are mainly related to total time costs, including access, egress, waiting and travel time invested, reliability, probability of accident and comfort. *External* costs are associated with construction (e.g. barrier effect and visual intrusion) and operation (e.g. noise, pollution and contribution to global warming). In this section, we concentrate on producer and external costs[3]. User costs are dealt with in section 2.3.

2.1.1 Infrastructure costs

The construction costs of a new HSR line are marked by the challenge to overcome the technical problems which prevent reaching speeds of above 300 km per hour, such as roadway level crossings, frequent stops or sharp curves, new signalling mechanisms and more powerful electrification systems. Building new HSR infrastructure involves three major types of cost: planning and land costs, infrastructure building costs and superstructure costs (UIC, 2005).

Feasibility studies, technical design, land acquisition, legal and administrative fees, licences, permits, etc., are included in *Planning and land costs*, which can reach up to 10% of total infrastructure costs in new railway lines requiring costly land expropriations. *Infrastructure building costs* involve terrain preparation and platform building. Depending on the characteristics of the terrain and the need for viaducts, bridges and tunnels, these costs can range from 15 to 50% of total investment. Finally, the rail-specific elements, such as tracks, sidings along the line, signalling systems, catenary, electrification communications and safety equipment, installations, etc., are called *superstructure costs*.

Railway infrastructure also requires the construction of stations. Although sometimes it is considered that the costs of building rail stations, which are singular buildings with expensive architectonic design, are above the minimum required for technical operation, these costs are part of the system and the associated services provided affect the generalised cost of travel (for example, quality of service in the stations reduces waiting time).

From the actual building costs (planning and land costs and main stations excluded) of 45 HSR lines in service, or under construction, the average cost per km of an HSR line ranges from between 9 and 40 million euros, with an average of 18 million. The upper values are associated with difficult terrain conditions and the crossing of high-density urban areas.

2.1.2 Operating costs

The operation of HSR services involves two types of cost: infrastructure maintenance and operating costs, and those related to the provision of transport services using the infrastructure. *Infrastructure operating costs* include the costs of labour, energy and other materials consumed by the maintenance and operation of tracks, terminals, stations, energy supplying and signalling systems, as well as traffic management and safety systems.

Some of these costs are fixed, and depend on operations routinely performed in accordance with technical and safety standards. In other cases, as with track maintenance, the cost is affected by the traffic intensity; similarly, the cost of maintaining electric traction installations and the catenary depends on the number of trains running on the infrastructure.

From data corresponding to five European countries (Belgium, France, Italy, the Netherlands and Spain), infrastructure maintenance costs *per km of single track* are, on average, equal to 30 000 euros per year.

The operating costs of HSR services (train operations, maintenance of rolling stock and equipment, energy, and sales and administration) vary between rail operators, depending on the specific technology used by trains and traffic volumes. In the case of Europe, almost each country has developed its own technological specificities; each train has different technical characteristics in terms of length, composition, seats, weight, power, traction, tilting features, etc. The estimated acquisition cost of rolling stock per seat ranges from 33 000 to 65 000 euros.

The train operating costs per seat range from 41 000 to 72 000 euros and rolling stock maintenance from 3 000 to 8 000 euros. Adding operating and maintenance costs, and taking into account that a train runs from between 300 000 and 500 000 km per year and that the number of seats per train ranges from 330 to 630, the cost per seat-km can be as high as twice in two different countries.

2.1.3 External costs

A common assumption regarding the introduction of HSR services is that negative externalities will be reduced in the affected corridor, thanks to the deviation of traffic from less environmentally friendly modes of transport.

Nevertheless, the building of an HSR line and operating trains leads to environmental costs in terms of land take, barrier effects, visual intrusion, noise, air pollution and contribution to global warming. The first four of these impacts are likely to be stronger where trains go through heavily populated areas. HSR trains are electrically powered, and therefore produce air pollution and global warming impacts when coal, oil and gas are the main electricity sources.

The negative environmental effects of the construction of a new high-speed rail line have to be balanced against the reduction of externalities in road and air transport when passengers shift to HSR. The final balance depends on several factors (see a more formal discussion in section 4) but basically the net effect depends on the magnitude of the negative externalities in HSR compared with the substituted mode, on the volume of traffic diverted and whether, and in what degree, the external cost is internalised.

To the extent that infrastructure charges on these modes do not cover the marginal social cost of the traffic concerned, there will be benefits from such diversion. Estimation of these benefits requires the valuation of the marginal costs of congestion, noise, air pollution and global warming and the external costs of accidents and their comparison with taxes and charges.

The marginal external costs (including accidents and environmental costs, but excluding congestion) per passenger-km for two European corridors have been estimated in INFRAS/IWW (2000). The results show that the external costs of the high-speed rail line between Paris and Brussels are less than a quarter of those for car or air. It is worth looking not only at the relative but also at the absolute values. For the HSR line Paris-Brussels, the external cost of 1 000 passenger-km is equal to €10.4 (€43.6 for cars and €47.5 for air transport). The external cost of HSR is highly dependent on the train load factors. For long distances the advantage over air is reduced, as much of the environmental cost of the air transport alternative occurs at take-off and landing.

2.2. Some basic calculation of HSR costs

Let us try to figure out the average producer cost per passenger-trip of a new HSR line. A railway line, called North-South is 500 km long. The average construction cost per km of this hypothetical line is equal to 18 million euros, the average cost in Europe. Land and planning costs add 10% to the construction costs. For simplicity, we will ignore the cost of building the stations (which varies within a wide range and could be substantial). Under these assumptions, the total construction cost is equal to €9 900 million.

Assuming the infrastructure does not depreciate when properly maintained and a social discount rate of 5%, this asset has an opportunity cost per annum equal to €495 million. To this fixed cost, the maintenance cost has to be added. This means €30 million per annum, taking into account that the average infrastructure maintenance cost per km of single track is equal to €30 000 per year.

Let us calculate the variable total cost, distinguishing three components: rolling stock, operating costs and train maintenance. The average cost of a train is €30 million and the number of seats 330. Each train runs 500 000 km per year. Assuming the average load factor reaches 80%, each train provides 132 million passenger-km. For an expected life of 20 years and no residual value, the annual cost of a train is equal to €2.4 million. Operating costs per train and year are equal to €25 million. Rolling stock maintenance costs equal €1.5 million per train and per year.

To calculate the cost per passenger trip on the North-South HSR line, we need to know the volume of demand. Assuming 5 million passenger trips in the first year of operation, with an average trip length of 500 km (a quite fair assumption), the average fixed cost (construction and maintenance infrastructure) per round trip is equal to €210. The average variable cost per round trip equals €218 euros. The total cost of a round trip per passenger in the first year of operation reaches €428. This average cost per round trip is obviously very sensitive to the volume of demand and the average trip length.

2.3. Where do HSR benefits come from?

Investing in HSR infrastructure is associated with lower total travel time, higher comfort and reliability, a reduction in the probability of accident and, in some cases, the release of extra capacity which helps to alleviate congestion for other modes of transport. Last but not least, it has been argued that HSR investment reduces the net environmental impact of transport and boosts regional development.

We have already shown that the environmental benefits of HSR are not so great and, in any case, depend heavily on the deviation of traffic from more environmentally damaging modes, the source of electricity generation and the density of urban areas crossed. Expected regional development effects are also controversial and are considered in section 2.4.

