THE DAVID HUME INSTITUTE

Central Scotland Airport Study

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Foreword

In this *Hume Occasional Paper*, The David Hume Institute is delighted to publish a contribution to the consultation process being undertaken in preparation for the Government White Paper on 'The Future of Air Transport in the United Kingdom', expected at the end of 2003.

The issue addressed in this Paper is the case for constructing a new airport in central Scotland. The question of a Central Scotland Airport is not new, but with transport infrastructure investments linking the current Glasgow and Edinburgh Airports to the heavy rail network, and the possibility of expanding one or other of these two airports, the time is certainly ripe for this issue to be re-appraised.

In the late summer of 2002, the Principals of Edinburgh University and of Glasgow University (Lord Sutherland and Sir Graeme Davies) supported this investigation by asking the academics involved to give their time to the project. Such are the well-known rivalries between Scotland's two main cities, that the representation of academics from Universities in both cities may, of course, be seen as an effort to ensure absence of bias in this investigation.

The findings described at length below are of great importance to the future development of the Scottish economy. The paper shows unambiguously that a Central Scotland Airport would not be an economically viable proposition. In pointing away from a Central Scotland Airport, however, the study focuses more clearly the importance of the development of Edinburgh and Glasgow Airports as major centres of air transport in Scotland. Much remains to be decided on that front, - for example, whether a new runway is needed at Edinburgh or at Glasgow - but, for the foreseeable future at least, the possibility of a Central Scotland Airport seems to have been removed from the policy agenda by the careful, empirical analysis in this *Hume Occasional Paper*.

Hector L MacQueen
30 January 2003

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Executive Summary

- There does not seem to be a case for constructing a new airport in central Scotland.
- Suitable sites for constructing a new airport in central Scotland are rare, but an area around Airth has been identified as a possibility (section 4).
- The costs of such a project have been estimated to be anything from £5.8billion to £7.4billion (Tables 7, 8 and 9 and section 5.1.6.2).
- The costs of operating a large new airport would be significantly lower than experienced at Edinburgh or Glasgow and would bring producer benefits (section 5.1.6.4 and Appendix-B-Figure 9).
- Travellers would experience benefits of a greater frequency of flights and a wider range of destinations. These benefits are offset somewhat by the reduced convenience of the Central Scotland Airport's location (section 5.1.6.3).
- Surface access distances to a Central Scotland Airport would increase by 56% to 66% over current levels (section 5.1.6.7).
- Transferring to a central Scotland location would mean over 3000 of the existing workforce at the two airports retaining their jobs, but 4,000 losing their jobs in Edinburgh and Glasgow (section 5.1.3 and Table 3).
- These lost jobs would be concentrated in the lower skilled occupations. Glasgow would be more badly affected than Edinburgh (section 5.1.3).
- Despite firms claiming that access to air transport is important, this indirect employment is widely spread and unlikely to change much locationally in response to the creation of a Central Scotland Airport (section 5.1.3).
- A Central Scotland Airport would be largely neutral to planning in west Edinburgh but would sharply conflict with Glasgow City and Clyde Valley Joint Structure Plans (section 5.1.4).

- The scope for creating a hub operation at a Central Scotland Airport is distinctly limited, in part owing to the success of Copenhagen Airport (section 3.2).
- The cost of such a construction significantly outweighs the estimated benefits, with benefit-cost-ratios of 0.45 to 0.58 being typical estimates (section 5.1.6.8 and Table 14).
- The benefit-cost ratio of a Central Scotland Airport is markedly less that other much more promising airport investment possibilities, such as an additional runway at Edinburgh with a benefit-cost-ratio of 2.93 (section 5.1.6.8 and Table 13).
- Were such a project as a central Scotland Airport ever to be viable, it would certainly be beyond the 2030 planning period.
- For an economy on the geographic margins of Europe, good air transport linkages are vital for growth (section 5.1.1).
- The above conclusions regarding a Central Scotland Airport imply that the responsibility for developing central Scotland's vital airlinks essentially rests with Edinburgh and Glasgow Airports, currently under the common ownership of BAA plc (section 5.1.2 and section 6).
- Serious consideration should, therefore, be given to maximising the potential of these assets – for example, by linking Edinburgh Airport directly to the M8 and by providing direct through rail links from Glasgow Airport through the City of Glasgow to Edinburgh Airport and the City of Edinburgh (section 6).

1. Introduction

The investigation reported here is an attempt to address one of the questions raised in the recent joint Department for Transport and Scottish Executive consultation document 'The Future of Air Transport in the United Kingdom: Scotland. A National Consultation' which forms part of the preparation for a white Paper on Aviation expected towards the end of this year. The question asked is:

"Should the case for constructing a new airport in central Scotland still be considered? What would be the basis for such a case? When should it be built and how might it be funded?"
(p172 of 'The Future Development of Air Transport in the United Kingdom: Scotland')

This paper examines the case to be made for establishing a Central Scotland Airport to serve in the place of Edinburgh and Glasgow Airports. This is a question that has been addressed several times in the past[2], but on this occasion it is brought back under consideration by a particular combination of transport related policy announcements in the summer of 2002. First, as mentioned above, in July of 2002 the Scottish Executive and the Department for Transport published a consultation document concerning the future development of air transport in Scotland. This is part of a larger UK-wide exercise. Among other details, the analysis for Scotland highlights the possible need for additional runway capacity at either Edinburgh or Glasgow Airports before 2030. The analysis was more favourable towards the additional runway and terminal capacity being built at Edinburgh. But wherever is the final outcome, a substantial capital expenditure is involved.

At around the same time, discussions were ongoing regarding the construction of heavy-rail links[3] to both Edinburgh and Glasgow Airports. Although of a more modest scale, this too involves substantial capital expenditure. Furthermore, in the nearer term, the impact of the 2002 Spending Review on the Scottish Budget, in the form of substantially higher spending on transport infrastructure, was attracting much press comment. In addition, not only was transport policy moving ahead at national level, but at the local level the joint Scottish Executive and City of Edinburgh Council 'West Edinburgh Planning Framework' consultation document[4] was explicitly addressing surface access to Edinburgh Airport, including direct motorway access for the airport.

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[2] John Yellowlees has brought to our attention that in the 1930s there had, of course, been a Central Scotland Airport as the following architectural guide entry makes clear:

> Entry on p 124 of Jacques (2001):
> "Central Scotland Airport, 1939, Alex Mair acting on the recommendations of the Maybury Report to build a central airport for Scotland, Scottish Aviation Ltd, with the characteristic fervour of the times, built on 600 acres near Inchyra Park a gleaming white semicircular terminal, complete with hangers in only three months. Its existence was short lived, alas, all passenger services ceasing the same year with the outbreak of war. Officially closed June 1955 and demolished shortly thereafter."

[3] See Scottish Executive (2002a).

[4] See Scottish Executive (2002b).

It, therefore, seemed timely to consider a somewhat more radical possibility of creating a new purpose-built, large capacity airport in central Scotland and closing the existing airports at Edinburgh and Glasgow – both of which are on sites that are historically determined and, having grown considerably since their inception, clearly constrained in their current locations. The idea of a Central Scotland Airport had been considered in the Scottish Air Transport Consultation Document and found to be unattractive[5]. The discussion there was, however, rather brief and the subject seemed to merit a fuller airing.

This paper attempts to follow the recently published Scottish Transport Appraisal Guidelines (STAG, Scottish Executive 2001), although the limited time and resource available to this project means that this is done at a rather more general level than would be necessary for a funding decision. Nevertheless, the current paper serves as a scoping exercise and, we hope, brings out some important aspects of air transport policy in Scotland in the 21st Century. Section 2 clarifies the objectives of the study. Section 3 offers our analysis of the problem, and section 4 examines possible options before turning in section 5 to appraisal. The paper concludes and summarises in section 6.

[5] See Department for Transport (2002a), pp. 163-174..

2. Objectives

The objective of a Central Scotland Airport would be to provide an airport facility which, by incorporating the latest airport design technology, attains operating economies not available at more dated and constrained airports. Furthermore, by combining the current and prospective traffic levels at both Edinburgh and Glasgow Airports, it would also be able to attain a significant scale of operation sooner than would otherwise be possible, and this scale of operation would result not only in additional operating economies but also in a larger choice of direct flights.

This potential expansion of choice for the traveller would be further enhanced if a new airport could offer some hubbing features whereby people choose to travel through the Central Scotland Airport on their way to other airport destinations, doing so owing to the ease of connection provided at a large scale modern airport. As far as a Central Scotland Airport is concerned, this hubbing activity brings extra passengers through the airport, allowing a further thickening of routes and assisting new route development and improved frequency on existing routes.

The new facility with its increased connectivity to other parts of Europe and the world, would enhance economic growth both by assisting indigenous businesses to link with overseas markets and by encouraging foreign direct investment by countering what is Scotland's geographically marginal location in Europe. There would also be direct advantages in enhancing the attraction of Scotland as a tourist destination.

Environmental advantages would also be available through diminished exposure of residents to noise pollution by moving air traffic away from the current urban locations of Edinburgh and Glasgow Airports to a somewhat more rural setting. On the other hand, measures would have to be taken to mitigate the generally longer surface access journey times to a new airport located in central Scotland.

While there would be an undoubted dislocation of employment for many of those working at Edinburgh and Glasgow airports at the time of changeover, there would be a substantial regional development potential to central Scotland which might bring a net advantage.

The above objectives of a proposed Central Scotland Airport can be considered under the general label of enhancing the overall economic well being of Scotland. But the current ownership structure of Edinburgh and Glasgow Airports – both are owned by BAA plc - means that it would also be necessary for the project to offer a financial return to the airports' owner such that it would be in the interest of BAA to invest in the project.

These objectives, therefore, cover 'economy', 'environment', 'safety', and 'accessibility'. These are four of the Scottish Executive's 2001 appraisal objectives (STAG, p2-1). The fifth, namely 'integration', is considered in terms of existing local structure plans, although no formal consultation process with stakeholders has been undertaken, owing to the constraints on time and resource.

3. Analysis of the Problem

3.1 Demand Forecasts

Aviation plays an important part in any modern economy. For Scotland, situated at the edge of Europe and distant from London, air transport is vital. Scrutiny of the activity levels of UK airports in 2001 (see Figure 1) reveals that Edinburgh and Glasgow airports are among the busiest in the UK, although of quite modest size when compared to the world's busiest airports (see Figure 2). Changing the capacity of airports or building new airports takes a considerable time[6]. There are complex and connected considerations of planning permission, funding, design, construction, surface access (road and rail), and so on to take into account. While Edinburgh and Glasgow Airports[7] are in private hands (BAA plc), the fact that air traffic is regulated by the Civil Aviation Authority and that surface access and other considerations involve the planning process, all results in there being a significant interplay between government and the private sector in these matters. Consequently a degree of forward planning is necessary. Furthermore, it is difficult to examine these issues from the perspective of a single airport – aviation is a highly interdependent business.

The interconnected nature of aviation has been explicitly recognised in the Government's recent review of Air Transport in the UK, the preparatory phase for a White Paper on the subject (now expected towards the end of 2003). Demand for air transport has been estimated forward to 2020 by the Department for Transport in DfT (2000) and extrapolated to 2030 in the consultation documents. While econometric forecasting of this nature is not without its hazards[8], recent predictions have been, if anything, on the low side. Figure 3 presents recent government forecasts of air traffic set against the actual outturn. Apart from the effects of the 1991 Gulf War, these forecasts appear to have been on the low side. Figure 4 presents the more long range estimates and, it will be noticed, that successive revisions to these have been in the upwards direction.

More detailed analysis of these figures, not presented here, reveals that, while the problem is most acute in the South East, there are clear indications of a shortfall in airport capacity in Scotland – and specifically at Edinburgh and/or Glasgow. With a forecast of the number of commercial air travellers in Scotland rising to around 50 million passengers per annum (mppa[9]) by 2030, Edinburgh is predicted to experience serious runway capacity shortages by 2013 and Glasgow to experience terminal capacity problems by 2018, and runway capacity shortages by around 2030. Thus, while there is no particular capacity constraint evident today at either Edinburgh or Glasgow Airports (and, indeed, unlike Heathrow there is no slot allocation

[6] For example, as Dempsey et al. (1997) discuss, the decision to close Stapleton Airport, some 7 miles from downtown Denver, to the opening of the new Denver International Airport, some 24 miles from downtown, took 21 years, between 1974 and 1995, from beginning to end.

[7] The six major Scottish Airports are Aberdeen (BAA plc); Edinburgh (BAA plc); Glasgow (BAA plc); Inverness (Scottish Executive); Prestwick (Infratil and others); and Dundee (Dundee City Council).

[8] Clearly a forecast is only as good as the assumed input factors. For example, airfare price is assumed to decline at 1% per annum. While this is lower than the 2% decline assumed in earlier forecasts, the possible impact of higher fuel process or environmentally oriented aviation taxes could undermine this assumption.

[9] This measure counts every terminal arrival and departure as a separate event.

committee[10] in operation at either), it is a matter of time before reconfiguration of these sites will be necessary.

The importance of air travel to Scotland can be illustrated by what is termed the 'propensity to fly' which measures the number of return air trips in an area per head of population (but includes trips made by out-of-area tourists and business people). Figure 5 shows that, apart from London, Scotland records the highest figure in the UK.

One complicating factor here is that air travel in Scotland is concentrated in the two central Scotland airports and, as Figures 6 and 7 illustrate in terms of the six major Scottish airports, a large proportion of this business is done in BAA owned[11] airports (92% of passengers and 92% of air transport movements occur in Aberdeen, Edinburgh, or Glasgow – BAA's three Scottish Airports). In terms of passengers, a large proportion of this traffic will be headed for one of BAA's airports in the South East (Heathrow, Gatwick and Luton). However, there is a view that the prime driver of competition in the aviation business comes from the airlines, not the airports. Indeed, the recent rise to prominence of 'budget' or 'no-frills' carriers[12] has increased the competitive pressure and compensated for the dulling effect brought about by the establishment of alliances[13] among the major scheduled carriers.

This study utilises the forecasts of air transport produced by the Department for Transport in the forecasting exercise described above and as distributed through the UK airports in the Department's passenger allocation model (SPASM[14]). Forecasts are made both with and without the availability of a Central Scotland Airport.

3.2 Hub Effects

Although the recent emergence of no-frills or budget carriers such as bmibaby, easyJet, Ryanair and so on has marked a resurgence of point-to-point flying, the established carriers are still very much locked into the 'hubs and spokes' system that emerged in the 1970s. The logic of this arrangement is that rather than attempting to establish routes among each of, say, eight cities (28 sectors, or routes, linking up each pair of cities), it may be easier for an airline to nominate one of these cities as a hub and connect all eight cities by routes from the other seven cities into that hub,

[10] Take-off and landing rights are allocated under EU regulations that generally recognise grandfather rights of established users (accounting for over 90% of slots at Heathrow). Failure to utilise a slot for 80% of the time results in its loss to the airline and reallocation. In the congested South East, new slot allocation and coordination is conducted through the independent not-for-profit Airport Coordination Ltd (see Little 2002, p34).

[11] The 1986 Airports Act turned BAA into a limited company, which was then floated on the Stock Exchange in the summer of 1987. See Doganis (1992, p27).

[12] The best known budget carriers on Scottish routes are bmibaby, easyJet, go (go has been taken over by easyJet and will from March 2003 disappear as a separate brand), and Ryanair.

[13] The following alliances currently exist: '**Oneworld**': Aer Lingus, American, British Airways, Cathay Pacific, Iberia, Finnair, Lan Chile, and Quantas,; '**Star Alliance**': Air Canada, Air New Zealand, All Nippon, Ansette Australia, Austrian, bmi british midland, Lufthansa, Lauda Air, Mexicana, SAS, Singapore Airlines, Thai, Tyolean, United, and VARIG; '**Skyteam**': Aeromexico, Air France, Alitalia, Czech Airlines, Delta, and Korean; '**Wings**': Braathens, Continental, Kenya, KLM, Northwest, Transavia.

[14] See Scott Wilson (2002) for details of this model.

resulting in seven routes – a substantial reduction in the routes that need to be served. In many cases, this would, of course, necessitate passengers making two flights to get to their destination, but for the airline the routes would be easier to sustain owing to the higher number of travellers on each sector.

If a Central Scotland Airport could be designated and operated as a hub where travellers could easily change planes (interline) for onward journeys to other destinations, this would offer the prospect of establishing a wider range than otherwise possible of viable sectors linking the Central Scotland Airport (and hence Scotland) more directly with other parts of the UK, Europe and the rest of the world.

Of course, nothing prevents either Edinburgh or Glasgow Airport emerging in such a role, but the pooling of the traffic from both of these airports in a Central Scotland Airport would result in the higher level of traffic, often seen as necessary for such operations, emerging much sooner than would happen if the two airports remained separate. The higher level of traffic and adequate airport capacity in terms of landing and take-off slots are seen as important ingredients, as most successful hub airports arrange flights with incoming and outgoing flights occurring in quite distinct 'waves' at various points in the day[15].

Figures 8 and 9 utilise data taken from a run of the DfT's air traffic forecasting model (SPASM) which attempts to model air traffic between 1999 and 2030 under the assumptions that: (i) a new Central Scotland Airport opens in the year 2021 designated as a hub airport; and (ii) that Edinburgh and Glasgow Airports close at the end of 2020. It is also assumed that airports in the South East are allowed to expand up to their currently planned maximum operating levels (known as the Regional Air Services Coordination or RASCO assumption). Between 1999 and 2020, Figure 8 shows the number (and Figure 9 the percentage) of passengers who travel through these airports and are either hubbing (i.e., interlining, or changing planes) at some other UK airport (specifically Gatwick, Heathrow or Manchester in this run) or hubbing at some other European hub (specifically Charles de Gaulle, Schiphol, or Frankfurt in this run). From 2021 onwards the choice of hubbing at the Central Scotland Airport is permitted. While this starts out quite healthily in 2021, it does not sustain as both the increase in direct routes brought about by increased traffic and additional airport capacity elsewhere in the system reduce the attraction of hubbing at a Central Scotland Airport.