The observation of existing HSR lines shows that user benefits deserve a closer examination. Let us start with total travel time. The user time invested in a round trip includes access and egress time, waiting time and in-vehicle time. The total user time savings will depend on the transport mode the passengers are coming from. Evidence from case studies on HSR development in seven countries shows that when the original mode is a conventional railway with an operating speed of 130 km/h, representative of many railway lines in Europe, the introduction of HSR services yields 45-50 minutes' savings for distances in the range of 350-400 km. When conventional trains run at 100 km/h, potential time savings are one hour or more, but when the operating speed is 160 km, the time saving is around half an hour over a distance of 450 km (Steer Davies Gleave, 2004). Access, egress and waiting times are practically the same.

When the passenger mode shifts from road or air, the situation changes dramatically. For road transport and line lengths of around 500 km, passengers benefit from travel time savings but they lose with respect to access, egress and waiting times. Benefits are higher than costs when the travel distance is long enough, as HSR runs, on average, twice as fast as the average car. Nevertheless, as the travel distance gets shorter, the advantage of HSR diminishes, as "in-vehicle time" loses weight with respect to access, egress and waiting times.

Air transport in some ways presents the opposite case to road transport. Increasing the distance reduces the HSR market share. For a 2 000 km trip (and shorter distances) the competitive advantage of HSR vanishes. But, what about the medium distance (500 km) where the market share of HSR is so high? Compared with a standard HSR line of 500-600 km, air transport has lower in-vehicle time. The advantage of HSR rests on access, egress and waiting times, plus differences in comfort.

The net user benefit of shifting a passenger from air to HSR could even be positive in the case of longer total travel after the shift. This would be the case if the values of time of access, egress and waiting are high enough to compensate the longer in-vehicle time. The relative advantage of HSR with respect to air transport is significantly affected by the existing differences in the values of time, and these values are not unconnected with the actual experience of waiting, queueing and passing through security control points in airports.

The generalised cost of air transport is seriously penalised by security controls at airports, and this translates into greater attractiveness for the HSR option. To explain the causes of the reduction in passengers' underlying willingness to pay for air travel, it is worth looking at the changes suffered by the airline product, with increased security and the need to arrive earlier at airports. "*Consider as an illustration the effect on air travel of required earlier arrival at airports. If passengers must now arrive at their origin airport one-and-a-half hours earlier than previously, then, under plausible* *assumptions of relevant parameters, travel could decline by 7% (a plausible range is 3-11%)* (Morrison and Winston, 2005)."

Benefits also come from generated traffic. The conventional approach for the measurement of the benefit of new traffic is to consider that the benefit to the infra-marginal user is equal to the difference in the generalised cost of travel with and without HSR. For the last unit of generated traffic, the traveller is indifferent between travelling (on either mode) or not, so the user benefit is zero. Assuming a linear demand function, the total user benefit of generated demand is equal to one-half of the difference in the generalised cost of travel.

Where the conventional rail network is congested or the airports affected are working close to maximum capacity, the construction of a new HSR line has the benefit of relieving capacity for suburban or regional passenger services or freight. In the case of airports, the additional capacity can be used to reduce congestion or scarcity. In any case, the introduction of HSR would produce this additional benefit.

2.4. HSR and its effects on regional inequalities

The framework of conventional cost-benefit does not include the evaluation of the impact of transport infrastructure projects on regional development. Puga (2002) argues that concentrating on the primary market and some closely related secondary market may be justified provided that two conditions are met: first, that distortions and market failures are not significant and so there is no need to worry about the indirect effects of the project; and second, "*the changes in levels of activity induced by the project fade away fairly rapidly as we move away from those activities more closely related to it. However, these conditions are often not met. There has been increasing realisation throughout economics that wide ranges of economic activities may be affected by market failure and distortions. And the type of cumulative causation mechanisms modelled by the new economic geography can make the effects of a project be amplified rather than dampened as they spread through the economy* (Puga, 2002)."

Should we worry about these wider economic benefits in the case of HSR investment? Puga (2002), Duranton and Puga (2001), Vickerman (1995, 2006) and Vives (2001) suggest that additional benefits are not expected to be very important in the case of high-speed railway infrastructure. The reason is that freight transport does not benefit from high speed and therefore the location of the industry is not going to be affected by this type of technology. Moreover, in the case of the service industry, HSR may lead to a concentration of economic activity in the core urban centres.

Recent research (Graham, 2007) suggests that agglomeration benefits in sectors such as financial services may be greater than in manufacturing. This is relevant to the urban commuting case but arguably is important for some HSR services (e.g. the North European network, which links a set of major financial centres and may be used for some form of weekly commuting). It may be erroneous to conclude that scale economies and agglomeration economies (productivity impacts) are only found in manufacturing and freight transport.

Investment in HSR as well as other transport infrastructure has been defended as a way to reduce regional inequalities. If the definition of personal equity is difficult, its spatial dimension is even more elusive. European regional funds aim to reduce regional inequalities, but the problem is to define clear objectives so that it is possible to compare the results of different policies.

The final regional effects of infrastructure investment are not clear and depend on the type of project and other conditions, such as wage rigidity and interregional migration. There are some ambiguities related to the role of opposite forces which affect the balance between agglomeration and dispersion. It is difficult, *a priori*, to predict the final effect.

An excellent summary of the main findings regarding the effects of infrastructure investment and regional inequalities is the following: "*Firms producing in locations with relatively many firms face stronger competition in the local product and factor markets. This tends to make activities dispersed in space. However, the combination of increasing returns to scale and trade costs encourages firms to locate close to large markets, which in turn are those with relatively many firms. This creates pecuniary externalities which favour the agglomeration of economic activities* (Puga, 2002)."

Reductions in trade or transport costs, by affecting the balance between dispersion and agglomeration forces, can decisively affect the spatial location of economic activities. For high trade costs, the need to supply markets locally encourages firms to locate in different regions. For intermediate values of transport costs, the incentives for self-sufficiency weaken. Pecuniary externalities then take over, and firms and workers cluster together. However, the price of local factors and the availability of goods tend to increase wherever agglomeration takes place. If this is the case, and there is enough mobility, as trade costs continue to fall, rising factor prices simply give an additional kick to agglomeration by inducing immigration. On the other hand, if there is little mobility, for very low transport costs it may be that firms relocate in response to wage differentials.

Whether there is too much or too little agglomeration in the absence of regional policy interventions is not clear. The fact that firms and workers move without taking into account the possible losses for those left behind implies that there may be too much agglomeration. On the other hand, when firms and workers move, since they do not fully take into account the benefits they bring for other firms and their impact on aggregate growth, there may be too little agglomeration. Thus, there is no general indication of the direction in which governments should push with regional policies when seeking efficiency. Even in terms of equity, the direction of policy is not obvious. Policies that increase agglomeration may, nevertheless, make those that remain in poorer regions better off by increasing production efficiency and the rate of growth.

Despite these ambiguities, European regional policies have the explicit aim of reducing regional inequalities. One of the main instruments for this is the improvement of transport infrastructure. However, it is not obvious that lower transport costs facilitate convergence. Roads and rail tracks can be used to travel both ways. A better connection between two regions with different development levels not only gives firms in a less developed region better access to the inputs and markets of more developed regions; it also makes it easier for firms in richer regions to supply poorer regions at a distance, and can thus harm the industrialisation prospects of less developed areas.

New economic geography models not only point out this potential ambiguity in the impact of lower transport costs on less developed regions, they also tell us that the overall effect depends on certain aspects of the economic environment (such as mobility and wage rigidities) and on characteristics of the projects. In this respect, the Trans-European Transport Network will give much of the EU better access to the main activity centres. However, the gap in relative accessibility between core and peripheral areas is likely to increase as a result of the new infrastructure, which reinforces the position of core regions as transport hubs. The emphasis on high-speed rail links is also likely to favour the main nodes of the network, and is unlikely to promote the development of new activity centres in minor nodes or in locations in-between nodes.

3. THE ECONOMIC EVALUATION OF HSR INVESTMENT

3.1. A simple cost-benefit model for the evaluation of HSR

Suppose that a new HSR project is being considered. The first step in the economic evaluation of this project is to identify how the investment, a "do something" alternative, compares with the situation *without* the project. A rigorous economic appraisal would compare several relevant "do something" alternatives with the base case. These alternatives include upgrading the conventional infrastructure, management measures, road and airport pricing or even the construction of new road and airport capacity. We assume here that relevant alternatives have been properly considered.

3.1.1 HSR as an improvement of the railways

The public investment in HSR infrastructure can be contemplated as a way of changing the generalised cost of rail travel in corridors where conventional rail, air transport and road are complements or substitutes. Instead of modelling the construction of HSR lines as a new transport mode, we consider this specific investment as *an improvement* of one of the existing modes of transport, the railway. Therefore, it is possible to ignore total willingness to pay and concentrate on the incremental changes in surpluses or, alternatively, on the changes in resource costs and willingness to pay.

We follow here a resource cost approach and ignore the distribution of benefits and costs (see subsection 5.3.2 for a brief discussion on equity) and concentrate on the change in net benefits and costs, ignoring transfers.

The social profitability of the investment in HSR requires the fulfilment of the following condition:

$$\int_0^T B(H)e^{-(r-g)t}dt > I + \int_0^T C_f e^{-rt}dt + \int_0^T C_q(Q)e^{-(r-g)t}dt\,, \qquad (1)$$

where:

B(H): annual social benefits of the project;
C_f: annual fixed maintenance and operating cost;
$C_q(Q)$: annual maintenance and operating cost depending on Q;
Q: passenger trips;
I: investment costs;
T: project life;
r: social discount rate;
g: annual growth of benefits and costs which depends on the level of real wages and Q.

B(H) is the annual gross social benefit of introducing high-speed rail in the corridor, subject to evaluation, where a "conventional transport mode" operates. The main components of *B(H)* are: time and cost savings from deviated traffic, increase in quality, generated trips, the reduction of externalities and, in general, any relevant indirect effect in secondary markets, particularly including the effects on other transport modes (the conventional transport modes). Other benefits, related to the relocation of economic activity and regional inequalities, are not included in *B(H)* and have been discussed in section 2.4. The net present value of the benefits included in equation (1) can be expressed as:

$$\int_0^T B(H)e^{-(r-g)t}dt = \int_0^T [v(\tau^0 - \tau^1)Q_0 + C_C](1+\alpha)e^{-(r-g)t}dt + \sum_{i=1}^{N}\int_0^T \delta_i(q_i^1 - q_i^0)e^{-(r-g)t}dt\,, \quad (2)$$

where:

v: average value of time (including differences in service quality);

τ^0: average user time per trip *without* the project;

τ^1: average user time per trip *with* the project;

Q_0: first year diverted demand to HSR;

C_C: annual variable cost of the conventional mode;

α: proportion of generated passengers *with* the project with respect to Q_0;

δ_i: distorsion in market *i*;

q_i^0: equilibrium demand in market *i without* the project;

q_i^1: equilibrium demand in market *i with* the project.

Equation (2) assumes that alternative transport operators break even and that the willingness to pay of new passenger trips is approximated through the proportion of generated passenger trips (α), (see de Rus and Nombela, 2007). Substituting (2) in (1), assuming indirect effects – last term of expression (2) – are equal to zero, it is possible to calculate the initial volume of demand required for a positive net present value (de Rus and Nombela, 2007).

The case for investing in a high-speed rail line requires a minimum level of demand in the first year of operation. This minimum demand threshold required for a positive NPV is higher, the lower the value of time, the average time saving per passenger, the proportion of generated traffic, the growth or benefits overtime, the project life and the cost savings in alternative modes; and the higher the investment, maintenance and operating costs, and the social discount rate.

De Rus and Nombela (2007) and de Rus and Nash (2007) calculate the required volume of demand in the first year of the project (Q_0) under different assumptions regarding the main parameters in (1) and (2). The results show that, with typical construction and operating costs, time savings, values of time, annual growth of benefits and the social discount rate, the minimum demand threshold required for a new high-speed line investment to be justified on social benefit terms is around 9 million passenger trips in the first year of the project. This initial demand volume was obtained under the assumption that benefits come mainly from time savings from deviated traffic, the willingness to pay of generated demand, and the avoidable costs of the reduction of services in alternative transport modes. The obvious conclusion is that the case for high-speed rail can be rarely justified on time saving benefits.

The economic rationale of spending public funds on new HSR lines depends more on its capacity to alleviate road and airport congestion, and to release capacity for conventional rail where saturation exists, than on the pure direct benefits of time and cost savings and the net willingness to pay of generated traffic. Therefore, the justification of investment in HSR is highly dependent on local conditions concerning airport capacity, the rail and road network situation, and existing volumes of demand. This is what one would expect anyway. The economic evaluation of a new technology has to compare these local conditions, reflected in the base case, with the "do something" of introducing the new alternative of transport.

3.1.2 Optimal timing

The fulfilment of condition (1) is not sufficient. Even with a positive NPV it might be better to postpone the construction of the new rail infrastructure (even assuming that there is no uncertainty and that no new information reveals a benefit from the delay). Let us assume that the annual growth rate of net benefits is higher than the social discount rate ($g>r$) and that the new infrastructure lasts long enough to be compatible with a positive NPV. Even in the case of explosive growth of net benefits, the question of optimal timing remains. It is worth waiting one year if:

$$\frac{rI}{1+r}+\frac{B_{T+1}-C_{T+1}}{(1+r)^{T+1}}>\frac{B_1-C_1+C_{C1}}{1+r}. \qquad (3)$$

From our 500 km HSR line (see section 2.2) and ignoring the net benefit of T+1 (which would be substantial), it is necessary to immediately calculate the value of the benefits for the first year of operation for the investment to be socially profitable now (assuming the project shows a positive NPV):

$$B_1>rI+C_1-C_{C1}. \qquad (4)$$

According to condition (4), the project should be started without delay if the gross benefit of the first year is higher than the first year's net social cost: the opportunity cost of capital plus the operating and maintenance costs of the new project, less the avoidable cost of the conventional transport mode. Using the data from section 2.2, the benefit per passenger for a round trip should be equal to 428 euros when the first year's volume of demand reaches 5 million passenger trips and the avoidable cost in the conventional mode is equal to zero. This means that the benefit per passenger trip (one direction only) should be at least 219 euros. For lower values it is better to postpone the investment.