Figures 10 and 11 repeat the analysis of Figures 8 and 9 but in this case there is no Central Scotland Airport but Edinburgh gains additional runway capacity in 2013 and is thereafter designated as a hub airport in the model. It can be seen that hubbing here is even less successful than in the Central Scotland Airport scenario, and seems to add very little advantage.

Air traffic projections aside, for a strategy of hubbing to be a success at least one airline has to champion the idea. British Airways already has a hub in Heathrow (and to a much lesser extent Gatwick) and operates a 'Eurohub' at Birmingham.

[15] A characteristic that demands an adequacy of airport capacity in terms of scheduling and optimal terminal layout to facilitate interlining passenger and baggage transfer between flights – something that Heathrow now lacks, placing it at a distinct competitive disadvantage to Paris Charles de Gaulle, Frankfurt, and Amsterdam Schiphol.

Geographically it would be the Scandinavian and Baltic countries that would present the most obvious market for interliners at a Central Scotland Airport, but SAS already operates a very successful hub operation in Copenhagen. It would be difficult for a central Scotland Airport to compete against this. As an additional complication, the other domestic carrier who could be considered as a possible candidate to champion a hub at a Central Scotland Airport is British Midland (bmi), but that company is a member of the Star Alliance with SAS and, consequently, less likely to see a Central Scotland Airport as a potential hub. Of course, airlines do operate secondary hubs, for example, British Airways at Birmingham (as already noted), Lufthansa at Munich, and SAS at Oslo.

Budget carriers do not, by the nature of their ticketing policy, operate official hub-type operations, but Prestwick has enjoyed significant growth in the past few years owing to the expansion of Ryanair at that airport (Liverpool has enjoyed even more marked expansion due to easyJet). However, while not interested in an official hub operation (and therefore decidedly unlikely to 'champion' a new hub), the competition between 'go' and Ryanair on the Edinburgh and Glasgow to Dublin routes in 2001-02 demonstrates[16] that budget airlines are prepared to utilise any type of airport, as long as they can secure economically viable landing slots.

Airlines who have previously attempted to establish flights on North American routes[17] have also experienced consumer resistance towards what is, by necessity, a limited frequency of flights to a restricted number of American cities when compared to the wider range and greater frequency of flights available to anyone who hubs in Heathrow (or one of the other major European hubs). Additionally, from the perspective of the viability of flights to the USA from Scotland, certain legal prohibitions[18] in the USA restricting the operations of non-US airlines do not help matters.

That said, however, small scale hubs (or regional or niche hubs) do exist. Basel-Mulhouse and Clermont Ferrand are commonly cited examples. But Clermont Ferrand airport, for example, operates on a very small scale and entirely due to the presence of Air France which uses the airport as a hub for its regional jet services. Additionally, as evidence from the USA demonstrates, one or two airlines frequently come to dominate hubs, creating a 'fortress hub' condition that can be to the detriment of the consumer. Figure 12 (based on Doganis, 2002, p257) presents the level of traffic accounted for by the principal airline (or, on occasion, two airlines[19]) in each of

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[16] After a period of intense price competition 'go' withdrew from the routes.

[17] Currently served only from Glasgow, on a seasonal basis to Chicago and low frequency basis to Toronto and New York.

[18] Legal prohibition both in terms of limiting the ownership share of a US carrier by a non-US airline and by limiting the freedoms of the air negotiated either in international conventions or in bilateral agreements – for example, the lack of 'eighth freedom' or cabotage rights to pick up and set down passengers on routes between two domestic airports within the USA.

[19] The Airport (airline/s) are as follows: ATLANTA (Delta), CHICAGO (United/American), LOS ANGELES (United/American), DALLAS/FT WORTH (American), DENVER (United), PHOENIX (America-West/Southwest), LAS VEGAS (Southwest), HOUSTON (Continental), SAN FRANCISCO (United), MINNEAPOLIS/ST PAUL (Northwest), DETROIT (Northwest), MIAMI (American), NEWARK (Continental), NEW YORK (American/Delta), ST LOUIS (TWA).

a range of well known USA hub airports. To date, this phenomenon has been less common in Europe[20].

From the perspective of the various considerations raised above, it does look unlikely that hubbing, as such, will play a major role in any Central Scotland Airport.

[20] Table 27 in Little (2001) indicates that 70% of traffic at Amsterdam (Schiphol) is connecting passengers, 55% at Frankfurt, 53% at Charles de Gaulle, but only around 35% at London Heathrow. While Lufthansa and its Star Alliance partners dominate connections at Frankfurt (and KLM and its Wings partners at Schiphol, Air France and SkyTeam partners at CDG) the scale of dominance is less than that in these US examples.

4. Option Generation - Location

In an early study by the Scottish Office in 1959 and referred to in a 1969 report, Scottish Office (1969a,b), four possible sites for a Central Scotland Airport were identified. These were: Airth; West of Stirling; West of Kirkintilloch; and Slammanan. In the Scottish Office (1969a) study, attention was given to the possibility of Slammanan as a site. After conducting a basic cost-benefit analysis of the possibility of a Central Scotland Airport at Slammanan, the report concluded that 'on present estimates it would appear to be a worthwhile project'. This conclusion was reached on the basis that the facility could be constructed for what was then £16m. This possibility was subsequently rejected by British Airports Authority, and when the topic was briefly revisited in a Department of Trade (1976, p109) consultation on airport strategy the issue was given only a brief and entirely negative mention.

In the Scottish Consultation Document by the DfT (2002a, pp 163-174) and the Scottish Executive, attention focused on a possible site at Airth. While this location may seem far from either major city (and we return to consider surface access in section 5.1.6.7 below), it should be borne in mind that many of the world's airports are constructed at significant distance from the cities they serve. Well known examples are Denver International (38.7km), Washington Dulles (43.5km), and Montreal Mirabel (66.1km). Table 1 presents a selection of airports ranked both by their date of opening and by their distance from the cities they serve. Although there is some tendency for recently opened airports to be constructed at greater distances from city centres (for obvious reasons), the possibility of artificial islands and other engineering advances have allowed the recent construction of some airports quite close in (e.g., Osaka Kansai). Environmental consideration regarding the pollution and congestion created by large distance surface access journeys have tended to put a brake on far flung developments.

To provide some fresh evidence on the possible airport sites in central Scotland, a team from the University of Edinburgh (Stewart, Hill and Mackaness, 2002) used Geographical Information Science to examine the central belt of Scotland for suitable sites (Zones of Opportunity, 'ZOOs') at which a Central Scotland Airport could be located. No attempt was made to consider geological aspects of the terrain and, indeed, it turned out that merely imposing the requirement that the land in a zone of dimension some 5km by 2.5km be reasonably flat and even[21] eliminated all but one or two sites.

The area around Airth appeared (as already identified in previous exercises) as a possible site but, apart from the existing airports at Edinburgh and Glasgow, no other serious contenders were found. Thus, even Slammanan, an often mentioned potential site, did not appear as viable in this analysis. The flat area that had been used for the 1939 Central Scotland Airport (see footnote 2, above) is now totally taken up by the BP oil refinery and other related industrial developments at Grangemouth.

[21] Flat even being defined in terms of the slope of the land of either 3% or 2% slope.

The Airth site, while not being without its challenges (see section 5.3.3 below), does offer good existing surface access from Edinburgh (via the M9 to junction 7), Glasgow (via the M876 and M80), and the north across the Kincardine Bridge (where a second crossing is planned). A through rail link would be more difficult and, without significant re-engineering, the most obvious solution is the creation of a short spur line off the current Larbert to Stirling rail route[22].

As mentioned above, Slammanan is often suggested as an alternative site, but this failed to appear as a suitable location in the GIS analysis. On top of the problem of having terrain that is not obviously suitable[23], Slammanan enjoys less favoured surface access, with the site lying, as it does, some 6 to 9 km to the north of the M8 and even more remote from the M9. Although, rail linkages would be possible along the route of the abandoned but soon to be restored Airdrie to Bathgate railway line.

BAA (2002) considered both the Airth and the Slammanan sites and provided costings for their respective development as a Central Scotland Airport. A discussion of these and other estimated construction costs is available in section 5.1.6.2.

[22] Although, as with the proposed Edinburgh and Glasgow rail links, there is an interchange penalty when travellers cannot make a direct journey.
[23] A Scottish Office engineering report by A B Wylie dating from 1969 (Scottish Office 1969) also casts doubts on the suitability of Slammanan in terms of geology, not to mention the proximity of Cumbernauld new town..

5. Appraisal

5.1 Economic

5.1.1 Connectivity

Connectivity and economic development are inextricably linked in a modern economy. Scotland needs good air links to the London area, to the rest of Europe and to points further a field, North America in particular. Over recent years, Scotland has been fortunate in preserving its main routes into the Heathrow hub. Since 1989, the number of domestic routes[24] into Heathrow has declined from 19 destinations served in 1989 to 8 routes in 2002. Both Edinburgh and Glasgow Airports continue to offer direct flights to Heathrow. In addition it is possible to hub at other domestic airports (Gatwick or Birmingham, for example) or, as is becoming increasingly common, to utilise popular hub airports such as Paris Charles de Gaulle, Amsterdam Schiphol, or Frankfurt . The advent of regional jets[25] may reduce the need for quite so much hubbing as thinner routes become economically viable, given the correct mix of business to leisure passengers.

There seems to be a well accepted case that economic development and growth is dependent on good air transport links. Probably the best known recent study in this area is that by Oxford Economic Forecasting (1999, 2002). This report provides estimates of the size of the contribution of aviation to the UK economy in terms of contribution to GDP and level of employment (direct, indirect and induced). In as far as this goes, it resembles many other studies and, unless one believes that in the absence of such jobs these workers would remain forever unemployed, it does not really capture the key importance of aviation to a modern economy. Where the study stands out and deserves special attention is in the way that it attempts to calculate by how much greater is the growth rate of the UK economy as compared to what would exist with no aviation, or less aviation. This endogenous growth or boost to productivity growth is, of course, the contribution that calls for aviation to be given special treatment.

The Oxford Economic Forecasting study was, indeed, able to isolate a statistically and empirically significant effect attributable to transport infrastructure[26]. But, due to the inadequacy of the data coverage available on aviation, estimation could not be successfully attempted for aviation alone. It is not possible, therefore, to isolate a particular productivity effect (sometimes termed the catalytic effect) due to aviation alone. However, the results obtained for overall transport infrastructure remain suggestive (and, it has to be said, consistent with common sense reflection of the importance of aviation in the modern economy).

A much fuller review of this topic is available in Graham (2001) who sounds a note of caution in terms of causality. The point here is that airports and airport developments

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[24] Department for Transport (2002e) p 26.

[25] A list of typical regional jet aircraft includes: Canadair, Dash 8, Dornier 328 Jet, Embraer ERJ-135, Embraer ERJ-145, Fokker 50, Fokker 70, Jetstream 31, Jetstream 41, Saab 340 and Saab 2000.

[26] The effect is summarised in Oxford Economic Forecasting (1999, p6) as a 10% increase in provision of transport services leading to an increase in overall UK productivity of 1.3%.

may be attracted to areas of high growth and, therefore, the association between aviation and growth may, indeed, exist but the direction of the causality may be less clear than some commentators believe[27]. It is, nevertheless, true that while there is often much opposition to the creation or expansion of an airport, it is probably no greater than the opposition that emerges to suggested airport closure.

5.1.2 Competition issues

Free competition in the provision of airport services is difficult to arrange. Network economies and related considerations mean that there is an advantage gained by the airport that successfully attracts the greatest traffic. This is a form of natural monopoly. It is further complicated by spatial competition whereby a location as close to the most people brings a competitive advantage. Without regulation there is a theoretical possibility that excess airport capacity would exist – mostly as near to city centres as could be arranged. In most economies it is accepted that airports must be regulated – not merely from a safety perspective but also from an economic perspective.

BAA already controls some 90% of passengers and ATMs in Scotland[28] (and ownership of Gatwick, Heathrow, and Stanstead complicates consideration). Any airport with a turnover of over £1m per year is subject to the oversight of the Civil Aviation Authority in levying airport charges. In 1997 the Competition Review (Scotland) accepted that voluntary regulation, as had been offered by BAA in Scotland, seemed to be working[29]. And, while there is some dissatisfaction with the lack of taxi-way development at Edinburgh Airport, and the occasional public expressions of unhappiness by airlines regarding the level of airport charges, there have been no substantive complaints from airlines.

As it seems antithetical to the objectives of the economic case made above for a Central Scotland Airport that Edinburgh and Glasgow Airports should continue to operate, it is, actually, quite fortunate that these two privately owned airports are currently in common ownership. The decision making power to close these facilities and move to a new site is thereby centralised. Additionally, BAA at privatisation retained compulsory purchase powers which also make matters more straightforward in what might otherwise be a complicated market coordination problem.

In the absence of any prospective Central Scotland Airport, of course, it may be wise to review the current airport ownership situation in central Scotland.

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[27] Oxford Economic Forecasting (1999, p79-85) discusses the instrumental variables technique used to remove any influence of such reverse causality in their estimates.

[28] See data presented in Figures 6 and 7 for 2000. This general observation still holds in 2001 even when data for Dundee are also included.

[29] Currently on an rpi-x formula basis, where -x is set at -3%. To put this in context, Heathrow, Gatwick and Stanstead operate under Civil Aviation Authority (CAA) regulation where, the '-x factor' has been -1% (1987-92); -8% (1992-94); -4% (1995); -1% (1996-97) and -3% for Heathrow and Gatwick (1997-2002) and +1% for Stanstead (1997-2002). Charges at Manchester are also regulated by the CAA. All of this is in a 'single-till' regime which includes aeronautical revenue (landing fees etc.) and non-aeronautical revenue (retail business etc.).

5.1.3 Labour Market Issues

Glasgow and Edinburgh airports currently employ about 7,250 staff on a Full-time Equivalent (FTE) basis. This is a small fraction of total employment in the central Belt, but with a significance well beyond its absolute numbers. The Fraser of Allander Institute estimated that a further 15,000 jobs in the region are supported directly or indirectly by the two airports.

In assessing the impact of the proposed creation of the Central Scotland Airport to open in 2021, a number of factors need to be taken into account.

i) Between 2003 and 2020 there will be considerable growth in employment as new routes and new airlines (e.g. Air Scotland) will be created. Estimates of the demand for air travel in this period suggest a growth of 150%.

ii) Employment will not rise by this amount as there will be gains in productivity due to technological substitution (e.g. automatic ticketing) and scale economies (e.g. traffic management and catering). Both airports currently have spare capacity, although a new runway is expected to be needed at either Edinburgh or Glasgow Airport before 2030 (between 2015-2020 if at Edinburgh and 2025-2030 if at Glasgow).

iii) The transfer of air transport to a Central Scotland Airport (CSA) will achieve further scale economies after 2020.

iv) The 2020 workforce will not all transfer to employment at a Central Scotland Airport because of increased commuting times. Jobs will be lost in Edinburgh and more significantly in Glasgow – Renfrew.

v) Different workers in different occupations will exhibit different propensities to either retain employment, to give up their job or to move house.

vi) The greater the distance between the old airport and the new airport the fewer workers will continue to remain in employment. In this respect workers at Glasgow airport are less likely to retain their employment at the Central Scotland Airport than are workers at Edinburgh airport.

vii) In addition to direct airport employment, a large number of jobs have been located because of the importance of proximity to one of the two existing airports. If proximity is truly important these enterprises may relocate to be closer to the new airport. In this case the propensity of workers to accept longer commutes will reflect occupations, income, gender, etc. If proximity is less important then the enterprises will operate at a disadvantage after the airport relocation.

viii) Given difficulties with public transport, workers in part-time employment and those with awkward shift patterns will be most disadvantaged by the change in airport site.

ix) Jobs at the new airport site unfilled by previous workers will recruit largely from the Falkirk-Grangemouth area: public transport is poor in the area although it will be improved by investment in infrastructure.

Current employment levels at the current airports and projected employment at a Central Scotland Airport can be estimated as follows:

Current employment at Glasgow airport	**5,033**	**FTEs**
Current employment at Edinburgh airport	**2,225**	**FTEs**
	7,258	
Expansion of airport use 2002-2020 + 150% =	**10,900**	
Total airport employment	**18,158**	
Job savings by increased productivity, 2.5% p.a. and scale economies = 50%		
Total employment	**9,100**	

Of the current workforce it is necessary to estimate how many will retain their jobs after the transfer to the Central Scotland Airport. To do this we use the model developed by Houston (2001) to describe worker behaviour after an employer move. The key variables include occupation, car ownership, household structure and changed length of commute. We only have data on occupation and changed length of commute. We estimate that two thirds of professional workers and crew will retain employment at the new site, half the clerical and skilled manual workers, and one quarter of the semi-skilled and unskilled workers will retain their airport employment after the transfer. Rather more of the Edinburgh Airport workers will transfer, rather fewer of the Glasgow Airport workers will retain employment. Table 2 gives the current occupational distribution at Glasgow and Edinburgh airports (Fraser of Allander, 2001) and for comparison Manchester Airport (Halcrow, 2002c).

Table 3 shows the proportion of workers retaining employment after employer relocation in the four main occupational groups. At the extremes of the distribution no professional workers ceased employment, whereas only one unskilled manual worker was able to retain his employment post move. In part this is attributable to income and car ownership levels, in part to difficulties associated with awkward shift patterns experienced by semi- and unskilled workers, and partly because lower skilled workers have less specific and therefore more locally transferable skills (e.g. a pilot or air traffic controller is unlikely to find re-employment locally in their profession once the existing airports have transferred to Airth).