From these data, different calculations can be made for different values of cost savings in the alternative mode. For example, taking the average revenue of 13.8 cents per seat-km in air transport, and assuming that the avoidable cost is equal to this figure, the required social benefit per passenger trip is 145 euros for the 500 km HSR line. This means that, assuming that benefits B_1 come only from time savings and the additional willingness to pay of generated demand, and given the present values of time in Europe, the fulfilment of condition (4) requires significant time savings in the projected line where non-additional benefits exist. It is worth stressing that the fact of passengers shifting from air to HSR does not prove that the condition is satisfied unless the average passenger is at least willing to pay 290 euros *more* per round trip over the price he was paying in the conventional mode.

4. INTERMODAL EFFECTS

4.1. Intermodal effects as benefits in the primary market

The construction of a new HSR line of a length within the range 400-600 km has a significant impact on air transport. Modal split changes dramatically in the affected corridor as the generalised cost of the railway is lower than the generalised cost of air transport. As the recently launched AVE Madrid-Barcelona illustrates, the introduction of HSR in a corridor 600 km long gives railways a role which was unforeseen with the average rail speeds of the recent past. The airlines carried 5 million passengers per year over the Madrid-Barcelona route, yet three months after the HSR services were introduced they were losing traffic at a rate of 1.2 million passenger trips per year (see Figure 1 and Table 1). This volume of traffic is approximately 50% of the market. What about other HSR lines?

The intermodal effect of HSR is stronger for lines with a longer period of operation. The effect of the introduction of HSR in medium distance corridors, where conventional rail, car and air were the previous alternatives, is quite significant, as Table 2 and Figure 2 illustrate. The HSR market share is correlated with rail's commercial speed and, with the exception of Madrid-Barcelona (recently launched), for those lines where the average rail speed is around 200 km, the market share of HSR is higher than 80%.

The high market share of railways for these medium distances is an argument in favour of investing in HSR technology. If passengers freely and overwhelmingly choose to shift from air to rail it follows that they will be better off with the change. But if passengers decide to move from air to rail because their general costs of travel are lower in the new alternative (certainly, this is not the case for everyone, as air transport maintains some traffic), this is not a guarantee that society will benefit from the change, as can easily be shown.

The direct benefits in the corridor where the HSR line is built come mainly from the deviation of traffic from the existing modes of transport, railways included. These benefits are accounted for in C_c and $v(\tau_1 - \tau_0)Q_0$ in equation (2), where time savings $(\tau_1 - \tau_0)$ should be interpreted as the average of the highest benefit obtained by the first user after the change, and zero, the value corresponding to the last user, who is indifferent to either alternative.

The intermodal effects measured in the primary market consist of the cost savings in the conventional mode and the product of the value of time, the average time savings and the number of passengers shifting from the conventional mode to the new transport alternative. The interesting point here is that these average values hide useful information regarding user behaviour and the understanding of intermodal competition.

Time savings can be disaggregated into access and egress, waiting and in-vehicle times. Each of these categories of time has a different value. Passengers usually give more value to savings coming from access, egress and waiting times than those coming from in-vehicle time; therefore, when users shift from road transport to HSR they save a substantial amount of in-vehicle time (three hours for a high-speed line 600 km long) but they invest access, waiting and egress time, partially offsetting the in-vehicle time savings. Moreover, as in-vehicle time generates less disutility than the other components, the final user benefits can even be negative.

The opposite case occurs in the case of air transport, where time savings experienced through users shifting to HSR come from a reduction in access, waiting and egress times which hardly offsets the substantial increase in vehicle time. Even with a negative balance in terms of time savings, the user benefit can be somewhat positive when the different values of time are considered (we do not include the ticket price in this comparison).

Looking at Table 3, it seems apparent that HSR is cheaper than air transport, at least if a non-restricted tourist fare is taken as the reference. Though the comparison is not straightforward, rail fares seem to be below the air alternative and, as section 2.2 shows, HSR average costs are quite above HSR prices; meanwhile, airlines operate in competitive markets and have to cover total producer costs. These facts deserve a closer examination because the direct benefits of deviated traffic from air transport are included through the term $v(\tau_1 - \tau_0)Q_0$ in equation (2), and the value in brackets could be very low where air transport provides a good service (let us remember that prices are transfers and do not count as social benefits).

The conclusion is that the case for HSR investment can rarely be justified on the grounds of benefits provided by the deviation of traffic from air transport. It seems apparent that higher benefits could be harvested through deviating traffic from road transport but this is more difficult in the range of distances considered. The benefits of deviating traffic from road and air exceed the direct benefits discussed above, as other indirect benefits could be obtained in the other transport modes when their traffic volumes diminish *with* the project. Let us examine the conditions required for obtaining additional benefits in the secondary markets.

4.2. Effects on secondary markets

It must be emphasized that time saving in the primary market is an intermodal effect, i.e. the direct benefit obtained by users of other transport modes who become HSR users. The reduction of traffic in the substitutive mode affects its generalised cost as do the travel costs of users who remain in the conventional mode.

The existing transport modes are not the only markets affected by the introduction of the new mode of transport. Many other markets in the economy are affected, as their products are complements to or substitutes for the primary markets. The treatment of these so-called “indirect effects” is similar for any secondary market, be it the air transport market or the restaurants of cities connected by high-speed rail.

Which indirect effects or secondary benefits should be included? The answer is in the expression:

$$\sum_{i=1}^{N} \int_0^T \delta_i (q_i^1 - q_i^0) e^{-(r-g)t} dt$$, included in equation (2).

There are N markets in the economy, besides the HSR product, and the equilibrium quantity changes in some of these markets $(q_i^1 - q_i^0)$ *with* the project. The change can be positive or negative. Suppose these markets are competitive, and unaffected by taxes or subsidies or any other distortion, so δ_i=0. In these circumstances there are no additional benefits. Therefore, for indirect effects to be translated into additional benefits (or costs) some distortion in the secondary market is needed (unemployment, externalities, taxes, subsidies, market power or any other difference between the marginal social cost and the willingness to pay in the equilibrium).

A similar approach can be used for the analysis of intermodal effects as secondary benefits.

Expression $\sum_{i=1}^{N}\int_0^T \delta_i(q_i^1 - q_i^0)e^{-(r-g)t}dt$ in equation (2) includes road and air transport markets.

For the sake of the analysis of intermodal effects, let us separate, say, air transport (or the road transport market) from the set of *N* markets affected by HSR investment, and call any of these transport options alternative mode *A*. The general expression that accounts for the indirect effect can be slightly modified for the discussion of intermodal effects.

$$\int_0^T (p_A - cm_A)q_A\varepsilon_{AH}\frac{\Delta p_H}{p_H}e^{-(r-g)t}dt\,, \qquad (5)$$

where:

p_A: full or generalised price of the alternative mode (air and road in this paper);
cm_A: marginal cost of the alternative mode;
q_A: demand in the alternative mode;
ε_{AH}: cross-elasticity of air (or road) with respect to the HSR generalised cost;
p_H : full or generalised price of a rail trip.

According to expression (5), the secondary intermodal effects can be positive or negative depending on the signs of distortion and cross-elasticity ($\frac{\Delta p_H}{p_H}$ is always negative *with* the project). Reductions in road congestion and airport delays have been identified as additional benefits derived from the introduction of HSR. Expression (5) shows that the existence of these benefits depends primarily on the inexistence of optimal pricing. Where road congestion or airport congestion charges are optimally designed there are no additional benefits in these markets.

Moreover, suppose there is no congestion pricing and therefore the price is lower than marginal cost. Even in this case, the existence of additional benefits depends on the cross-elasticity of demand in the alternative mode with respect to the change in the generalised cost of travelling by train. This cross-elasticity is very low (in absolute terms) for roads and air outside medium-range distances or when the proportion of passenger-trip interconnecting flights is high.

Finally, it is worth stressing that the excessive economic cost caused by the airport and road sectors, due to capacity problems, can be dealt with through other economic approaches (congestion pricing and investment), which should be considered in the *ex ante* evaluation of new HSR lines as part of the relevant "do something" alternatives.

5. PRICING

5.1. Rail, road and air transport accounts

The cost and revenue information provided by the UNITE project allows the comparison of the total social costs of transport and the corresponding transport charges, taxes and revenues for each country included in the study. The methodology is explained in Link *et al.* (2000) and basically consists of the identification and estimation of costs and revenues by mode of transport, with further disaggregation by different categories of vehicle and user. On the cost side, the accounts distinguish between infrastructure costs, supplier operating costs and accident and environmental costs, with a further distinction between internal and external costs.

On the revenue side, the accounts distinguish between user charges and taxes, and the discussion is open as to whether fuel tax should be considered part of the revenues allocated to road or part of general taxation without any transport relationship. Revenues include user charges and transport-related taxes, such as VAT, that differ from the standard tax rate. General taxes that do not differ from the standard rate of indirect taxes are excluded from the accounts, as these are not specific to the transport sector.

We have greatly simplified the road, rail and air transport accounts in order to show, in general terms, how far costs are from being covered by revenues in each mode. Tables 4, 5 and 6 show this comparison for France, Germany, Spain and the Netherlands. There are no specific reasons for choosing these countries, beyond data quality and the introduction of high-speed rail.

The costs and revenues in the tables are infrastructure costs, supplier operating costs, accident costs (external), environmental costs and taxes, charges and subsidies. A brief summary follows.

Infrastructure costs include capital costs (new investment and replacement), maintenance and operating costs of transport infrastructure. *Supplier operating costs* include vehicles, personnel and administration costs incurred by rail transport operators for the provision of transport services, though, due to data availability, the final information differs from country to country.

Accident costs only include the external costs of accidents, so the internal costs of accidents, as time costs, are user costs and therefore are not included in the accounts for the purposes of this paper. Internal and external accident costs varied between countries, depending on insurance practices, the coverage of their national health systems, etc. When these costs are not paid by the transport user they are included in the accounts, as happens to be the case with the loss of production due to accidents, the rehabilitation costs of accident victims when these costs are covered by national health, the costs of police, and of material damage to public property when not covered by insurance companies.

Environmental costs include the environmental impacts of transport, such as air pollution, noise and global warming.

Given the difficulties of gathering the data for the UNITE accounts and the differences in data quality by country, it is not sensible to go too far in comparing countries or transport modes.

Nevertheless, some useful information arises from a quick look at the data. The following comments are not specific to the countries in the tables and can be applied to a wide group of European countries.

Railways show the lowest ratio of social costs covered by commercial revenue or specific taxes. Railway companies generate passenger and freight revenue that is not always enough to cover supplier operating costs. This is not the case for road or air transport, with a ratio of revenue/total social cost closer to one. Nevertheless, these modes present higher environmental costs, particularly in the case of air transport. When environmental costs are excluded, road and air transport revenues more than cover infrastructure and supplier operating costs.

The average ratio of cost coverage is not homogeneous along the network. In France, for example, infrastructure charges are substantially higher for the HSR lines than for the conventional network (three to four times the marginal cost). Nevertheless, cross-subsidization is not enough to cover full costs. As pointed out in Crozet (2007), in the cost calculation the financial costs of HSR lines are not included. The French infrastructure manager pays more than €600 million annually in financial costs linked to the construction of new HSR lines[4].

The immediate conclusion is that if each mode covered its own social costs this would lead to a substantial increase in rail fares compared to the increase in air and road transport. Internalising externalities would affect freight more than road passenger transport. Two issues arise here regarding HSR investment and pricing: the optimal prices to be charged in the already existing HSR lines and the prices to be considered when evaluating the construction of new lines. These issues need to be resolved together, leading to discussion of the pricing principles to be followed.

5.2. Optimal pricing, investment and modal split

Both intramodal and intermodal competition require a sound and clear pricing policy that allows the transport user to choose his preferred option within a transport mode or when choosing between air, maritime, rail or road transport. It seems clear (equity issues aside) that for the preferred user option to be the best from the social perspective, prices should reflect the opportunity costs of his choice.

There are two aspects to optimal pricing regarding HSR, air and road market shares: firstly, the calculation of the opportunity cost when a significant proportion of total costs in railways are fixed and, secondly, the marked differences in how the cost of travel for each transport mode is generally affected by air, road and HSR infrastructure and operation.

5.2.1 Short-run or long-run marginal cost?

Let us assume that supplier operating costs, variable maintenance and infrastructure operating costs and external costs are already included in the generalised cost. Should the investment costs and the quasi-fixed maintenance and operating costs also be included in the full price?

The European Commission proposes a charging system based on each mode of transport internalising its social costs, to reach an efficient distribution of traffic across different modes and ensure that these operators are treated equally to achieve fair competition.

How much should a rail operator be charged for the use of infrastructure in a particular time or demand condition? In principle, he should be charged the "marginal social cost" of running the train in that particular situation. Given the presence of economies of scale, significant indivisibilities and fixed and joint costs, pricing according to marginal social costs is far from an easy task.

Moreover, governments pursue other objectives rather than short-term static efficiency, making the application of this charging system more complicated. The European Commission is particularly interested in the development of international transport within the Union, and in the internalisation of externalities. Infrastructure charges should differ by mode and location when the local conditions vary, but should not discriminate between users by nationality or location. The "user pays" and "fair competition" principles are also invoked when arguing that each mode of transport should cover its total social costs.

Charging according to short-run marginal costs is incompatible with cost recovery when the rail infrastructure network is built and there is excess capacity. Some critics argue that the natural alternative is long-run marginal costs. Short-run marginal costs equal the change in total costs when new traffic is added, given a constant network capacity. Long-run marginal costs account for the change in total costs allowing for an optimal adjustment of capacity.

Long-run and short-run marginal costs are equal, assuming perfect demand forecast and perfect divisibility of capital, but both assumptions are unrealistic with regard to transport, and the consequences of choosing a pricing principle are quite important in practical terms. In the case of HSR investment, short-run marginal cost pricing implies prices below average costs and the need for public funds to cover infrastructure costs[5].

Given the capacity available, any additional traffic willing to pay in excess of the additional cost imposed on the system should be allowed to enter. In the most extreme case, when capacity is well above demand (forecasting error, indivisibilities or both), the short-run marginal cost can be very low compared with average cost. Should rail infrastructure pricing be exclusively based on short-run marginal costs? Not necessarily.