The percentages of job retainers in the Central Scotland Airport case are lower than those in the Houston study because the distances of relocation and increased commutes will be longer in the Airport case. This is particularly true of the Glasgow Airport workers where not only are distances longer post-relocation but there is a "wrong side" effect. Table 4 shows the current residential location of the workforces of both airports. Almost 60% of Glasgow Airport's workforce lives in Renfrew, west of Glasgow, thus necessitating a change of public transport to get to the new airport site. Only about 10% of the Glasgow Airport staff are likely to find themselves with a shorter commute post-relocation and even this may require at least one change of public transport. The great majority of Edinburgh Airport workers live in Edinburgh and Lothian, west of Edinburgh, and are therefore well placed for accessing jobs at the Central Scotland Airport.

On these assumptions we can estimate the likely workforce response to the creation of a Central Scotland Airport at Airth and the closure of Glasgow and Edinburgh Airports. As Table 5 shows we estimate that, with just over 9,000 jobs in 2020, 34% of these will be filled by existing workers, and 46% will be filled by new workers taking existing positions; a further 1,820 (20%) of jobs will be "new" jobs. It should be pointed out that these are 2002 figures applied to 2020 projections: there will undoubtedly be a transitional period as (i) employment growth with the rising demand for air travel not fully offset by productivity gains, and (ii) existing workers will adjust to the forthcoming relocation by seeking other employment before relocation of the airports.

In total the labour market around Falkirk – Grangemouth – north Lanarkshire – west Lothian is likely to have to find an additional 4,200 workers although some may travel from farther afield. Poor public transport, however, means that it is unlikely that many of the additional workers will come from north of the Forth (despite the creation of the second Kincardine Bridge) or from east Glasgow. At the same time the economy of Renfrewshire – west Glasgow will lose about 3,000 jobs and that of west Edinburgh and Lothian will lose about 1,200 jobs as a result of the relocation. With the recent downturn in the electronics industry both areas will find it difficult to replace these jobs, although the loss from Glasgow Airport will be the more serious both in absolute and in relative terms.

In addition to the direct employment at the airport the creation of the Central Scotland Airport and the closure of Glasgow and Edinburgh Airports will have implications for employers whose current location may in part have been determined by proximity to the existing airport. The Fraser of Allander (2000) report has estimated the airport employment multiplier to be in the range 3.12-3.23.

The total employment change therefore potentially involves a further 15,500 jobs throughout Scotland (Table 6) on a 2002 employment basis. Few of these jobs however are likely to be lost to the Scottish economy as a result of the airport location. Indeed the creation of a better connected and more modern airport operational after 2021 may encourage an increase in both indigenous firms and in Foreign Direct Investment. Estimates of such gains are difficult to make but the estimated growth of airport staff up to 2020 suggests, given the current multipliers above, that some 4,500 additional jobs might be created.

Perhaps more important is the possibility that existing enterprises will relocate as a consequence of the new airport. A study of 1,900 businesses in central Scotland (Turok, Bailey, 2002) asked about the importance of locational factors. In manufacturing firms, 57% rated passenger access to air travel important, 44% rated air freight facilities important. In business service firms the figures were 74% and 65% respectively. Figures were marginally higher for firms located close to the existing airports and for recently located/established firms (less than 5 years at the current site). Figures are marginally, but not significantly higher for firms near Glasgow Airport, than for those near Edinburgh Airport (although this may be due to the concentration of freight facilities at Prestwick).

Despite this claimed importance of proximity to airports, the Fraser of Allander study (Table 6) shows that the indirect employment attributable to the airports is geographically very widely spread. Indeed more indirect employment is created by Glasgow Airport in Edinburgh and Lothian than it is in Glasgow, and almost as much is created by Edinburgh Airport in Glasgow as it is in Edinburgh and Lothian. Lanarkshire and Tayside are the third and fourth most significant locations for indirect employment for both airports: both are likely to benefit from airport relocation.

Finally, part of the indirect employment will occur with the construction of the new airport. Including indirect multiplier effects some 3,000 jobs are likely to be created in the construction period, based on estimates of the labour requirement for the fifth Heathrow terminal. There may well however be some severe skill shortages in construction at the Airth site,

5.1.4 Regional Planning Implications

5.1.4.1 Introduction

Airports are seen as economic growth poles in which clusters of activities occur because of untraded externalities and improved access. The scale of investment at the Central Scotland Airport at Airth and the accompanying disinvestments at Glasgow and Edinburgh Airports have huge implications for local and regional planning at the three sites. Whilst local plans would need to incorporate airport changes the spatial extent of the impact may make the wider regional impact more significant. The recent Cities Review ("Building Better Cities") has stressed the need for cities to consult with their surrounding areas on major issues such as airports and transport systems.

5.1.4.2 Central Scotland

The new airport at Airth will undoubtedly provide a stimulus to the local economy. The current Falkirk district plan for the period 2003-2031 seeks to create an additional 4,500 jobs emphasising the leisure and retail sectors at Middlefield/Westfield, biomanufacturing at Grangemouth, and increased new firm formation rates at Grangemouth Enterprise Centre and in Falkirk. Improved access will help airport-related economic growth in Cumbernauld and north Lanarkshire. Existing major employers in the district such as BP Grangemouth are enthusiastic about the possibility of a Central Scotland Airport despite recent concern about job cuts. Development of employment north of the Forth in Clackmannan is likely to be limited, despite improved access.

Most of the growth will come either from new businesses, many supplying local services to the airport, and the improved attraction of Foreign (i.e. non-Scottish) Direct Investment into the area.

5.1.4.3 Edinburgh and Lothian

The immediate job losses with the closure of Edinburgh Airport are relatively small, compared with recent job losses in the electronics sector in west Lothian (NEC, Livingston, 1,250 jobs: Motorola, Livingston, 3,150 jobs). The continuing growth of the Edinburgh economy will generate sufficient additional employment. The relative proximity of Edinburgh Airport and Airth (20 minutes) will mean that a new airport will have little distorting effect. Airth lies west of Edinburgh, as does the current airport and forms an extension of the western growth quadrant (one of two, with the South East Wedge). Developments related to the current airport such as Edinburgh Park – Gyle – Hermiston Gate are unlikely to be affected by the relocation to Airth.

5.1.4.4 Glasgow and the West

Glasgow is likely to be adversely affected by the closure of the city's airport which will be fiercely resisted by the city's politicians. The move to Airth will adversely affect developments west of the city such as the Cardonald Business Park some 20 minutes from the existing airport. Even more vulnerable are the economies of the towns west of Glasgow (Inverclyde, Renfrew – Paisley) for whom current high levels of access to the airport are almost the only advantage). These towns have also suffered recent major job losses in electronics (Fullarton, Gourock, 500 jobs; Hewlett-Packard, Erskine, 650 jobs; Inventec, Glasgow, 600 jobs). Developments in Glasgow, such as the Business quarter in the city centre will offer some replacement employment. The sub-regional plan, the Glasgow and Clyde Valley Joint Structure Plan, charged with co-ordinating economic growth in the Clyde basin has evolved a linear growth corridor, paralleling the River Clyde. This has Glasgow Airport at its western end and the Ravenscraig site at its eastern edge. The movement of the airport to Airth would seriously erode the critical mass at the western end of the corridor. Further development at Braehead (retail) is unlikely to replace Airport employment although the recently announced Glasgow Harbour development (mixed residential, leisure, business, hotel) while even more recently downsized, will provide some replacement employment.

5.1.5 Alternative Use Value of Sites

As a partial offset to the write-off of the capital investment in the current Edinburgh and Glasgow Airport sites, there is the potential of finding alternative uses for these sites. A non-trivial complication arises in assessing a value for this, is the fact that both sites sit in Green Belt and operate as a non-conforming use within the Green Belt.

With the pressure for development towards the west from an expanding financial services sector, the Edinburgh Airport site is undoubtedly the more attractive of the two. Even in the absence of a Central Scotland Airport, there is likely to be substantial pressure to allow expanded economic development on or near to the Edinburgh Airport site. But, the West Edinburgh Planning Framework Consultative Document (Scottish Executive 2002b) indicates that there is no expectation of a release of Green Belt land for economic development before 2030, and certainly not before 2020. With the timing of a Central Scotland Airport around 2020, this does not rule out the prospect that the Edinburgh Airport site might be available for economic development, but, at the moment, it would seem unwise to rely on such an outcome[30].

The possible development value of the two airport sites was examined by a property development company[31]. In forming an initial view of the situation, they took into account elements such as gross land values by use, likely percentage of developable land, infrastructure cost per acre, Section 106 costs per acre, percentage of affordable housing, phasing costs/discount for quantum, and costs of realisation. The conclusion was that an estimated value for the Edinburgh Airport site was £150million and for the Glasgow Airport site was £40million. Of course, these estimates must be treated with a substantial degree of caution and remain largely subjective at this stage. In the cost benefit estimates presented below, we assume the alternative use values at zero in one case (Table 14 below) and at the values discussed here in the other case (Table 15 below). As we shall see, the impact of the alternative use value assumption on the benefit-cost-ratios is modest in all cases, and in no case does the ratio exceed unity.

5.1.6 Cost Benefit Analysis

5.1.6.1 Dates:

The basic assumptions for the cost benefit analysis are that Edinburgh and Glasgow Airports would close at the end of 2020 and Central Scotland Airport open in 2021. Some airports that linger on after the creation of a larger facility meant to replace them (such as happened at Love Field in Dallas after the opening in 1974 of Dallas-Fort-Worth Airport) do mange to carve out a niche existence (in this case by becoming the home of the first no-frills airline, Southwest Airlines[32]). But the result

[30] It is interesting to note that in the Scottish Office (1969, p14) exercise with respect to an airport at Slammanan, the observation that Turnhouse (as Edinburgh Airport was then) was in the Green Belt met with the comment that 'Turnhouse is actually in the Green Belt, but it is extremely unlikely that such a site, if it ceased to be an airport, would revert simply to agriculture'.

[31] We are grateful to Iain Wotherspoon and David Peck of Kilmartin Property Group for assistance in this matter.

[32] Not that this happened without stiff opposition from those airlines that had moved to DFW, and Southwest was originally restricted to flying from Love Field only to the four adjoining states. The presence of Ryanair at Prestwick is somewhat similar to this situation, although without the restrictions.

is often less happy in other situations, such as at Milan where the continued operation of Linate inhibits the full development of Malpensa which opened in 1999.

There may have been other mistakes made in the development of Denver International Airport, but they made sure that Stapleton closed for passenger traffic in 1995. Similarly Paris Le Bourget was replace by Paris Charles de Gaulle[33]. With the exception of China Airlines, all international traffic had to use Narita on opening rather than Haneda Airport. And, in Hong Kong, Chek Lap Kok replaced Kai Tak Airport.

5.1.6.2 Construction Costs:

Two sets of costs are utilised. The first derives from those prepared by BAA plc. In terms of terminal construction, of course, BAA have substantial recent experience in the preparation phase for the new Heathrow Terminal Five. A second set of costings was prepared by an independent firm of engineering consultants[34]. This provides a cross check on the BAA estimates. It is clear that with such large sums of money involved that the estimated cost can prove crucial in driving the cost-benefit analysis.

Table 7 provides the costs supplied by BAA and Tables 8 and 9 those supplied by the independent engineering consultants. In the construction phase, many unexpected difficulties can arise. Thus, in the case of the new airport at Osaka (Kansai), the partly land-filled island on which it was being built started to sink and hydraulic ramps had to be used as support. Hong Kong's new Chep Lak Lok was created partly on a flattened granite island and partly on landfill, and all at considerably more expense than first imagined. Other airports, notably Munich's Franz Josef Strauss Airport which opened in 1992, seem to meet no serious snags and to operate effectively from day one. There is, however, a risk that seems to exceed what is usually allowed in the planning process[35]. In the BAA cost estimates, an allowance of 25% is made against risks. This is levied after all costs, including on-costs (professional fees and so on) of 20%, have been computed. The independent engineer's estimates already contain a contingency factor in the construction costs (of some 15%) and an allowance of 25% was made for on-costs. Their advice was that a further 20% would cover contingency risk.

The new Treasury Green Book now requires the use of indicators of appraisal optimism. This is being interpreted as costs (including contingency and on-costs) being increased by a further 44%, which is a standard engineering upper bound for optimism bias. There is also a move to set benefits in the first three years after construction at zero, to allow for any delays in project completion. These innovations are not adopted here, as the estimates are meant to be compared to those produced for other airport projects in the Air Transport Consultation Documents for the various regions of the UK (including Scotland). For the same reason of comparability, we

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[33] And new international traffic was all directed to CDG as opposed to Orly. See Little (2001 p64) for details on this and others.

[34] This is available at http://www.ed.ac.uk/dhi/

[35] In a well known quote referring to Denver International Airport, Robert Crandall (then CEO of American Airlines) labelled the project a 'field of dreams'. See Dempsey et al. (1997, p20).

shall use a 6% real discount rate rather than the 3.5% real now being favoured by the Treasury.

The two sets of estimates are dimensionally similar with a Central Scotland Airport at Airth being £7.4 billion under the BAA estimates and £5.8 billion according to the independent engineer. BAA propose construction[36] in two phases and the engineer a three phase approach. For Slammanan the figures are £7.3 billion and £6.6 billion respectively (see Table 7 and 8). The estimated cost of a Central Scotland Airport mentioned in the DfT (2002a) Scotland Consultation Document (p170) is a more modest £1.4 billion, although the assumed capacity is 20mppa (million passengers per annum) in a single runway airport. It is worth noting that, assuming 70mppa capacity is available at the new airports whose costs are resented here, then the costs per mppa in these estimates produced above range between £93 million per mppa and £104 million per mppa, which is at the very top of the £65m to £100m per mppa range discussed in the DfT's (2002) Part 3 Study (paragraph 10.7.14).

We will concentrate here on the figures for Airth (the Geographical Information Science investigation, Stewart et al. (2002) raised doubts as to the suitability of the Slammanan site). Whether £7.4 billion or £5.8 billion, these are clearly huge sums of money. Runways are assumed to be refurbished at 10% every 8 years and terminals at 10% every 10 years.

5.1.6.3 Benefits:

The major benefit brought about by the opening of a Central Scotland Airport is enhanced airport capacity in what would otherwise be a constrained system. Additional passengers would be able to fly through a Central Scotland Airport than would be possible with Edinburgh and Glasgow in their current runway configurations. One source of benefit is, therefore, experienced by these additional (or 'generated') air passengers using Central Scotland Airport.

Another benefit arises from the fact that concentrating flights in one airport rather than two offers the clear prospect of travellers having a greater range of flight destinations from which to choose and also the advantage of more convenient (frequent) flights. These benefits to existing travellers are also estimated.

Both the benefits to generated passengers and the benefits to existing passengers are computed using the DfT passenger allocation model (SPASM), which is discussed in more detail below. Appendix A offers a brief summary of the DfT's Spreadsheet Costs and Benefits (SCAB) software used in computing the benefit-cost-ratios of these possible investments.

One key consideration of opening a new Central Scotland Airport is that in the opening year (say 2021) two functional airports (Edinburgh and Glasgow) will be abandoned. While the new airport would offer enhanced capacity and advantages to travellers owing to more frequent flights and more direct flights, there will be many travellers for whom one of the existing airports would have been more attractive. It is

[36] Both approaches envisage starting with two parallel runways of at least 3km length, and then at a later stage adding a third shorter runway to take the airport up to its final capacity of 60 to 70mppa.

necessary, therefore, to make allowance for the value that travellers would have placed on these airports had they remained open, and to deduct this from the measured advantages brought by the Central Scotland Airport (advantages, as mentioned above, brought about by greater capacity). In this way we attempt to measure what might be termed the social convenience loss of closing down two functioning airports. The approach again makes use of the DfT's passenger allocation model (SPASM) to estimate the value that would be placed on Edinburgh and Glasgow airports by estimating the counterfactual demand curves for their use in the presence of a Central Scotland Airport, and entering this in the SCAB cost benefit analysis programme.

5.1.6.4 Operating Costs:

New airports can achieve economies both by operating more efficiently through moving nearer to the most efficient mode of operation (moving onto the costs curve) and, in the case of a larger airport replacing two smaller ones, by moving along the cost curve to gain economies of scale. There are some doubts as to the exact scope for economies of scale at airports once a certain minimum size is attained and some authors, such as Doganis (1992, p50) prefer to regard the cost curve as 'L' shaped. But from a detailed analysis of the literature and from some preliminary results obtained by econometric analysis of available airport cost data for both UK and other European airports, we believe that substantial operating efficiencies are available at a larger modern airport facility. Details of our analysis are available in Appendix B, where Appendix Figure 9 presents the clearest evidence of declining costs with scale.

The basic assumption embedded in the DfT modelling of new airports is that costs fall from £5.88 per passenger to £4.49 per passenger a 23.6% reduction. The base estimates are derived from Bath University Airport Statistics for 2000 and the assumed efficiencies are those embedded in the study of the Midlands New Airport projections. These assumptions are also used in the cost benefit analysis performed here.

5.1.6.5 Airport revenue:

The revenue side of an airport's operations offers additional gains to be made by moving to a new larger airport facility, particularly in terms of non-aeronautical income[37] through the additional opportunities opened up for enhanced shopping facilities and so on that are provided by a newly built airport of a significant scale. The airport employees themselves can create a substantial customer base as can 'meeters and greeters'. And, as has been shown at Frankfurt[38], even non-airport users can be attracted into the airport by its leisure and retail oriented facilities.

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[37] Doganis (1992, p 54) categorises airport income into aeronautical (landing fees; airport air traffic control charges; aircraft parking, hangarage and picketing; passenger charges; freight charges; airport services and aircraft handling; baggage handling; fuel throughput surcharge) and non-aeronautical (rents or lease income from airlines and other tenants; recharges to tenants for electricity, water, cleaning etc.; concession income from shops, banks, car parks, hotels, restaurants; direct sales through airport operated shops etc.; car-park revenue; land development etc.).

[38] Frankfurt offers an English language cinema, a bowling alley and a large discoteque (see Doganis 1992, p114).