Pricing according to short-run marginal cost, with indivisibilities and economies of scale, leads to insufficient revenues for the recovery of infrastructure capital costs. Additional taxation needed to cover the gap has an additional cost in term of the distortion imposed on the rest of the economy. The second problem is related to incentives, as subsidization usually reduces effort to minimize costs. Another drawback comes from the way in which capacity costs are covered, as users only pay variable costs and non-users pay capacity costs. In addition to the equity side (it is difficult to think of HSR passengers as an equity target) we face a dynamic efficiency question: are the users willing to pay for capacity? If there are corridors where this is not the case, the government would be providing more than optimal capacity.

Even assuming that users are willing to pay for capacity (given prices equal to short-run marginal costs), it may be argued that demand is receiving a misleading signal in terms of the cost of expanding capacity in the long term. It may well be that a price structure which includes some charges for long-term replacement costs would be associated with a social surplus insufficient to justify the investment.

It is not necessary to defend long-run marginal cost to recognise that deviating from short-run marginal cost is the norm. Prices should not only follow costs but also demand considerations. Railway infrastructure managers are expected to pursue economic efficiency when charging for the use of the rail network, but efficiency has a long-term dimension. Adequate revenue is required for long-term investment. This is a real dilemma, and the way out is to price so that short-term marginal costs are covered and include an additional charge to contribute to fixed and common costs. This additional charge should be set to minimize efficiency losses, and the way to achieve this is, in principle, through discrimination, depending on the value of service; but political acceptability and information problems make Ramsey pricing difficult to implement.

When setting charges, the European Union faces the problem of equity or fair competition with more intensity than for efficiency considerations. Ramsey pricing may be compatible with economic efficiency but very difficult to apply in practice, e.g. when two competing operators are treated differently for the sake of raising revenue while minimizing efficiency loss. Moreover, it is actually fairly difficult to apply Ramsey pricing to train paths. This is because the infrastructure manager has little knowledge of what traffic individual trains are carrying and its elasticity.

Despite some contradictions, the Commission seems to favour a short-run marginal cost pricing (European Commission, 1995, 1998; Nash, 2001). It is expected that marginal cost charging will allow full capital cost recovery, given that prices in congested corridors and the internalisation of congestion and external effects will produce enough revenue to satisfy financial constraints, at least across the modes. In the cases of insufficient revenues, the Commission recommends additional "non-discriminatory" and "non-distorting" fixed charges (European Commission, 2001b).

The effects of charging according to short-run marginal cost on the expansion of HSR lines are significant. Low prices favour the reallocation of traffic from competing modes and encourage traffic generation, with feedback on the future expansion of the network. Pricing according to short-run marginal cost leaves a key question unanswered: are rail users willing to pay for the new technology? Unless this question is answered before investment decisions are taken, marginal cost pricing is not a guarantee for an efficient allocation of resources.

5.2.2 Road, airport congestion and the generalised cost of travel

Airport delays and road congestion increase the generalised cost of travel. HSR is more punctual and reliable than air transport. Road congestion is pervasive at peak times. The asymmetries between HSR and road are self-evident: road infrastructure and operations are vertically separated, while HSR infrastructure and operations are vertically integrated in practice. Furthermore, there is a single HSR operator by country. In contrast, there are thousands of motorists entering simultaneously into a limited-capacity infrastructure, without any co-ordination among them.

The standard treatment of congestion is well known in the economic literature: users should pay for costs imposed on other users who share the road; thus internalising the costs they impose upon others will mean taking decisions according to marginal social costs. A practical implementation of this principle is to charge users during peak-hours, aiming to move those users with a lower valuation for trips to alternative routes or time periods (Walters, 1961; Vickrey, 1963).

Airport demand is close to capacity at peak times, and similar solutions to road are offered: managing demand by peak-load pricing and capacity investment[6]. Nevertheless, airport congestion and road congestion are far from being the same phenomenon. Airports' air-side and land-side infrastructure are shared among a relatively small number of agents. Decisions on entry are not random, but scheduled and controlled by a planner. In principle, airport congestion should only be due to bad weather or other uncontrollable factors. If the planner decides on the number of flights arriving and departing per hour, delays should be an infrequent event, as with HSR services.

The point is that there are other reasons beyond bad weather or exogenous causes that explain airport congestion. A flight can be out of schedule due to problems experienced at the airport of origin, at the destination airport, or during the flight itself. A combination of all these factors frequently occurs, but the explanation of these delays is quite often attributable to the decisions of the airlines regarding fleet size, personnel, maintenance schemes, etc. Moreover, delays can be the consequence of the airport's management policy.

When airport managers and airlines take decisions on flight schedules, they impose some external costs on themselves as well as on passengers. Airports' decisions concerning slot allocation usually aim to serve as much latent demand as possible, disregarding the occasional system overload. In the same way, the airlines design flight schedules to maximize their profits, without taking into account the external costs imposed on passengers and other airlines, when timetables are impossible to fulfil because of minor disruptions.

New investment capacity can be used for new slots as well as to reduce delays, but this last policy implies less activity and fewer profits for the airport manager. The airport does not internalise the externality imposed on passengers, who experience the increase in the generalised cost of air transport[7]. Therefore, airport congestion should not be reduced to a peak pricing problem. Congestion occurs as an externality which is not internalised, and this happens in peak and off-peak periods. Agents causing delays should pay for the marginal cost of congestion. Internalisation of congestion costs could be achieved simply by using congestion fees, which force airlines and airports to compensate each other and passengers for the external congestion costs imposed by flight delays (Nombela, de Rus and Betancor, 2004).

5.3. The long-term effect of pricing

Prices have different economic functions. Prices act as a device to maintain equilibrium in markets avoiding both excess of demand or underutilised capacity; moreover, prices are signals in competitive markets guiding the allocation of resources where the consumer's willingness to pay is at least equal to the opportunity costs of those resources elsewhere. Entry and exit in these markets follow the price adjustment when demand is higher or lower than supply.

Transport prices are no different in this respect to other prices in the economy. Competitive transport markets behave in the same way. Therefore, when prices are lower or higher than marginal social costs in a particular transport mode, the level of economic activity in this mode and the traffic volume are sub-optimal, unless this is compensated for in other markets related to the primary market, through substitutability or complementarity relationships.

It is well known that a transport user choosing a particular mode of transport in a particular place and time imposes a marginal cost to himself (the user cost and the share of the producer cost – infrastructure and vehicles – included in the price), to the rest of society (external cost of accidents and environmental externalities) and to the taxpayers (the share of the producer cost that has been subsidized). When the generalised price is lower than the marginal social cost, as happens when freight is transported by a heavy vehicle on a congested road, the amount of freight transport on that road and at that time is higher than optimal. Pricing according to marginal social costs would increase the generalised price of this transport option, reducing the amount of road traffic and inducing long-term adjustments – from increasing the rail freight transport share to reducing the need for specialised labour in the production of spare parts for trucks.

Is there a rationale for HSR fares that fall short of covering infrastructure costs? It might be argued that economies of scale and strong indivisibilities justify the deficits, but the question is, should users be willing to pay for HSR infrastructure before new lines are built? HSR prices provide key information to transport users on where, how and when to travel, or even whether to travel or not.