The assumption made here is that the average revenue per passenger rises from £7.72 to £9.26. This is a 20% increase. This is consistent with estimates used by the DfT in other new airport modelling exercises, such as that for the possible Midlands and Cliffe new airports and is discussed in Arup (2002, para 5.2.45).

5.1.6.6 Demand:

The air passenger forecasts used in the cost-benefit analysis are made on the basis of a policy of constrained growth in the South East, a scenario that was found to produce the highest passenger throughput at a Central Scotland Airport (some 46mppa by 2030). This assumes that regional airports (particularly Birmingham and Manchester) are unconstrained, but that capacity in the South East is held at the level currently in the planning system[39].

The base model (where there is no new Central Scotland Airport) allows Edinburgh and Glasgow Airports to expand with demand up to traffic levels of 16mppa[40] and 13mppa in 2020 and to further expand to reach final capacities of 20mppa and 30mppa sometime after 2030. These figures are displayed in Figure 13. The option model allows for Edinburgh and Glasgow Airports to close at the end of 2020 to be replaced with a Central Scotland Airport whose capacity increases as needed up to an eventual 70mppa. At the outset in 2021, it carries 36mppa and this rises to 46mppa by 2030. This scenario is described in Figure 14.

The exact estimates of passenger movements (and related air traffic movements) in Figures 13 and 14 are produced by runs of the DfT's Passenger Allocation Model[41] (SPASM). At the heart of this model is a multinomial logit model which allocates passengers from each UK district origin (there are some 455 of these, 53 of which define Scotland) to airports in a probabilistic fashion according to the generalised cost of their travel at each respective airport. Thus the lower the generalised cost of travelling via a particular airport the more likely that any particular traveller (and hence the greater proportion of travellers) will choose that airport. Generalised costs include the costs of accessing the airport in question, and the cost of reaching the final destination from that airport. All aspects are monetized so that cost here embraces time and expense.

Different types of passenger (business versus leisure, and domestic versus international) are modelled separately. Extensive use is made of Civil Aviation Authority (CAA) passenger surveys in modelling the pattern of demand by district ground origin and by route flown. The base levels from 2000 through 2020 are taken as the DfT's *Air Traffic Forecasts for the United Kingdom 2000*, as discussed earlier (see Figures 3 and 4 above). A profile of growth factors is used to project[42] demand forward from 2020.

[39] This excludes the recently approved Heathrow Terminal 5.
[40] Recall that mppa is million passengers per annum, where every terminal arrival or departure is counted.
[41] See Scott Wilson (2002) for details. This is an iterative general equilibrium model.
[42] While these projections make use of established propensity to fly data and are, to an extent, 'sense checked', the further estimates are from 2020 the less reliable they will be.

Passenger trips are converted into expected air transport movements[43], and both passengers and air transport movements (ATMs) are constrained to lie within the projected capacity of airports. In order to keep the demand for air travel consistent with available supply at each airport, then airport specific shadow costs are imposed for either or both passengers (terminal shadow costs) and runways (ATM shadow costs). The purpose of these shadow costs is to ensure that demand at any airport is always consistent with available capacity[44]. As a consequence, however, some travellers end up allocated to journeys (or modes) that are less convenient than travelling through that particular airport. The extent to which these shadow costs can be relaxed when capacity is increased somewhere in the system is a measure of the benefit brought about by this easing in capacity. Appendix A provides more detail.

5.1.6.7 *Surface Access Costs:*

Surface access is computed utilising the National Airport Accessibility Model (NAAM) which utilises a network model of rail, road and coach connections from 455 district zones of the UK to each of the UK's airports (including a Central Scotland Airport located at Airth). The model takes account of known planned developments in the transport infrastructure[45] of the UK, including the trunk road schemes in the Scottish Executive's *Strategic Roads Review Scheme Decisions*. In addition to explicit travel costs (fares, vehicle operating costs etc.), time is valued according to the *Transport Economics Note*[46] by type of traveller.

Some idea of what is involved can be gathered from Figure 15 which uses the district origins and destination data from the CAA data for domestic end-to-end trips. This shows an increase for current Edinburgh passengers from an average journey of 32km to and average of 53km (+66%) and, for Glasgow, from 39km to 61km (+56%). Figure 16 uses average road access times to show that times rise from an average of 36 minutes for Edinburgh passengers to 52 minutes (+44%) when they use a Central Scotland Airport at Airth. For Glasgow passengers the rise is from 41 minutes to 59 minutes (+44%). Of course, investment in improved public transport links would shift the modal choice away from private transport road (cars and taxis accounting for over 80% of trips at Edinburgh Airport and over 90% at Glasgow Airport), and could also expedite journeys. But this could also happen at the existing airports.

The costs of surface access play a key part in computing the generalised costs of air travel in the SPASM passenger allocation model used in the estimates presented below. This is a key consideration in computing the consumer (traveller) benefits to be realised by relaxing capacity constraints at airports and facilitating additional travel by air. Heavy rail links are assumed to be available at Edinburgh and Glasgow Airports post 2010 and at Central Scotland Airport on opening.

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[43] This is done using a device known as a Larame Graphs.

[44] Shadow costs at constrained airports beyond the 2030 period modelled in SPASM are projected by use of assumed price elasticities by type of traveller (thus –0.8 for scheduled business travellers, -1.2 for schedule leisure travellers and so on. See Scott Wilson (2002, p71)).

[45] An allowance is made for trunk road congestion effects revised at 2010 and 2020 in the model. See Scott Wilson (2002, p46).

[46] Available on the Department for Transport web site at www.dft.gov.uk

5.1.6.8 Costs and Benefits:

The results of earlier cost-benefit analyses reported in the various consultation documents that have formed part of the Air Transport consultation process are presented in Tables 10 through 12. In Table 10, the benefits of adding runway capacity in the South East are seen to strongly outweigh the costs, with benefit-cost-ratios of around 3.0 being typical. Table 11 illustrates that a new Midlands Airport (Table 11, packages 3 and 4) offers benefits in excess of costs, with benefit-cost-ratios in the region of 1.6 to 1.8. All values here and in what follows are computed in terms of £2000.

Similarly, in Table 12 the various runway development options considered for Scotland are shown, at least in the cases of developments at Edinburgh, to be highly favourable, with an additional runway at Edinburgh (either close parallel as in package 3-late, or widely separated as in package 4-late) producing benefit-cost-ratios of 2.4. These estimates for Scotland were produced on the assumption of three extra runways being developed in the South East.

In order to focus on the assessment of the costs and benefits of a Central Scotland Airport, an analysis using the same base scenario (20mppa max at Edinburgh Airport) is conducted against an alternative of a second runway at Edinburgh, allowing traffic at Edinburgh to rise to 33 mppa by 2030. In terms of value for money, the cost benefit analysis of this option can then be compared against the cost benefit analyses obtained under various estimates of the Central Scotland Airport option. This extra airport capacity at Edinburgh, while leaving Glasgow at a capacity of 14.8 mppa, is similar to package 4 in the Scottish Consultation Document (p 187), except that in this analysis the South East airports are constrained (this provides more growth of air traffic in Scotland).

The results are shown in Table 13 and reveal an even more promising return than that estimated in the Consultation Document for Scotland (Department for Transport 2002a) – mainly due to the assumption in Table 13 that the South East will be constrained[47]. A benefit-cost-ratio of 2.93 is a very positive result and one against which any proposed Central Scotland Airport must be compared..

Under the same assumptions as in Table 13, the results in Table 14 for a Central Scotland Airport are much less promising. There are five packages considered. The first is the DfT pattern of costings, but assuming a £50million per mppa cost of airport capacity development (a cost far lower than anything considered reasonable by the DfT, BAA or our independent engineer). Even under this low-cost regime, the benefits brought about are lower than the project costs, with a benefit-cost-ratio of 0.78. In package 2 (Table 14), the £80million per mppa costings (used by the DfT) produce a benefit-cost-ratio of 0.50. Under the higher end of the costings considered

[47] The DfT software used in Table 13 is the same as that used in other Consultation Documents for other regions (DfT 2002e, p153, document 18) although slightly different from that utilised in the Scotland Consultation Document. In addition, and importantly, the Scotland Consultation Document results assume three extra runways in the South East, whereas here we assume none of these goes ahead.

by the DfT (£100million per mppa), option 3 returns an even more disappointing benefit-cost-ratio of 0.41.

When the BAA cost estimates (£7.44billion) are used in package 4, the benefit-cost-ratio estimated is 0.45. Of course, nothing less than 1.0 should be considered viable, and, in such mega-projects as new airports, a benefit-cost-ratio considerably larger than 1.0 would usually be expected.

Finally, using the cost estimates from our independent engineers, package 5 reveals that the benefit-cost-ratio is a modest 0.58. while this is better than under the BAA assumptions (reflecting the lower cost estimates produced by the independent engineer), it is far worse than what would be required for such a project to command support.

Table 15 revisits each of the packages analysed in Table 14, but rather than ignoring the alternative use value of the Edinburgh and Glasgow Airport sites, it uses the estimated value of £190million provided by the property developer who assisted in this exercise[48]. It can be seen that while, unsurprisingly, this consideration improves the strength of the project under each scenario (packages 1 through 5), such is the scale of the investment cost that empirically the improvement is modest and in no case does any of the packages approach viability.

From this analysis, then, it seems that a Central Scotland Airport would not represent a socially productive investment. In particular, consideration of the alternative scenario of investment in an additional runway at Edinburgh (or, indeed, some of the other packages discussed earlier) would offer far better value for money. As will be discussed later, other environmental considerations would also tend to weigh against the Central Scotland Airport – and particularly one where the economic analysis is already so unfavourable.

When compared with cost benefit results from other possible developments considered in the consultation process[49] (and indeed that presented in Table 13), it can be seen that the Central Scotland Airport offers an unacceptably poor return.

5.2 Financial

Whereas a project of the magnitude of a Central Scotland Airport would present significant financing problems to any one local authority or single-airport company, the size of BAA means that an investment of this magnitude can be contemplated. It must, however, make commercial sense, otherwise BAA would be failing its shareholders in proceeding with such a project.

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[48] We are grateful to Iain Wotherspoon and David Peck of Kilmartin Property Group for assistance in this matter.

[49] The SCAB software (DfT 2002e, p153, document 18) used in this paper is the same as used in the DfT consultation documents (South East, Midlands, etc.) and although in the Edinburgh and Glasgow Airports Arup (2002) Part 3 Study a slightly different approach was adopted, this is unlikely to affect the comparisons.

Given the poor results obtained above in estimating the size of the benefits to society against the costs involved, it cannot be expected that BAA would enjoy a high internal rate of return from this investment. The estimates[50] in Table 16 present values for the nominal rate of return that BAA might be expect under the various options outlined in Tables 14 and 15. Given that these are nominal rates of return and, given the intrinsic risk involved in large projects, a rate of return of 12.5% might be considered as a minimum to attract a commercial investor. The returns in Table 16 are sufficiently low to make it clear that BAA would not consider this a sensible use of its shareholders' funds.

5.3 Environment

5.3.1 Safety

Establishing Public Safety Zones would, in the case of Airth, necessitate the purchase and removal of a certain amount of housing. The exact implication here would depend on the alignment and situation of the runways. No exact consideration to this detail is given here.

In more general terms, as the BAA report makes clear, it is expected that flight approach and departure could be successfully managed within the landscape of Airth's surroundings.

5.3.2 Airspace

The closure of Edinburgh and Glasgow would ensure that no air traffic control problems arose.

5.3.3 Ecology

The Forth Estuary is, of course, a Site of Special Scientific Interest (SSSI) and the proximity of such a large expanse of inland water raises a serious issue of bird strike for the Airth site. Airth Castle and the Pineapple would also require special consideration. No attempt has been made here to consider the environmental impact in any detail, but the proximity of Dunmore Moss and other features would require careful assessment.

Slammanan is also a site where wintering bean geese are found, a species[51] protected under the Wildlife and Countryside Act 1981. In addition, the meteorology of any site (and, in particular, Slammanan at a height of 220 metres) would require assessment, as even with the prevalence of Instrument Landing Systems some basic visibility is required for landings and, indeed, not all aircraft carry such equipment.

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[50] Thanks are due to DfT for supplying software for this analysis.

[51] Information provided by a member of the Bean Goose Action Group (BGAG).

5.3.4 Noise

The use of the Forth Valley for aircraft deployment means that Airth offers the potential of a modest impact of noise pollution. By comparison, continuing and expanding air traffic at Edinburgh and Glasgow exposes a larger population to noise pollution. This is larger in Glasgow under current flight traffic but is likely to increase at Edinburgh with any expansion in use of the cross-wind runway.

6. Conclusion and General Observations

The building of an airport of the size of Central Scotland Airport would have to be regarded as a 'megaproject', and with such ventures comes the danger of optimism bias. While allowances are make in cost estimates both for 'on costs' and for 'risk', recent advice from the Treasury is, effectively, that a risk element of some 44% should be added to project costs after on-costs and construction contingencies have been included. In addition, a delay of three years from the proposed start date should be built into estimates of benefits to allow for late delivery of the project. The allowance for risk was variously 20% and 25% in the estimates used here, and no allowance was made for late delivery.

Even without these considerations, it does not seem possible to make the case for a Central Scotland Airport. In part, the case falls because with the availability Edinburgh and Glasgow Airports most travellers to and from central Scotland are already well served. Both of these sites are capable of further development. To close these sites and create a more remote, albeit larger, airport facility, the benefits would have to be very large. But the fact is that while, in many ways, larger is better in terms of choice and frequency, the offerings of Edinburgh and Glasgow Airports would not be so inferior as to allow the benefits to outweigh the considerable costs of developing a new airport. A new airport that would, by necessity, be more removed than the current airports are from Scotland's two major conurbations.

None of this means that air transport is not important. As the work of Oxford Economic Forecasting makes clear, transport infrastructure and economic growth are inextricably linked. This is certainly true for air transport and is an unavoidable consideration for any economy, such as Scotland, that is geographically at the fringe of Europe. We may not be able to alter geography, but air transport can change economic geography. With good air transport linkages into the rest of Europe and to North America, Scotland's geographically peripheral status ceases to present a commercial hurdle. Given Edinburgh Airport's and Glasgow Airport's continuing airlinks into Heathrow (and other European hubs), this suggest that Scotland's economic interests lie not only in developing airlinks at Edinburgh and Glasgow but also in seeing expansion of capacity in the South East.

Within Scotland, the development of Edinburgh and Glasgow Airports remains a key issue in Scotland's economic development. With fast through rail links between the cities and their respective airports, and thereby between the airports themselves, passenger choice can be enhanced. With the development of capacity at Edinburgh or Glasgow, central Scotland can continue to offer services that connect Scotland with the rest of the world. Whether this is best achieved with both airports under common ownership is a matter that may have to be revisited.

In terms of our reply to the question posed by the DfT and the Scottish Executive consultation document 'The Future of Air Transport in the United Kingdom: Scotland. A National Consultation':

> "Should the case for constructing a new airport in central Scotland still be considered? What would be the basis for such a case? When should it be built and how might it be funded?"

(p172 of 'The Future Development of Air Transport in the United Kingdom: Scotland'):

Our answer must be a decided 'No. There is no basis for constructing a new airport in central Scotland'.

Aknowledgements.

We would like to thank BAA plc, the Department for Transport and the Scottish Executive for their helpfulness and openness during the conduct of this research exercise. In addition, a great number of people gave freely of their time in cooperating with this project. The authors are extremely grateful. While too many to mention in their totality we would like to name the following with our thanks: Fiona Black (easyJet); Graham Buchan (Glasgow and Clyde Valley Joint Structure Plan); Peter Burt (HBoS); Chris Cain (DfT); Iain Cameron (Scottish Executive); Iain Docherty (Univ. Glasgow); Donal Dowds (BAA); Brian Finch (Vulkan Consultants); Anne Follin (BAA); Stephen Garland (Scotland Office); Stuart Gulliver (Univ. Glasgow); Alan Henderson (City of Edinburgh); Chris Hill (Univ. Edinburgh); Peter Hind (rdc); Neil Jackson (Scottish Executive); Mervyn Jones (BP); Mark Judd (Scott Wilson); Kevin Kane (Scottish Enterprise); Ken Macdonald (Clackmananshire Economic Development Partnership); William Mackaness (Univ. Edinburgh); P McKenzie Williams (Transport Research Laboratory); Stewart MacVicar (BAA); Paul McCartney (Scottish Executive); John Martin (Scottish Executive); Steve Morrison (Northeastern Univ.); David Peck (Kilmartin Property Group); Jamie Ross (Scottish Executive); Alistair Shaw (West Lothian); Laura Stewart (Univ. Edinburgh); Andrew Tannonhill (Glasgow Chamber of Commerce); Jeff Thompson (DfT); Ivan Turok (Univ. Glasgow); Iain Wotherspoon (Kilmartin Property Group); John Yellowlees (ScotRail);

Appendix A

Cost-Benefit Analysis

The cost-benefit analysis results presented above are derived from the DfT's SCAB (Spreadsheet Cost Benefit Analysis) Model (see Halcrow Group Ltd. (2002)). The present value of costs and benefits over the period 2000 through 2006 are considered in 2000 terms by using the current Treasury test discount rate of 6% per annum (real terms). Results are expressed as a benefit-cost-ratio (BCR) where, clearly, numbers in excess of 1.0 are regarded as potentially viable and where projects with larger BCRs are ranked ahead of those with lower BCRs.

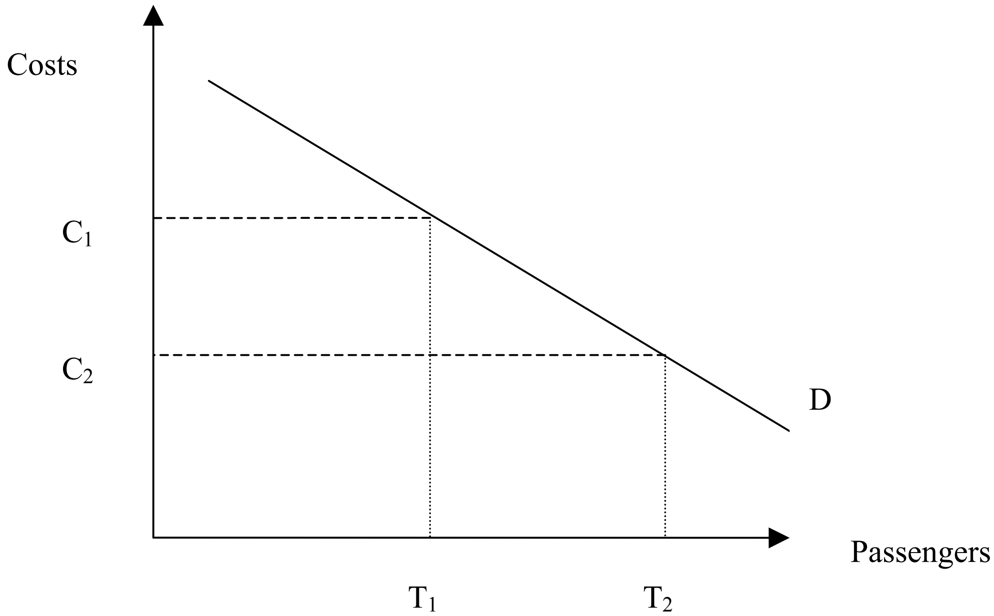
SCAB, in turn, utilises output produced by the SPASM Model (see Scott Wilson (2002)) which predicts passenger demand at the main UK airports for the years through 2030. The SPASM model uses the general air traffic forecasts produced by the Department of Transport in combination with details about the surface location and destination points (data defined in 455 UK districts of which 53 are in Scotland).

Using the 'National Airport Accessibility Model' (NAAM) to compute the surface access costs in conjunction with detailed information regarding flight fares, frequencies and connections available throughout the world's airports (29 existing UK airports and 48 rest-of-world destinations) demand is predicted at each UK airport. When demand exceeds capacity at any particular airport (owing to limited runaway and/or terminal capacity) an extra cost or 'shadow cost' is computed to be added to the travel costs that is sufficient to check demand to the supply that is available.

The total costs faced by air passengers are the 'generalised costs'. When capacity anywhere in the system is increased, it is possible to relax the imposed shadow costs. Such a relaxation of costs will obviously occur at the focal airport where capacity has been increased, but it will also occur at other airports throughout the system. The model is, therefore, a general equilibrium model. Lower shadow costs will mean lower generalised costs and greater demand for air travel.

The consumer benefits arising from extra capacity can be identified by the benefits due to the extra air travel (hitherto 'rationed' by the imposition of shadow costs) – generated benefits. There will also be a potential benefit to existing travellers brought about through the extra capacity permitting additional flights and thereby reducing the overall travel time, either due to more direct flights or due to more frequent flights.

(i) Benefits to generated passengers:



$$Benefit \equiv \frac{1}{2}(T_2 - T_1)(C_1 - C_2)$$

Where the move C_1 to C_2 in generalised costs is due to the reduction in shadow costs with the removal of some capacity constraint in the system under the option being considered (e.g. close Edinburgh and Glasgow and open larger capacity Central Scotland Airport). This is a system wide effect and the results are measured against a 'do nothing' scenario (in this exercise the 'do nothing' scenario is to keep the South East constrained in terms of airport capacity. This produces the largest uplift in traffic through a Central Scotland Airport under the SPASM runs.

(ii) Benefit to existing passengers

Computes reduced costs for existing passengers (who would have used an alternative, possibly less convenient, airport). Benefits of increased frequency of throughput due to new capacity – this affects fully-flexible ticket holders only

Benefit =

□ (existing Pax)(hours in day)*(wait time factor)(VOT)(fare factor)(days in year)(Diff/ATM)

Where,

Diff/ATM = (NR/BATM) – (NR/OATM)

Diff = Difference in Routes
ATM = Air Transport Movements per annum
NR = Number of Routes
BATM = Base Scheduled ATMs
OATM= Option's Scheduled ATMs

(iii) Benefits to freight users – imported from separate DfT model and not modified here.

(iv) Benefit to Government from extra revenue via APD (air passenger duty) which is set at a basic rate of £40 for non-EEA and £10 for EEA, and at a reduced rate of £20/ £5 – mainly for charters).

(v) Producer benefits of additional capacity which in terms of expanding capacity at existing airports merely allows for the increased volume (with average margin on that extra volume). With the Central Scotland Airport as a new airport, however, it is necessary to allow for economies of scale and for more efficient operating configuration.,

(vi) Recognising capital costs net of any redevelopment benefits available from redeploying existing sites.

(vii) External Costs are not explicitly incorporated into the model but separate recognition is made for these.

Environmental evaluation – sensitivity tests but not in core calculation.

Climate Change = (CO2) carbon tax : the effect can be simulated through SPASM run with higher prices. A £70 per ton of carbon tax has the effect of reducing demand[52] by some 1%.

In the vicinity of an airport and at levels above 57dB, noise has been shown via house prices obtained from the land register to have a 0.5% to 1% impact on house prices per 1 decibel over the 57dB level.

Air Quality (NO2, PM10, SO2) – no explicit allowance is made here.

(viii) Wider economic benefits including productivity, foreign direct investment (FDI), and tourism are discussed above.

[52] Doganis (2002, p 207) discusses demand elasticities, giving price elasticity for high income countries in the range –0.66 to –0.27 and income elasticities in the range 1.80 to 2.44.

Appendix B

Costs

When considering the efficiency of airports it is important to distinguish between different types of economies. Economies of density occur when, given the size of runways, terminal buildings and access roads, an increase in volume (however measured) results in lower average costs. Over simplistically this corresponds to a movement down a traditional short run average cost curve towards its tangency with the long run average cost curve where the SRAC curve corresponds to a given size of capital stock. Economies of scale occur when, if capital increases by k%, and it is optimally utilised, volume increases by more than k%. The existence of economies of density does not imply that economies of scale are available nor vice versa (see Braentigam et al: 1984).

The distinction between these concepts is important because it may be the case that the existing airports, EDI and GLA, have failed to achieve economies of density which can be achieved without capital expense on terminals and runways. On the other hand if no economies of density are available because the current capital is optimally utilised, a replacement airport may still have lower average costs than the weighted average of those of EDI and GLA due to economies of scale.

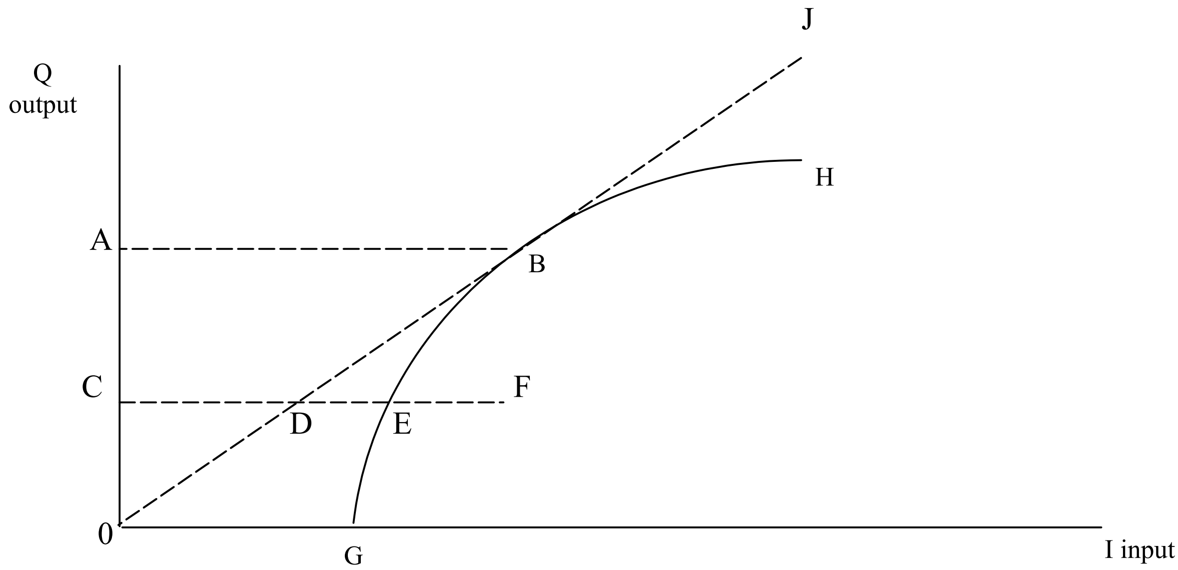
The Efficiency of Airports

In this section we review the empirical literature which presents estimates of the efficiencies of airports. We consider studies which have used three methods: Data Envelopment Analysis (DEA), Stochastic Frontier Analysis and Statistical Cost Analysis.

1. Data Envelopment Analysis

In DEA one estimates a production frontier using a number of linear programming programs. The efficiency of each airport – a decision making unit – is compared with the most efficient airport, and for each airport a returns to scale parameter is also estimated. This is explained in more detail as follows.

Consider Figure 1 which shows a one input one output production frontier, GH.



At point B, average productivity is maximised. An airport operating at F is less efficient relative to E and to B. A measure of the productivity of F relative to that of B is the ratio of average productivities, h_F = (OC/CF)/(OA/AB).

Airports, like many organisations, have multiple outputs and inputs. For a given mix of outputs and of inputs, Banker (1984) has defined the most productive scale size (MPSS) as that at which outputs per unit of inputs are maximised. For a single output - single input production function this is represented by point B in Figure 1. Therefore h_F indicates the efficiency of F relative to the MPSS for that output-input mix. (A different output-input mix may result in a different MPSS). Note that since at the MPSS average productivity is maximised, at B constant returns to scale occur. Notice also that h_F measures both the deviation of F from the production frontier (at E) and the deviation of E from B. The former represents technical efficiency, economies of density in a one output context, and the latter represents economies of scale due to size.

In detail, the Charnes et al. (1978) DEA model is set up as follows. Suppose we have q airports, (a= 1…q), using n inputs, I_j, (j = 1…n), and m outputs, Q_m, m = 1…m. We have data on each output and each input for each airport. For each airport we choose the weights on the outputs and weights on the inputs to maximise the weighted sum of outputs divided by the weighted sum of inputs subject to a constraint that this ratio must be less than or equal to 1 for each airport. This is repeated for each airport. Thus for one airport 0 and m outputs and n inputs:

$$\max_{\alpha,\beta} \frac{\sum_{i=1}^{m} \alpha_i Q_{i0}}{\sum_{j=1}^{n} \beta_j I_{j0}} \qquad \text{s.t.} \quad \sum_{i=1}^{n} \alpha_i Q_{ia} \leq \sum_{j=1}^{n} \beta_j I_{j0}$$

$$a = 1....q$$

$$\alpha_i, \beta_j \geq 0$$

where α_i and β_j are parameters to be estimated. The constraint ensures the maximum efficiency is set at 1. Charnes showed that this fractional programme has an equivalent linear programme formulation. To gain an estimate of h, the linear programme [usually in its dual form] is solved. The linear programme is:

$$\max \sum_{i=1}^{m} \mu_i Q_{io} \qquad \text{s.t.} \quad \sum_{i=1}^{m} \mu_i Q_{ia} \leq \sum_{j=1}^{n} \beta_j I_{ja}$$

$$\sum_{j=1}^{n} \beta_j I_{jo} = 1$$

$$a = 1....q$$

and the dual is

$$\text{Min } h_0 \qquad \text{s.t.} \quad \sum \lambda_a Q_{ia} = Q_{io}$$

$$i = 1....m$$

$$\sum_{j=1}^{n} \lambda_a I_{ja} = h_o I_{jo}$$

The efficiency of Airport o relative to that of the other airports is given by the value of h_o.

Banker (1984) shows that if we define

$$K_o = \sum_{a=1}^{q} \lambda_a$$

then $K_o>1$ implies decreasing returns to scale, and $K_o<1$ implies increasing returns to scale for airport o.

There has been a recent flurry of DEA analyses of airports. The studies differ in degree of technical sophistication and methodology. For example Sarkis (2000) estimates five indices of relative efficiency whereas most studies consider only the Charnes, Cooper, Rhodes (CCR) model (which assumes constant returns to scale – the frontier is OJ in Figure 1) or the Banker, Charnes and Cooper (1984) (BCC model), which assumes variable returns to scale and the frontier is GH in Figure 1). The studies differ in variables representing outputs: most studies include number of passengers and air traffic movements (ATM), and often volumes of cargo. The studies also differ in the variables representing inputs. Most include number of employees, and the numbers of runways, and gates are common.

One common finding is that the relative efficiency of most airports has increased during the 1990s. This is true of airports in the UK, US and Europe. The other findings are peculiar to individual studies.

Gillen and Lall (1997) considered twenty one US airports using data for 1989-93. They use two models, one relating to terminal services and one to movements. The used a tobit model to explore the relationship between the relative efficiency of each airport (estimated by DEA) and structural variables, environmental variables and managerial variables. For movements they found that a greater number of airlines with hubs, an increase in the number of gates, being on a preferential flight path and limiting operating hours all increased efficiency. Alternatively, airside area, having rotational runways, preferential runway use, a limit on stage II aircraft, and a noise budget all reduced efficiency. In terms of terminals, the number of airlines with hubs, terminal area, and number of baggage belts per gate reduced efficiency, whereas a larger number of gates, and a high proportion of international passengers increased efficiency. However this study did not report whether increasing or decreasing returns to scale were detected for terminal services and assumed them away for movements.

A more recent US study by Sarkis (2000) considered 44 US airports for 1990-94. He concluded that 22 of these airports were technically or scale efficient in at least one of the five years and 14 were efficient in all years. Like Gillen and Lall (1997) this study also investigates whether efficiency is associated with particular airport characteristics. He found that airports carrying a hub were more efficient (and then argued that this was leading major carriers to consolidate their operations at major hubs). Second, being part of a multiple airport system, as opposed to a single system, had no effect on efficiency. Third being in a snow belt region reduced efficiency. Again this study omits results which show increasing or decreasing returns to scale. In addition, the data related to relatively large airports and the authors express concern that this may bias the results.

Turning to studies of European airports, Pels et al (2001) considered 34 airports between 1995 and 1997. They found that for passenger movements, six airports had decreasing returns to scale whereas 25 had increasing returns to scale (with three indistinguishable between either). For ATMs none airports had decreasing returns to scale and 25 increasing returns to scale. This suggests that most airports would need to increase scale to reach their mpss. In addition Pels et al found that larger airports are relatively more efficient. However an acknowledged weakness of this study is that no labour input was included. Similar results concerning the proportion of airports with decreasing returns to scale rather than increasing returns to scale were found by Martin and Ranán (2001). They studied 37 Spanish airports in 1997 to find 9 out of 29 had decreasing returns to scale but 20 had increasing returns to scale. Those with decreasing returns were found to serve medium sized cities. These are the only two studies which indicate the proportion of airports with decreasing returns and increasing returns. Unfortunately, like all DEA studies, the technique does not yield estimates of likely costs.

Finally, Parker (1999) studied BAA airports and 22 independents for the years 1979/80 to 1995/6. He found that there were 41 relatively efficient airports (each airport year was treated as a separate observation) and 152 inefficient airport-years. In particular, the technical efficiency of Glasgow remained high from 1980/1 to 1996/7. Edinburgh's efficiency increased 1988/89 to 1990/1 then remained low until 1995/6. By 1996/7 Glasgow and Edinburgh were two of the five most efficient airports in the sample. Notice however that this study estimates technical efficiency not scale efficiency. In terms of Figure 1 it measures, for each airport, OC/CF relative to OC/CE not relative to OA/AB. Glasgow and Edinburgh could be below their mpss, i.e. too small to have constant returns to scale.

2. Stochastic Frontier Analysis

With this approach a production frontier is estimated using a parametric econometric model. Consider Figure 1. If the production function is GH for a one input one output process then all observed output-input combinations must lie either on the function or below it. If OLS is used to estimate the frontier we will estimate a line below the function. With stochastic frontier analysis the parameters are estimated with an error term which is censored. The difference between the observed and predicted output can be due to firstly, random error and secondly, inefficiency. Both errors are explicitly incorporated into the estimated function. The model to be estimated and which was proposed by Aigner, Lovell and Schmidt (1977), is therefore,

$$Q_a = f\left(I_a, e^T\right)e^{\varepsilon_a} \quad \varepsilon_a = (v_a - u_a(z_a))$$

$$v_a \sim N\left(0, \sigma_v^2\right) \qquad u_a \sim N\left(d_a, \sigma_u^2\right) \qquad d_a = z\delta$$

where T = state of technology
Q_a, I_a are as above
v is the usual stochastic error and is independent of u
u is the deviation from the frontier and is non negative, i.e. censored at zero
z is a vector of variables which are not inputs, and which explain u
δ is a vector of coefficients to be estimated

Aigner et al derived the density function for the absolute value of u and, from this, the likelihood function for estimating the model parameters.

Pels (2000) estimated stochastic frontiers for ATMs and air passenger movements (APMs). A flexible functional form (the translog - see below) was adopted. The state of technology was taken as the number of runways and treated as a fixed factor. The inputs to the ATM model were: the surface area of the airport, the number of remote aircraft parking positions and the number of parking positions at the terminal. The inputs to the APM model were the number of baggage claims and the number of check-in desks. They found that having coordinated slots and limited hours of operations reduced inefficiency in terms of ATMs. For the APM model, high load factors and limited hours of operation are associated with less inefficiency. Calculation of a returns to scale parameter suggested the average airport has constant returns to scale for ATMs but increasing returns for APMs. In addition, he found scale elasticity to be strongly negatively correlated with increasing returns: small airports have stronger increasing returns to scale than larger airports.