When infrastructure costs are not included in transport prices, according to the rationale of short-term marginal social cost, the price signal tells consumers that is efficient to shift from road or air transport to rail. This, of course, could be true in the short-term, when optimal prices are not affected by the fixed costs of the existing HSR network, but the world is dynamic and fixed costs matter in the long run.

The problem is that prices that do not reflect infrastructure costs in a transport mode where these costs exceed 50% of total producer costs. They act as long-term signals to consumers for their travel decisions and consequently for the future allocation of resources between transport modes or between transport, education or health. An extensive HSR network can be developed based on suboptimal prices decided by the government. These prices are not related to the opportunity costs of the network's existence but, once it is built, bygones are bygones and speculation on welfare in a counterfactual, with a different allocation of resources, is not very practical.

The defence of cost-benefit analysis in this context is quite relevant. Even accepting that short-term marginal cost is the right pricing policy, investing in a new HSR line requires that the willingness to pay for capacity be higher than the investment costs and any other cost not attributable to changes in demand during the lifetime of the infrastructure. This does not solve the problems of fair competition between different transport modes or the equity issue of taxpayers paying HSR fixed costs, but at least it puts a filter on the most socially unprofitable projects.

6. CONCLUSIONS

Investment in high-speed rail (HSR) infrastructure is being supported by governments and supranational agencies with the declared aim of working for a more sustainable transport system. HSR is considered more efficient and less environmentally damaging than air or road transport. The truth in both arguments rests heavily on the volume of demand of the affected corridors and several key local conditions, such as the degree of airport or road congestion, the existing capacity in the conventional rail network, values of time, travel distances, construction costs, the source of electricity generation or the proportion of urban areas crossed by trains.

The engineering of HSR is complicated but its economics are very simple. The high proportion of fixed and sunk costs, indivisibilities, long-life and asset specificities make this public investment risky, with a very wide range of values for the average cost per passenger-trip. The social profitability of investing public money in this technology depends, in principle, on the volume of demand to be transported and the incremental user benefit with respect to available competing alternatives.

The lack of private participation in HSR projects increases the risk of losing money, i.e. of losing the net benefits from the best alternative use of public funds. HSR investment may be adequate for some corridors, with capacity problems in their railway networks or with road and airport congestion, but its convenience is closely related to the above-mentioned conditions and the volume of demand to be expected. Moreover, even in the case of particularly favourable conditions, the net present value of HSR investment has to be compared with other "do something" alternatives, such as road or airport pricing and/or investment, upgrading of conventional trains, etc. When the investment cost associated with new HSR lines does not pass the market tests, and visibility is reduced by industry propaganda, short-term political interests and subsidized rail fares, conventional cost-benefit analysis can help to distinguish good projects from "white elephants".

NOTES

1. “The fact is that, almost two centuries after the first train ran, the railways are still a means of transport with major potential, and it is renewal of the railways which is the key to achieving modal rebalance. This will require ambitious measures which do not depend on European regulations alone but must be driven by the stakeholders in the sector.” European Commission (2001a).

2. “Intermodality with rail must produce significant capacity gains by transforming competition between rail and air into complementarity between the two modes, with high-speed train connections between cities. We can no longer think of maintaining air links to destinations for where there is a competitive high-speed rail alternative. In this way, capacity could be transferred to routes where no high-speed rail service exists.” European Commission (2001a).

3. The description of HSR costs is based on Campos *et al.* (2005) and de Rus and Nash (2007).

4. It is also worth stressing that the social and financial profitability of HSR lines may be decreasing once the investment in the main corridors has been completed. “Currently operating parts of the HSR lines should be distinguished from those which will be brought into service in coming years. These lines are indeed less and less profitable (Paris-Strasbourg, Rhin-Rhône HSL, HSL to Brittany or Bordeaux). They require even larger public subsidies or maintain or even increase the French infrastructure manager´s indebtedness.” (Crozet, 2007).

5. For a discussion on marginal cost pricing in transport, see Rothengatter (2003) and Nash (2003).

6. Airport peak load pricing is treated in: Levine, 1969; Carlin and Park, 1970; Morrison, 1983; Fisher, 1989; Morrison and Winston, 1989; Oum and Zhang, 1990; Daniel, 1995, 2001; Wolf, 1998; Daniel and Pawha, 2000; Hansen, 2002; Brueckner, 2002a, 2002b.

7. Air passengers are agents who bear congestion costs but are only compensated on limited occasions. Usually payments are only received from airlines as compensation for long delays or lost connections.