Notice however that, unlike DEA which is non parametric, stochastic frontier analysis does assume a particular parameterised distribution for the error terms. The associated distributions may not be appropriate and so may result in biased estimates. Furthermore a specific functional form must be assumed for the production function, although in the case of Pels a flexible form was estimated. A further difficulty with both of the above methods is that they establish relative efficiency. Neither gives estimates of costs. The latter technique just estimates the production function and explanations of deviations from it. Prices would need to be applied to the inputs to yield cost figures and this was not done in the Pels op cit. study.

3. Statistical Cost Analysis

With statistical cost analysis a stochastic model relating costs to explanatory variables is estimated. One of the earliest studies relating to airports, by Keeler (1970), used pooled time series-cross section data for US airports for 1965-67. Keeler used OLS to estimate two separate models: one for capital costs, the other for operating costs. As explanatory variables he used ATMs and general aviation. He found constant returns to scale. Doganis (1973, 74, 78) used UK data and also parameterised models for capital and operating costs separately. His output measure was workload units, a composite measure of the number of passengers plus the weight of cargo in units of 200lbs. Doganis and Thompson (1974) estimated cost curves for 18 UK airports for 1969-70. To remove the effects of certain confounding factors they artificially increased the costs of those airports without a recent development programme, and those which did not provide air traffic control, because both factors raised costs. Their resulting equation was

Log (average costs) = 2.444 - 0.366 log [WLU]

$R^2 = 0.768$

This equation indicates thet most economies of scale were gained once an output rate of 1 million WLU/year was reached. If no adjustments were made, economies of scale were almost entirely incorporated by 3M WLU/year.

These studies are open to criticism. Tolofari et al. (1990) argued that all studies which separately estimate an operating costs model and a capital costs model would result in biased parameter estimates because the error terms are likely to be correlated and the separate estimation of the equations fails to adequately model this. A simultaneous equation approach which incorporates this correlation is required. Second, the models in the above papers assume a Cobb-Douglas functional form which assumes elasticity of substitution between inputs equal to 1. Such a restriction may result in biased parameter estimates if it is not appropriate. Thirdly, both studies are subject to Friedman's (1955) regression fallacy. Essentially, airports do not constantly adjust runway and terminal capacity to be optimal for their APM and ATM. If smaller airports operate their runways and terminals below capacity (defined as the output where SAC = LAC), and if large airports operate close to or above capacity, then the estimated cost curve may suggest economies (and possibly diseconomies of scale) when in fact none or at least fewer, exist (see Reekie and Crook 1994). Doganis and Thompson (1994) tried to adjust for this but explicitly state they may not have done so adequately. Fourthly, a common problem of many statistical cost analyses (Reekie and Crook op. cit.) is the inaccuracy with which output and the costs they gave rise to, coincide. In the case of airports, phased capital expenditure may mean that in any one year costs are higher or lower than the correct figure. Tolofari et al. (1990) found evidence this was true of UK airports. Fifthly, one may expect that the variance of costs is correlated with airport size: heteroscedasticity. There is no evidence that Doganis Thompson tested for this.

However the Tolofari et al. (1990) study did accommodate many of these criticisms. They use pooled cross section-time series data for seven BAA Airports for 1979-87 to model a short run total cost (STC) function with fixed capital stock. Then, at the mean values of all variables except capital, capital costs (a function of the amount of capital) are added to total variable costs to derive short run total costs for each airport. For each airport the value of capital which minimises short run total costs is calculated and substituted into the short run total variable costs (STVC) function. A constant which represents the cost of capital is included to give long run total costs.

To allow for a flexible functional form rather than the Cobb-Douglas form of Doganis, Tolofari et al. adopt the translog function of Christensen, Jorgensen and Lau (1973). The translog function has the form:

$$STVC = \sum_{v=1}^{p} \alpha_{v0} X_v + 0.5 \sum_{v=1}^{p} \sum_{u=1}^{p} \alpha_{vu} X_v X_u$$

where X_j = ln (variable$_j$/average of observations for variable j).

In Tolofari et al. (1990), the X variables are output (WLU), the input prices of labour, equipment, and residual factors, capital stock, pax per ATM, percentage of international passengers, percentage of terminal capacity used and a time trend. Economic theory requires certain constraints are applied. For example one may deduce cost share equations and the implied cost share of the three 'inputs' must sum to one. Thus the model is estimated jointly with two sector share equations. Tolofari used Zellner's (1962) SURE estimators.

Tolofari et al. give the parameters of both a STVC function and a long run total cost function. They find that, for the mean airport, i.e. at the mean values of all of the variables used, economies of scale exist but "would be exhausted when output is 2.783 times its mean level" which would occur at 20.3 mppa WLUs.

It would have been desirable to use the parameters from this study to estimate STVC and LAC values for Edinburgh, Glasgow and the proposed new airport. However Tolofari's LTC equation incorporates the constant (which depends on the optimal amount of capital) for the mean sized airport and the optimal capital for each individual airport must be estimated to predict from their equation. This is regrettable because it is the most sophisticated study of airport costs which has been published. However, they do give estimates of SAVC and LAC for Glasgow, Edinburgh, Prestwick and Aberdeen for each of their twelve years of study. For 1986/7, the most recent, these figures are shown in Table 2.

Table 2: Average costs in 1986 at 1986 prices

	SAVC (£/WLU)	LAC (£/WCU)
Edinburgh	4.72	7.91
Glasgow	4.74	5.61
Prestwick	19.17	85.72
Aberdeen	4.66	6.45

from Tolofari et al. Tables 22 and 25A

By 2003 inflation would have increased these costs. In addition changed relative prices of labour and capital may have resulted in factor substitution and also technical progress will have occurred resulting in improved productivity. It is therefore difficult to use these figures for the new airport.

Analysis using CRI and TRL data

Almost all of the variables in Tolofari et al.'s translog function were statistically significant. This indicates that the level of SAVC and LAC at any given WLU will shift up or down as the input prices of labour, equipment and other factors, as well as time and the percentage of international passengers and capital stock changes. But no up to date estimates of costs are available for any given combination of values of these variables. However, we do have two data sets which we have used to explore the possible existence of economies of scale between airports at different sizes, especially between 16 million pax to 40 million pax.

(i) Centre for Regulated Industries (CRI) Dataset.

The CRI (at Bath University) statistics are available from 1988-89 annually, and give details of passengers and cargo carried, costs, revenues, profits, assets and numbers employed. The data are available for around 27 UK-only airports. We have analysed operating costs and long run costs. We have considered two definitions of operating costs: one including depreciation and one excluding depreciation; and two measures of output: WLU and number of passengers (pax). In all four cases we have estimated an unrestricted Cobb-Douglas cost function cross-sectionally for 2000-2001 using simple OLS. This takes the form:

$$TOC_i = \alpha_j \prod_{j=1}^{5} X_{ji}^{\beta_j} \quad \Rightarrow \quad AOC_i = \alpha_j \prod_{j=1}^{4} X_{ji}^{\beta_j} .\text{output}_i^{\beta_5 - 1}$$

where TOC_i = total operating costs for airport i;
X_{ji} = explanatory variable j for airport i;
α,β_j = parameters to be estimated

The explanatory variables were WLU or pax, price of staff, price of other costs, passengers divided by air transport movements, the percentage of passengers classified as international and total assets. The price of staff was estimated by dividing staff costs by numbers employed. Prices of 'other costs' were estimated as expenditure on other costs divided by the value of tangible assets (see Tolofari op. cit.).

We adopted a Cobb-Douglas form because we did not have enough degrees of freedom for a full translog function. Essentially we have estimated a translog in first order terms only. The input prices affect operating costs directly, but also by causing possible factor substitution. More passengers per air traffic movement would be expected to reduce average operating costs by enabling a more intensive use of resources, whereas international passengers are more costly to process than domestic passengers and so would increase operating costs (Doganis: 1974 and Tolofari op cit). For equations relating to WLU as the output measure, no data was available for Bristol, and Highlands and Islands Airportwas omitted because there was no data on the percentage of passengers who were international. The WLU equations were therefore estimated for 25 airports and the pax equations for 26 airports.

Operating costs are a short run concept. As such they will vary with the volume of fixed inputs. The fixed input was total assets (terminals, runways etc). However, when estimating the costs of a new airport, operating costs often have depreciation included. We have therefore considered such a definition.

The results showed that the significance of the individual variables, and the magnitude of the coefficients (which are elasticities of total costs with respect to the variable) differed considerably according to whether we included or excluded capital stock. This was because WLU and pax are highly correlated with capital stock.

We have represented our results by plots of observed and predicted average operating costs against WLU (Figures 1 and 2) and Pax (Figures 3 and 4). Figures 1 and 3 exclude depreciation, Figures 2 and 4 include it. In all cases capital stock is included. (Because of their extreme values the results for London Biggin Hill and Southend are not included in the Figures, but are in the analysis).

The Figures give a visual indication of how well the models fit the data (the R^2 values are between 0.928 and 0.927). At each observed level of output the predicted values show the predicted cost of an airport operated at that output, given the prices of staff and other costs it faced, the percentage of international passengers it catered for and the passengers per air traffic movement which used it. The predicted values therefore occur at different values of these variables. They do not show the value of average operating cost if all other variables except output were held constant. This is useful because the values of the explanatory variables may well be related to output, and to hold them all fixed to estimate costs at each output would probably give a poorer prediction of the likely costs at that output.

The models show very similar results: a steep decrease in average operating costs until around 5 million WLU or 4 million Pax and then very mild, but persistent decreases in costs until at least 64 million Pax, or 80 million WLU. The exclusion of capital stock from the equations makes virtually no difference to these patterns.

We also estimated a *long run* total cost function (LTC) where LTC was defined as operating costs plus staff costs plus depreciation plus 8% of total fixed assets (an 8% opportunity cost of funds was used by Parker (1999)).

Figures 5 and 6 show plots for WLU and pax respectively, of observed and predicted values of long run average total costs derived from the corresponding estimated LTC equations. The LTC equations (with $R^2 = 0.935$) fitted the data marginally better than the total operating costs curves. Again predicted LAC decreases sharply until around 4 million Pax, 5 million WLU and continues to decrease until at least 64 million Pax, 80 million WLU. Of course, these results are merely suggestive of the theoretical LAC curve because we have not allowed for airports operating above the LAC. Further research is required to clarify this issue.

Figures 7 and 8 show observed LAC and predicted LAC where the latter are predicted for the means of all variables (except output) for the cases which were used in the estimation. Again Southend and London Biggin Hill were omitted so as not to distort the Figures. In both Figures the predicted values differ considerably from the observed values at very low outputs. Part of these differences are due to the explanatory variables - prices, percentage of international passengers - varying with output: they do not apply at all output rates, only at the means. However the predicted curves are similar to the observed values from around 15 million WLU and 12 million Pax and above. Both curves predict slowly declining LAC. The predicted values for airports in the sample at the larger Pax values are:

Pax (millions)	**Airport**	**Predicted LAC using 8% of cost of capital (£ per passenger)**
19.11	Manchester	15.60
32.24	Gatwick	15.29
64.67	Heathrow	14.88

(ii) TRL Dataset

The Transport Research Laboratory (TRL) has assembled data on 44 airports and airport groups from throughout the world(1). The data cover much the same variables as the CRI data. However, the TRL data has the advantage that non-core activities have been removed. We obtained data for the years ending 1 July 1998 - 30 June 1999, 1 July 1999 - 30 June 2000 and 1 July 2000-30 June 2001. Not every year is available for every airport. We have deleted airport Groups and Hong Kong, which was a clear outlier. Again we estimated Cobb Douglas cost functions. All data was inflated to be at year 2000 prices and all currencies were converted to units of SDRs using IMF conversion rates.

When we model the short run total costs, converted to average costs, the estimated equation was:

$$\log STC = 0.307 + 0.06307 \log WLU + 0.05506 \log P_L + 0.573 \log P_o$$

$$+ 0.326 \log P_D + 0.985 \log TA - 0.175 \log PATM + 0.004052 \log INT.$$

$R^2 = 0.969$ $F_{7,53} = 237.85$ (significance = 0.000)
where P_L is the imputed price of staff, P_o that of operating costs, P_D that of equipment (i.e. depreciation), TA is total assets, PATM is passengers per air traffic movement, and INT is the percentage of passengers who were international. With an R^2 of 0.969 the model fitted the data well.

The long run average cost data (LAC) is short run total cost plus capital costs at an assumed 8%, divided by WLU. Again a negative relationship is apparent in the raw data and the equation fitted well. The estimated equation was:

$$\log(LRTC) = -4.001 + 0.759 \log WLU - 0.03416 \log P_L + 0.06822 \log P_O + 0.169 \log P_D$$

$$+ 0.887 \log PATM + 0.0183 \log INT$$

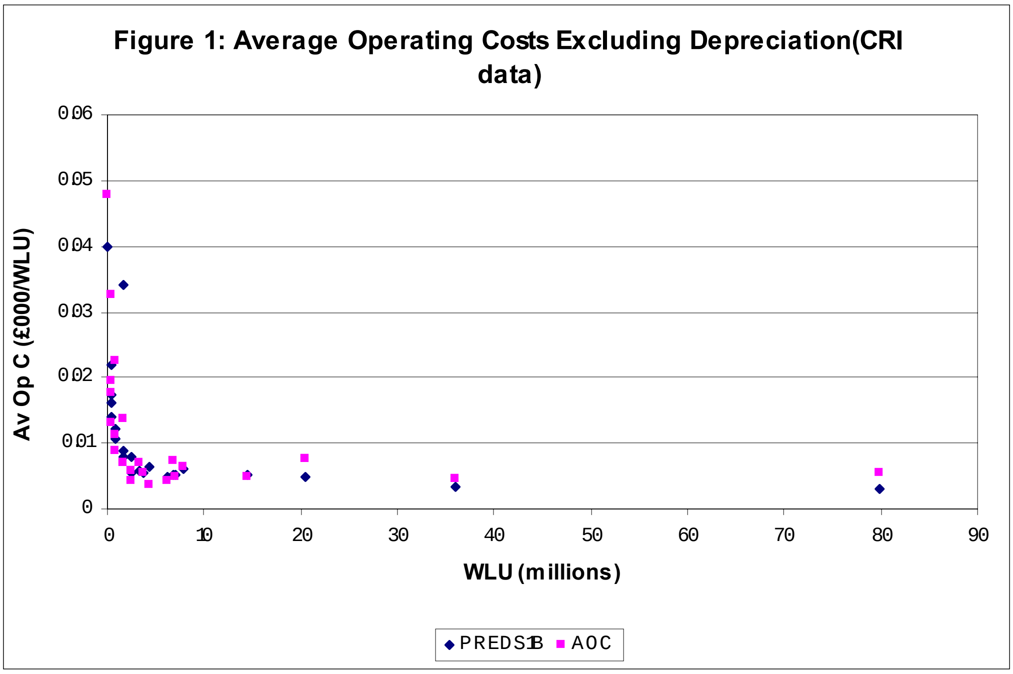
$R^2 = 0.799$ $F_{6,54} = 35.878$ (significance=0.000)

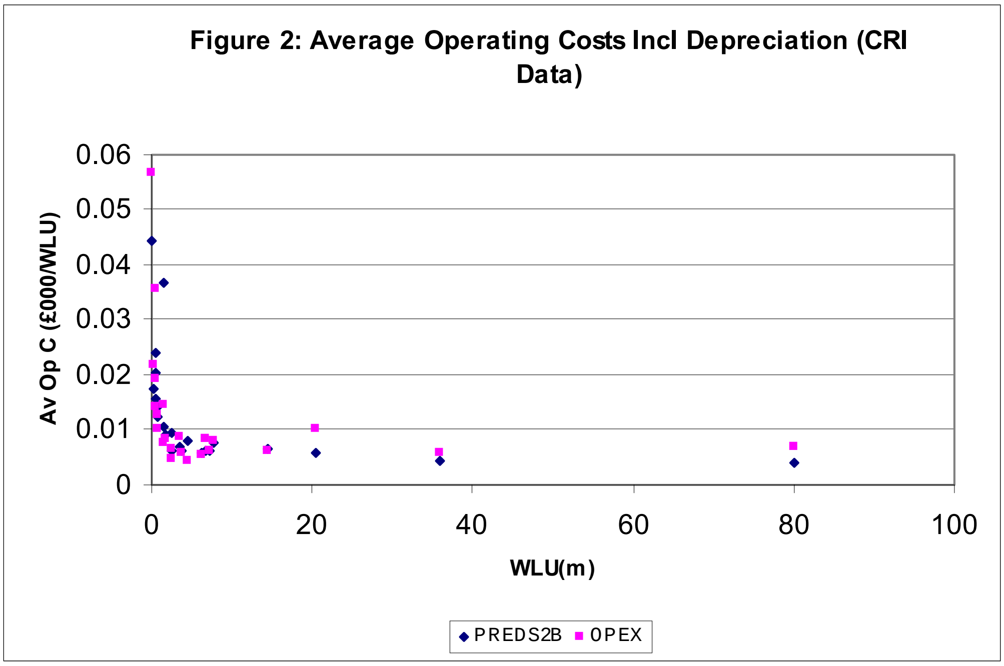
The fit is poorer than for the short run data. However, when we plot the predicted LAC values against WLU at the *mean values* of the other explanatory variables a clear declining curve is derived, as is shown in Figure 9. In this Figure we have plotted a value for all airports for which we have WLU data (including many which were not used to estimate the equation because some of the explanatory variables had missing values). This suggests there are clear economies of scale right up to 90 million WLU. The predicted average costs of Edinburgh and of Glasgow are indicated in the Figure by the letters ‘E’ and ‘G’ respectively. The predicted average costs of a new airport with 30 million WLU per year is indicated by the letter ‘N’. The difference between an airport operating at around 7.127 million WLU (the output of Glasgow in 2000-2001) and 30 million WLU is 31.69% of its 7.127 million WLU figure (from SDR11.33 to SDR7.74). Between 7.127 million WLU and 70 million WLU it is 44.31% of its 7.127 million WLU value (from SDR11.33 to SDR6.31). Of course further research is needed. We have assumed all airports operate with the optimal amount of capital with no economies of density available. This is unlikely to be true and so the true LAC curve may be lower than the estimated curve.

Notes

(1) We are grateful to P McKenzie Williams for allowing us to use this dataset. All errors in its use are our responsibility.

Appendix B Figures





Appendix B Figures

Figure 3: Average Operating Costs (Excl Depreciation) CRI Data

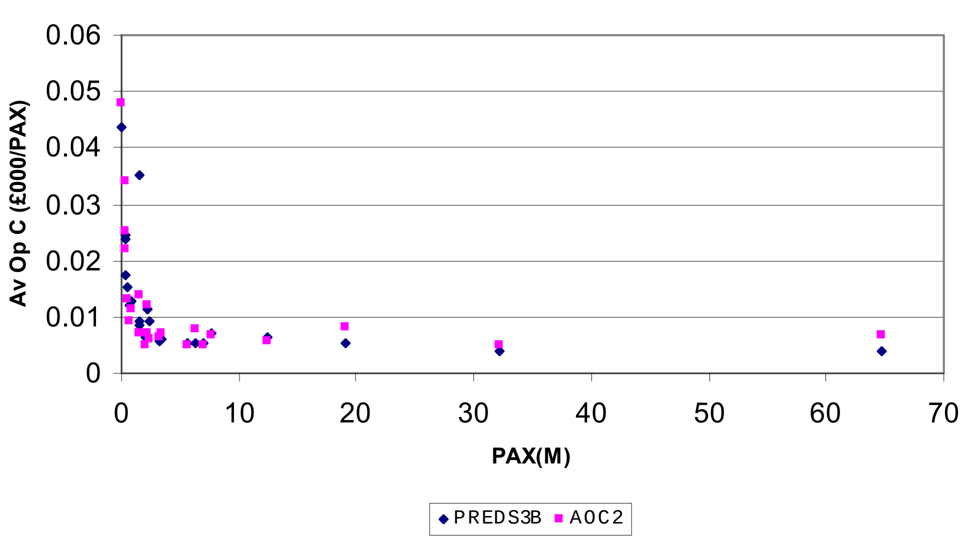
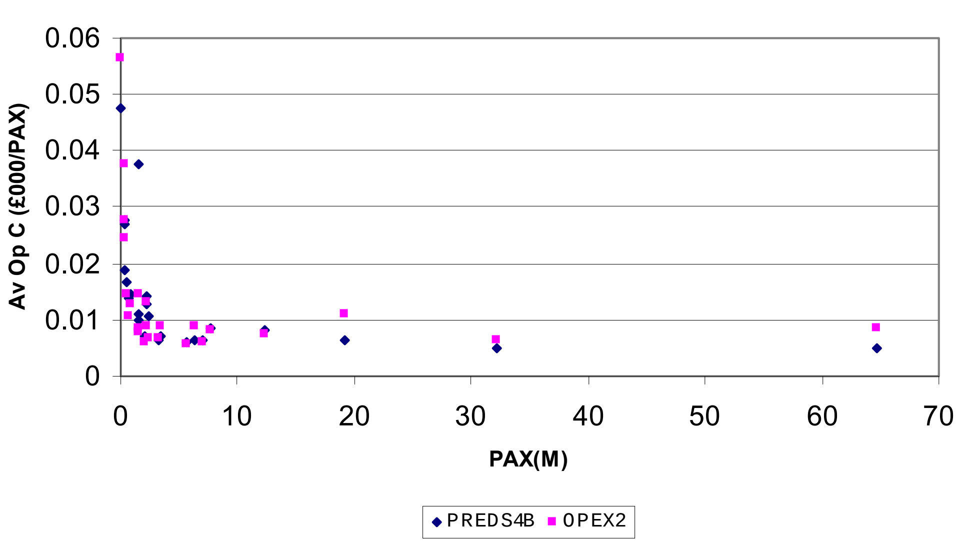


Figure 4:Average Operating Cost (including Depreciation)CRI Data



Appendix B Figures

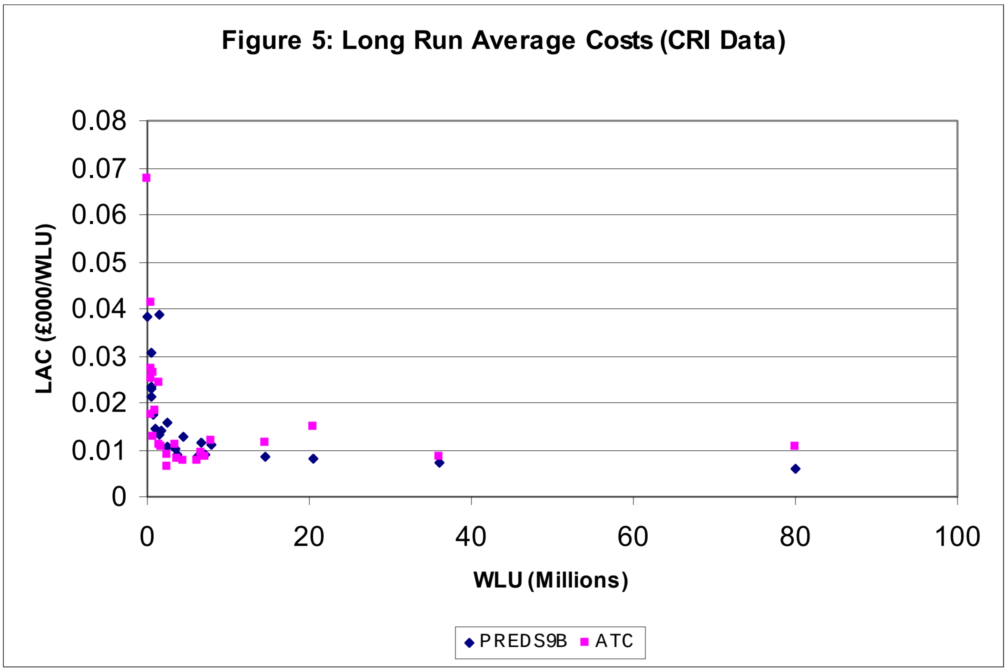


Figure 5: Long Run Average Costs (CRI Data)

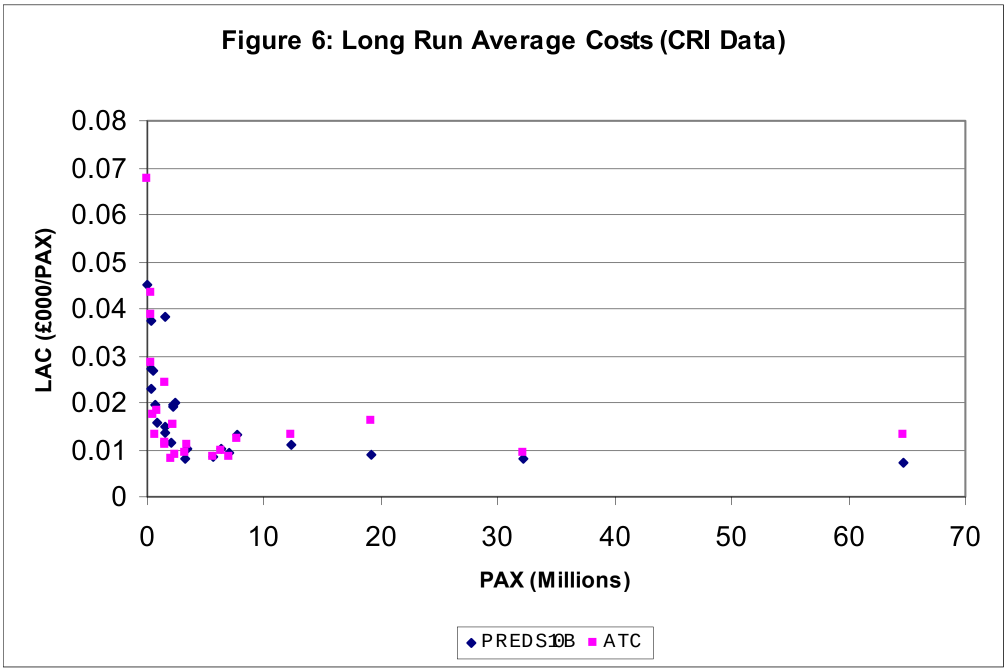


Figure 6: Long Run Average Costs (CRI Data)

Appendix B Figures

Figure 7: Predicted Long Run Average Costs (at means) (CRI Data)

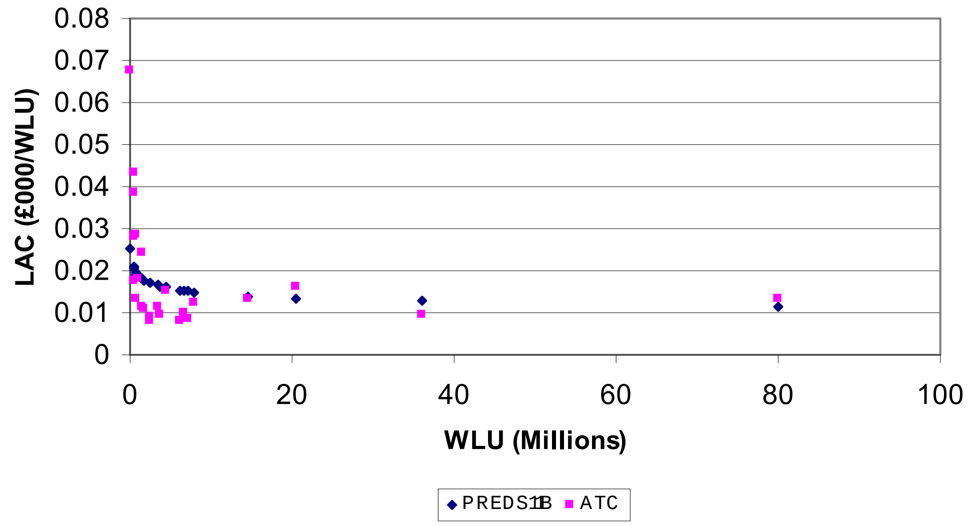
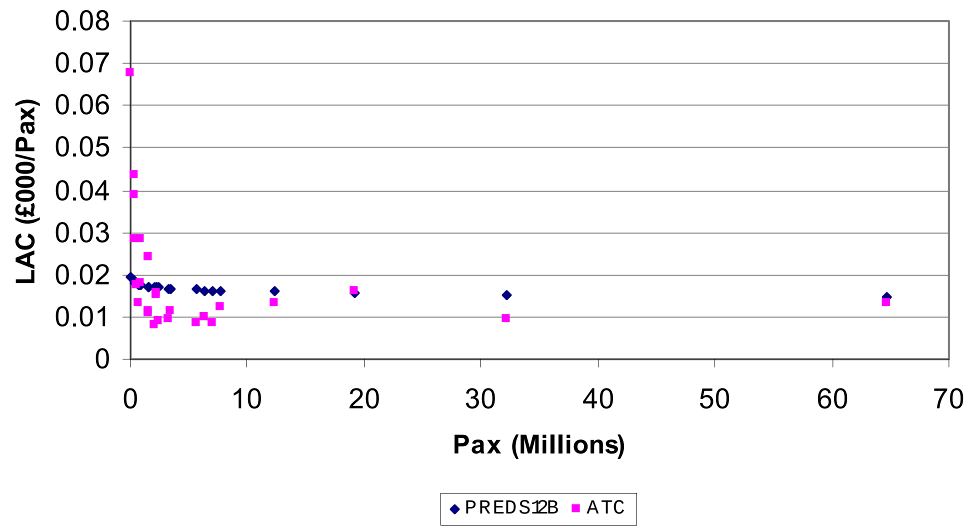


Figure 8: Predicted Long Run Average Costs (at means) (CRI Data)



Appendix B Figures

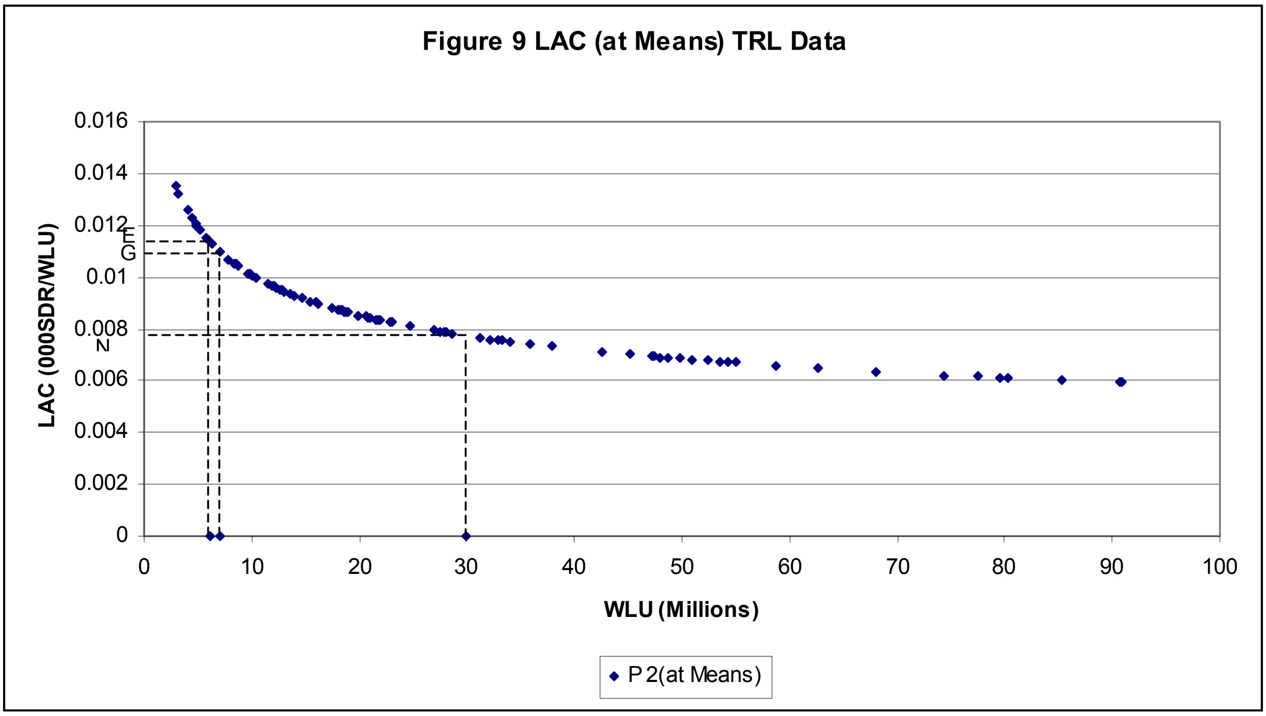


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Table 1

Distance from City Centre of some well known airports (past and present)

A. By date open

Airport	Date Open	Distance from City Centre (km)
Atlanta Hartsfield	1925	14.5
Honk Kong Kai Tak	1929	4.8
Denver Stapleton	1929	11.3
Vancouver International	1930	11.3
Los Angeles Int'l LAX	1930	32.3
Frankfurt Rhein/Main	1936	8.1
Toronto Int'l Malton	1937	27.3
Munich Riem	1939	11.3
New York La Guardia	1939	12.9
London Heathrow	1946	24.2
New York JFK	1948	24.2
Chicago O'Hare	1955	24.2
Paris Orly	1961	14.5
Washington Dulles	1962	43.5
Kansas City	1963	27.4
Houston Intercontinental	1969	27.4
Paris Charles de Gaulle	1974	19.4
Dallas Fort Worth	1974	27.4
Montreal Mirabel	1975	64.5
Tokyo Narita	1978	66.1
Munich Franz Josef Strauss	1992	25.8
Osaka Kansai	1994	6.0
Denver Int'l	1995	38.7
Hong Kong CLK Airport	1997	24.2
Kuala Lumpar Sepang Int'l	1998	66.1
Bangkok Nong Kgu Hao Int'l	2000	30.0
Seoul Yongjong Int'l	2000	52.0

B. By distance from city centre

Airport	Date Open	Distance from City Centre (km)
Honk Kong Kai Tak	1929	4.8
Osaka Kansai	1994	6.0
Frankfurt Rhein/Main	1936	8.1
Denver Stapleton	1929	11.3
Vancouver International	1930	11.3
Munich Riem	1939	11.3
New York La Guardia	1939	12.9
Atlanta Hartsfield	1925	14.5
Paris Orly	1961	14.5
Paris Charles de Gaulle	1974	19.4
London Heathrow	1946	24.2
New York JFK	1948	24.2
Chicago O'Hare	1955	24.2
Hong Kong CLK Airport	1997	24.2
Munich Franz Josef Strauss	1992	25.8
Toronto Int'l Malton	1937	27.3
Kansas City	1963	27.4
Houston Intercontinental	1969	27.4
Dallas Fort Worth	1974	27.4
Bangkok Nong Kgu Hao Int'l	2000	30.0
Los Angeles Int'l LAX	1930	32.3
Denver Int'l	1995	38.7
Washington Dulles	1962	43.5
Seoul Yongjong Int'l	2000	52.0
Montreal Mirabel	1975	64.5
Tokyo Narita	1978	66.1
Kuala Lumpar Sepang Int'l	1998	66.1

Source: Dempsey et al. (1997) p232 Table 6-1.
Note: 1 km = 0.62miles; 8km = 5miles (approximately).