TABLES AND FIGURES

Figure 1. **Air passenger-trips Madrid-Barcelona (both ways), 1999-2008**

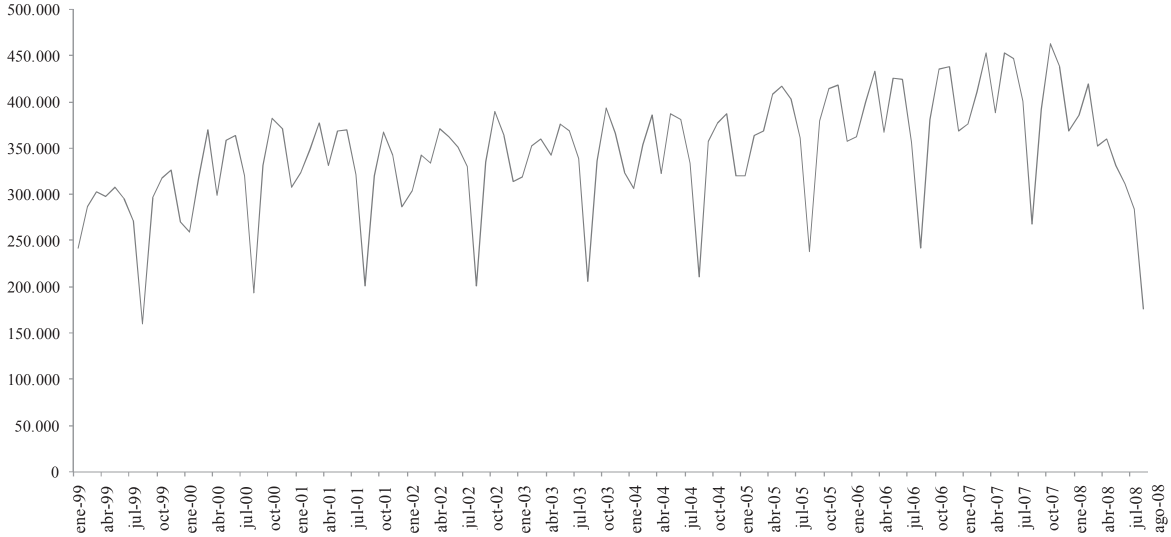

Figure 2. **HSR market share and railway speed**

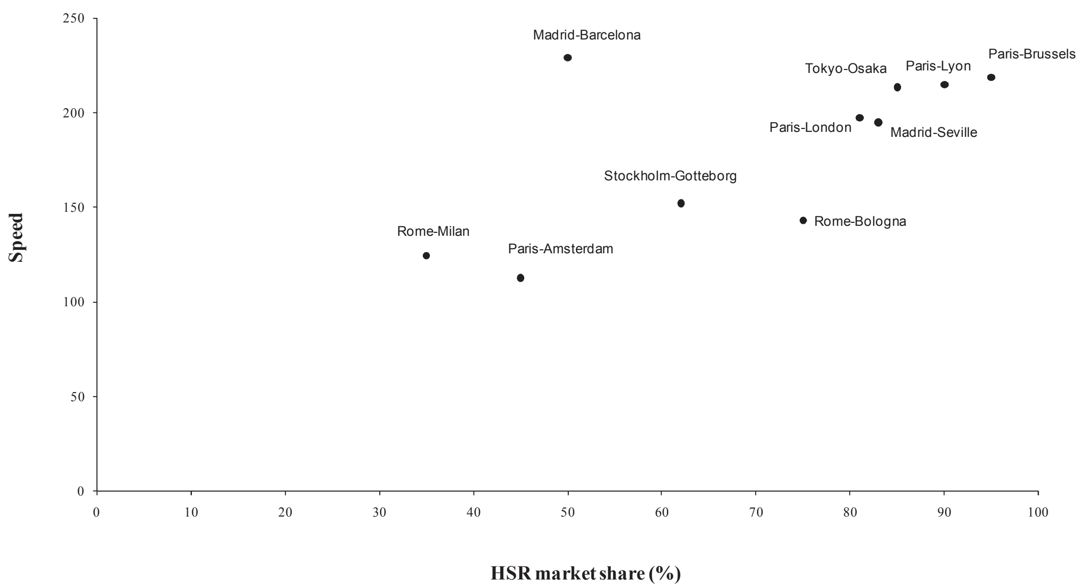

Table 1. **The effect of the introduction of the HSR line on the air route Madrid-Barcelona**

Variable	Coefficient	Std. Error	t-Statistic
T	1085.647**	52.51942	20.67135
D1	1086.346	8013.471	0.135565
D2	39493.1**	8011.922	4.929291
D3	63200.28**	8058.094	7.843081
D4	36942.43**	8055.184	4.586169
D5	66001.19**	8052.615	8.196242
D6	57633.64**	8050.389	7.159113
D7	16882.79*	8048.504	2.097631
D8	-106664.7**	8046.962	-13.25527
D9	26849.61**	8218.743	3.266875
D10	71301.29**	8217.904	8.676336
D11	60510.31**	8217.401	7.363681
AVE	-102085.3**	8136.273	-12.54694
C	259042.1**	6609.939	39.18978

R-squared: 0.927483; Adjusted R-squared: 0.918240; Durbin-Watson stat: 1.317196; *,** significant at the 5 or 1 per cent level.

D1: January, AVE: Months with HSR in operation (March to August).

Table 2. **Travel time and market share for selected high-speed rail lines**

	Length (km)	Travel time (h:min)	Speed (km/h)	Market share (%)	
				Rail	Air
Madrid-Barcelona	630	2:45	229.09	50	50
Madrid-Seville	471	2:25	194.90	83	17
Paris-Amsterdam (1)	450	4:00	112.50	45	55
Paris-Brussels	310	1:25	218.82	95	5
Paris-London	444	2:15	197.33	81	19
Paris-Lyon	430	2:00	215.00	90	10
Rome-Bologna (2)	358	2:30	143.20	75	25
Rome-Milan (3)	560	4:30	124.44	35	65
Stockholm-Gotteborg (4)	455	3:00	151.67	62	38
Tokyo-Osaka	515	2:25	213.10	85	15

(1) High speed only Paris-Bruselles
(2) High speed only Rome-Florence
(3) High speed only Rome-Florence
(4) Upgraded conventional line

Table 3. **Rail and air fares (return ticket) in some corridors with HSR**

	Railway		**Airline**		**Ratio (Railway/Airline)**	
	Minimum price (with restrictions)	Tourist fare	Minimum price (with restrictions)	Tourist fare	Minimum price (with restrictions)	Tourist fare
Madrid-Barcelona	211	249	111	421	1.90	0.59
Madrid-Seville	134	149	81	530	1.66	0.28
Paris-Amsterdam	116	210	760	788	0.15	0.27
Paris-Brussels	90	164	324	337	0.28	0.49
Paris-London	124	435	218	653	0.57	0.67
Paris-Lyons	79	136	225	623	0.35	0.22
Rome-Bologna	78	78	233	517	0.33	0.15
Rome-Milan	110	118	165	652	0.66	0.18
Stockholm-Goteborg	78	155	150	224	0.52	0.69

Table 4. **Road accounts**

(€ millions, 1998)

	France	**Germany**	**Spain**	**Netherlands**
Costs				
Infrastructure costs	25 520	25 176	6 224	4 411
Accident costs (user external)	1 528	14 549	2 307	1 421
Environmental costs	18 157	18 505	6 506	2 479
Total	**45 205**	**58 230**	**15 037**	**8 311**
Revenues				
Directly related to a specific cost category	4 167	411	919	91
Vehicle taxes	4 983	7 757	2 174	4 298
Fuel tax	18 720	28 983	8 428	5 040
VAT	16 146	4 565	1 349	857
Total	**44 016**	**41 716**	**12 870**	**10 286**

Table 5. **Rail accounts**

(€ millions, 1998)

	France	Germany	Spain	Netherlands
Costs				
Infrastructure costs	4 790	12 621	3 500	1 095
Supplier operating costs	9 998	7 336	2 013	2 339
Accident cost (external)	3	83	19	59
Environmental costs	129	1 403	296	34
Total	**14 920**	**21 443**	**5 828**	**3 527**
Revenues				
Passenger and freight revenue	7 326	8 614	1 495	1 365
Subsidies for concessionary fares	296	4 244	n.a.	81
Other specific revenues	504			
Fuel tax	35	217	n.a.	n.a.
VAT	280	34	n.a.	n.a.
Total	**8 441**	**13 109**	**1 495**	**1 446**

Table 6. **Air transport accounts**

(€ millions, 1998)

	France	Germany	Spain	Netherlands
Costs				
Infrastructure costs	1 080	3 488	411	98 (2)
External accident costs	0	35	4	0.5
Environmental costs	97	874	458	226
Total	**1 177** (1)	**4 397**	**873**	**325**
Revenues				
Airport revenues	1 687	3 121	501	224
Air traffic control revenues	1 117	815	341	n.a.
Total	**2 804**	**3 936**	**842**	**224**

(1) Excluding noise costs. (2) Excluding running costs.

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COMPETITIVE INTERACTION BETWEEN AIRPORTS, AIRLINES AND HIGH-SPEED RAIL

How should airports be regulated to contain market power? This report first examines whether they need to be regulated at all. It concludes that because regulation is inevitably imperfect and costly, policy makers should establish conditions for competition to emerge between airports in preference to comprehensive regulation, whenever possible.

Economic regulation is sometimes necessary, such as when airports are heavily congested. The report determines which approaches are likely to work best and also assesses strategies for managing greenhouse gas emissions. It finds that although including aviation in an open emission trading scheme could help mitigate emissions efficiently across the economy, it should not be expected to produce major cuts in CO_2-emissions in aviation itself.

Finally the report identifies the economic conditions under which high-speed rail can provide a competitive substitute for aviation, revealing the limited relevance of rail to reducing greenhouse gas emissions from this part of the transport market.

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