Table 2

Occupational Distribution of Jobs at Airports

	Glasgow/Edinburgh	Manchester
Professional, crew	26%	29%
Clerical, sales	23%	32%
Skilled manual	11%	14%
Semi and unskilled	39%	30%

Table 3

Proportion of workers retaining employment after relocation

	Retained	Lost jobs
Professional, managerial	78%	22%
Clerical	65%	35%
Skilled manual	51%	49%
Semi and unskilled	39%	61%

(Houston, 2002, p.257)

Table 4

Direct employment by LEC area

	Glasgow	Edinburgh
Renfrewshire	2,965	-
Glasgow	648	-
Ayrshire	538	-
Lanarkshire	370	-
Dunbartonshire	343	-
Forth Valley	55	104
Edinburgh, Lothian	73	1854
Fife	22	220
Other	20	46
	5,033	2,2225

Source: Fraser of Allander

Table 5

New Labour Force at Central Scotland Airport

Workers from existing airports	3,120	34.4%
Jobs to be filled after relocation	4,140	45.6%
Additional recruitment 2002-2020	1,820	20.0%
Total employment	9,080	

Table 6

Indirect Employment Related to Airports

	Glasgow Airport	Edinburgh Airport
Renfrewshire	510	232
Glasgow	1,828	848
Ayrshire	551	255
Lanarkshire	996	462
Dunbartonshire	306	142
Forth Valley	503	233
Edinburgh, Lothian	2,010	933
Fife	573	266
Dumfries, Galloway	267	124
Tayside	792	367
Other	2,342	1,091
Total	10,679	4,954

(Fraser of Allander, 2000)

Table 7

Central Scotland Airport Costs as estimated by BAA

Item/ Category:	**Airth £m**	**Slammanan £m**
PHASE I *(to 30mppa)*		
Terminal and satellite	400	400
Transit system	450	450
Aircraft pavements	500	500
Utilities, Drainage, Airside roads	80	80
Earthworks, demolitions etc.	1000	950
Ancillary facilities, Cargo, Maintenance etc.	540	540
Air traffic control facilities	50	50
On costs at 20%	604	595
Risk Allowance at 25%	906	890
Sub Total	*4530*	*4455*
Rail connection	65	55
Motorway Spur	95	65
On costs at 20%	32	24
Risk Allowance at 25%	48	36
Sub Total	*240*	*180*
Mitigation, Noise, Ecological, Staff etc.	100	100
TOTAL PHASE I	**4870**	**4735**
PHASE II *(to 60mppa)*		
Terminal and satellite	400	400
Transit system	450	450
Aircraft pavements	300	300
Utilities, Drainage, Airside roads	65	65
Ancillary facilities, Cargo, Maintenance etc.	500	500
On costs at 20%	340	340
Risk Allowance at 25%	515	515
TOTAL PHASE II	**2570**	**2570**
GRAND TOTAL	**7440**	**7305**

Source: BAA supplied figures 18-12-02

Table 8

Independent Engineer's Costings of Central Scotland Airport – SUMMARY					
		Airth	Airth	Slammanan	Slammanan
		No Risk Factor	With Risk Factor	No Risk Factor	With Risk Factor
		£(m)	£(m)	£(m)	£(m)
Phase 1 - 40 mppa (2021)	Airport Costs	3096.08	3715.30	3527.73	4233.28
	Non-Airport Costs	178.39	214.07	178.39	214.07
Phase 2 - 18 mppa (2030)	Airport Costs	977.82	1173.39	1079.53	1295.44
	Non-Airport Costs	80.28	96.33	80.28	96.33
Phase 3 - 12 mppa (2038)	Airport Costs	784.56	941.48	856.22	1027.46
	Non-Airport Costs	54.21	65.05	54.21	65.05
TOTAL - 70 mppa	Airport Costs	4858.47	5830.16	5463.48	6556.18
	Total Non-Airport Costs	312.88	375.45	312.88	375.45
	Total Airport Costs	4858.47	5830.16	5463.48	6556.18

Table 9

Independent Engineer's Costings of Central Scotland Airport			
	Airth		**Slammanan**
Phase 1 - 40 mppa	**£(m)**		**£(m)**
Terminal & Satellites	655.75		655.75
Pavements	248.60		248.60
Utility Services	129.50		129.50
Roads within Airport	19.00		19.00
Airside Rail/Tracked Transit/People Mover	220.00		220.00
Enabling Works	374.00		700.09
Drainage	38.85		33.87
Landscaping	51.81		51.81
Air Traffic Control	60.00		60.00
Instrument Landing System	8.00		8.00
Aircraft Ground Lighting (AGL)	3.75		3.75
Petroleum Oil Line (POL)	27.00		27.00
Fire Crash Rescue (FCR)	20.00		20.00
Emergency Services Facilities	4.50		4.50
On site Car parking	104.26		104.26
Land Acquisition and Property	41.28		37.45
Public Highway Works	17.50		48.00
Rail Connections	130.00		82.50
Sub-Total	2153.80		2454.07
Construction Cost Contingency (15 %)	323.07		368.11
On-costs (25%)	619.22		705.55
Phase 1 TOTAL ESTIMATED AIRPORT CONSTRUCTION COST AT 3Q 2000 £m	**3096.08**		**3527.73**
Cargo	23.40		23.40
Maintenance	25.20		25.20
Support	75.50		75.50
Sub-Total	124.10		124.10
Construction Cost Contingency (15 %)	18.62		18.62
On-costs (25%)	35.68		35.68
Phase 1 TOTAL ESTIMATED NON-AIRPORT CONSTRUCTION COST AT 3Q 2000 £m	178.39		178.39
Phase 2 - 18 mppa	**£(m)**		**£(m)**
Terminal & Satellites	251.30		251.30
Pavements	14.19		14.19
Utility Services	27.75		27.75

Roads within Airport	2.50		2.50
Airside Rail/Tracked Transit/People Mover	152.50		152.50
Enabling Works	65.00		141.75
Drainage	5.02		5.02
Landscaping	10.69		10.69
Air Traffic Control	0.00		0.00
Petroleum Oil Line (POL)	1.50		1.50
On site Car parking	46.28		46.28
Public Highway Works	6.00		0.00
Rail Connections	97.50		97.50
Sub-Total	680.22		750.98
Construction Cost Contingency (15 %)	102.03		112.65
On-costs (25%)	195.56		215.91
Phase 2 TOTAL ESTIMATED AIRPORT CONSTRUCTION COST AT 3Q 2000 £m	**977.82**		**1079.53**
Cargo	10.53		10.53
Maintenance	11.34		11.34
Support	33.98		33.98
Sub-Total	55.85		55.85
Construction Cost Contingency (15 %)	8.38		8.38
On-costs (25%)	16.06		16.06
Phase 2 TOTAL ESTIMATED NON-AIRPORT CONSTRUCTION COST AT 3Q 2000 £m	80.28		80.28
Phase 3 - 12 mppa	£(m)		£(m)
Terminal & Satellites	231.70		231.70
Pavements	74.14		74.14
Utility Services	27.75		27.75
Roads within Airport	0.30		0.30
Airside Rail/Tracked Transit/People Mover	110.50		110.50
Enabling Works	43.00		94.00
Drainage	10.00		8.84
Landscaping	10.69		10.69
Instrument Landing System	4.00		4.00
Aircraft Ground Lighting (AGL)	0.75		0.75
Petroleum Oil Line (POL)	1.50		1.50
On site Car parking	31.46		31.46
Sub-Total	545.78		595.63
Construction Cost Contingency (15 %)	81.87		89.34
On-costs (25%)	156.91		171.24
Phase 3 TOTAL ESTIMATED AIRPORT CONSTRUCTION COST AT 3Q 2000 £m	**784.56**		**856.22**
Cargo	7.50		7.50
Maintenance	7.56		7.56
Support	22.65		22.65
Sub-Total	37.71		37.71
Construction Cost Contingency (15 %)	5.66		5.66

On-costs (25%)	10.84		10.84
Phase 3 TOTAL ESTIMATED NON-AIRPORT CONSTRUCTION COST AT 3Q 2000 £m	54.21		54.21
Overall Total – all costs	5171.35		5732.99
Overall Total – all costs including risk allowance at 20%	6205.62		6879.59
Overall Total – all Airport costs	4858.47		5463.48
Overall Total – all Airport costs including risk allowance at 20%	5830.16		6556.18

Table 10

DfT Estimates of Costs and Benefits of Airport Options in the South East
(Present value discounted at 6 per cent in real terms)

Package	Package Description	Gross benefit (£b)	Costs	Benefit Cost Ratio (BCR)
1	Max use existing runways	6.7	1.8	3.7
2	Heathrow- 1 new runway	12.0	4.2	2.9
3	Stanstead- 1 new runway	11.0	3.9	2.8
4	Stanstead- 2 new runways	14.0	4.6	3.0
5	Heathrow and Stanstead- 1 new runway each	17.8	5.5	3.2
6	Stanstead- 3 new runways	17.8	5.2	3.4
7	Heathrow +1 and Stanstead +2 runways	20.9	6.2	3.4
8	Cliffe- 4 runways	17.3	8.9	1.9

Source: 'The Future Development of Air Transport in The United Kingdom: South East (DfT) Table 14.6 p107

Table 11

DfT Estimates of Costs and Benefits of Airport Options in the Midlands
(Present value discounted at 6 per cent in real terms)

Package	Package Description	Gross benefit (£b)	Costs (£b)	Benefit Cost Ratio (BCR)
1	new Close-spaced at Birmingham in 2016 and new Wide spaced at East Midland in 2027	1.132	0.598	1.9
2	new Wide-spaced at Birmingham in 2016 and new Wide spaced at East Midland in 2027	2.239	0.794	2.8
3	New 3-runway Midlands airport, close Birmingham and Coventry airports 2016	5.261	3.363	1.6
4	New 3-runway Midlands airport, close Birmingham and Coventry airports 2021	4.653	2.56	1.8

Under SE Constrained scenario.

Source: 'The Future Development of Air Transport in The United Kingdom: Midlands (DfT) p 146,147,150 and RAS 3:Midlands Main Report Table 5.3a p 30

Table 12

DfT Estimates of Costs and Benefits of Airport Options in Scotland (Present value discounted at 6 per cent in real terms)

Package Number	Package Description	Gross benefit (£m)	Costs (£m)	Benefit-Cost-Ratio (BCR)
1	Max Use existing facilities 2029	219.0	273.8	0.8
2 early	EDI Cross wind 2013	105.0	131.3	0.8
3 early	EDI Close Parallel 2013	260.0	433.3	0.6
4 early	EDI Wide Spaced 2013	260.0	433.3	0.6
5 early	GLA Crosswind 2023	81.0	202.5	0.4
6 early	GLA Close Parallel 2023	81.0	135.0	0.6
7/7a early	EDI Phased Development	260.0	325.0	0.8
2 late	EDI Cross wind 2023	188.0	94.0	2.0
3 late	EDI Close Parallel 2023	717.0	298.8	2.4
4 late	EDI Wide Spaced 2023	717.0	298.8	2.4
5 late	GLA Crosswind 2029	419.0	380.9	1.1
6 late	GLA Close Parallel 2029	419.0	349.2	1.2
7/7a late	EDI Phased Development 2023	717.0	256.1	2.8

Source: 'The Future Development of Air Transport in The United Kingdom: Scotland (DfT) Table 7.10 p196

Table 13

DfT Estimates of Costs and Benefits of Airport Options in Scotland
(Present value discounted at 6 per cent in real terms)

Package	Package Description	Gross benefit (£b)	Costs (£b)	Net benefits (£b)	Benefit Cost Ratio (BCR)
1	Test Comparator of Additional Runway (Widely Separated) at Edinburgh in 2013 and Glasgow limited to current runway capacity.	1.660	0.566	1.094	2.93

Source: Supplied as comparator case by Department for Transport. Uses identical SCAB software and assumptions (SE constrained) as deployed in following table for the analysis of Central Scotland Airport. [Ref: 12 DEC SCAB_J62.xls]

Table 14

Estimates of Costs and Benefits of Central Scotland Airport (Present value discounted at 6 per cent in real terms)

Assumes a Central Scotland Airport opening in 2021 and Edinburgh and Glasgow closing at end of 2020.

Package	Package Description	Gross benefit (£b)	Costs (£b)	Net benefits (£b)	Benefit Cost Ratio (BCR)
1	DfT assumption of £50m per mppa	0.993	1.265	-0.272	0.78
2	DfT assumption of £80m per mppa	0.993	1.977	-0.984	0.50
3	DfT assumption of £100m per mppa	0.993	2.451	-1.458	0.41
4	BAA Cost Estimates	0.993	2.191	-1.198	0.45
5	Independent Engineer's Cost Estimates	0.993	1.722	-0.729	0.58

Source: Derived using Spreadsheet Costs and Benefits (SCAB) software supplied by Department for Transport, in conjunction with various estimates regarding costs and phasing of a Central Scotland Airport. Assumes South East constrained scenario and uses passenger and air transport movements as estimated in DfT SPASM forecasting software.

Table 15

Estimates of Costs and Benefits of Central Scotland Airport (Present value discounted at 6 per cent in real terms)

Assumes a Central Scotland Airport opening in 2021 and Edinburgh and Glasgow closing at end of 2020.

Package	Package Description	Gross benefit (£b)	Costs (£b)	Net benefits (£b)	Benefit Cost Ratio (BCR)
1	DfT assumption of £50m per mppa	0.993	1.209	-0.216	0.82
2	DfT assumption of £80m per mppa	0.993	1.921	-0.928	0.52
3	DfT assumption of £100m per mppa	0.993	2.396	-1.403	0.41
4	BAA Cost Estimates	0.993	2.135	-1.142	0.47
5	Independent Engineer's Cost Estimates	0.993	1.667	-0.674	0.60

Source: Derived using Spreadsheet Costs and Benefits (SCAB) software supplied by Department for Transport, in conjunction with various estimates regarding costs and phasing of a Central Scotland Airport. Assumes South East constrained scenario and uses passenger and air transport movements as estimated in DfT SPASM forecasting software.

Table 16

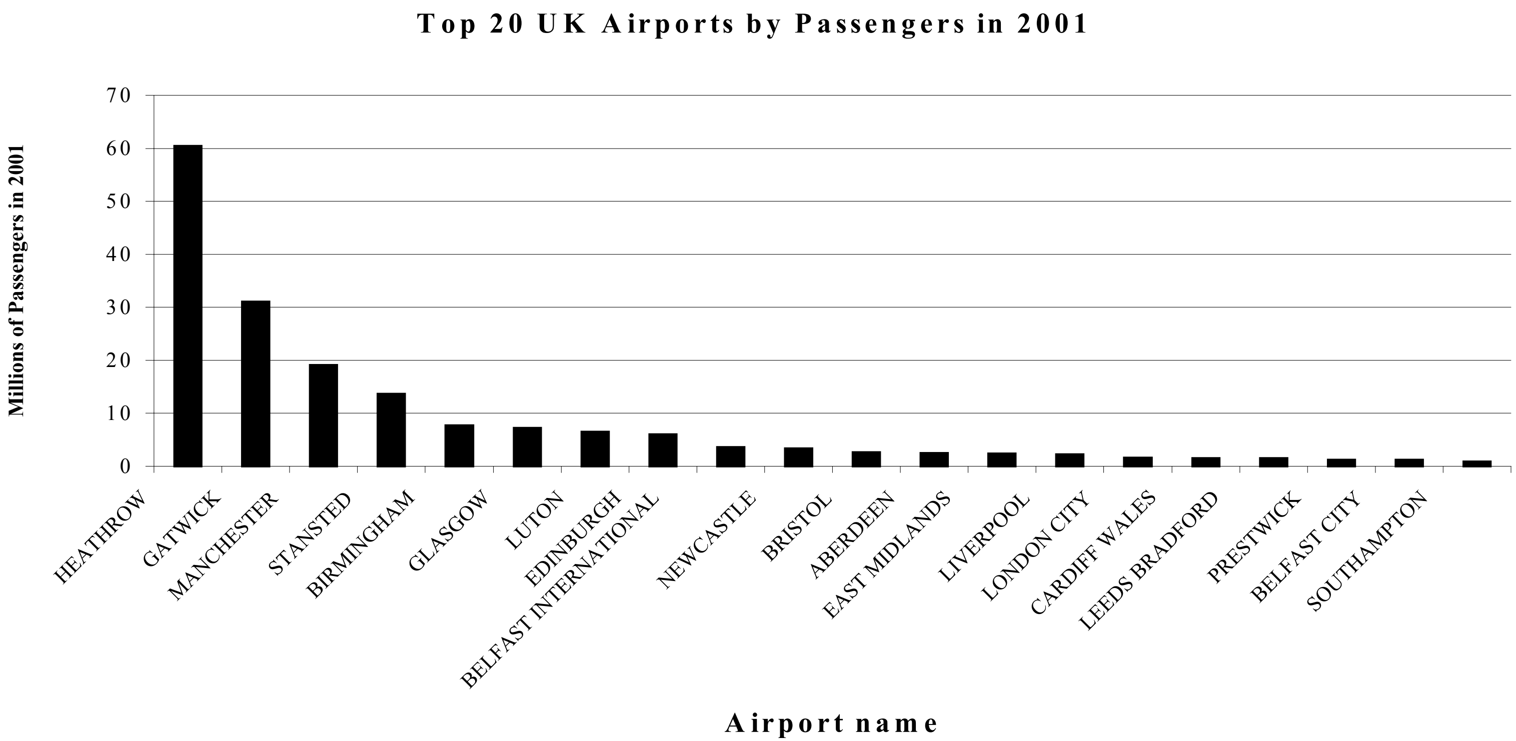
Estimates of Financial Internal Rate of Return of Central Scotland Airport

Assumes a Central Scotland Airport opening in 2021 and Edinburgh and Glasgow closing at end of 2020.

Package	Package Description	Ignoring Alternative Use Value of EDI and GLA airport sites	Incorporating Alternative Use Value of both EDI and GLA airport sites at £190m
1	DfT assumption of £50m per mppa	4.95%	5.22%
2	DfT assumption of £80m per mppa	2.75%	2.61%
3	DfT assumption of £100m per mppa	1.80%	1.92%
4	BAA Cost Estimates	1.56%	1.66%
5	Independent Engineer's Cost Estimates	2.58%	2.71%

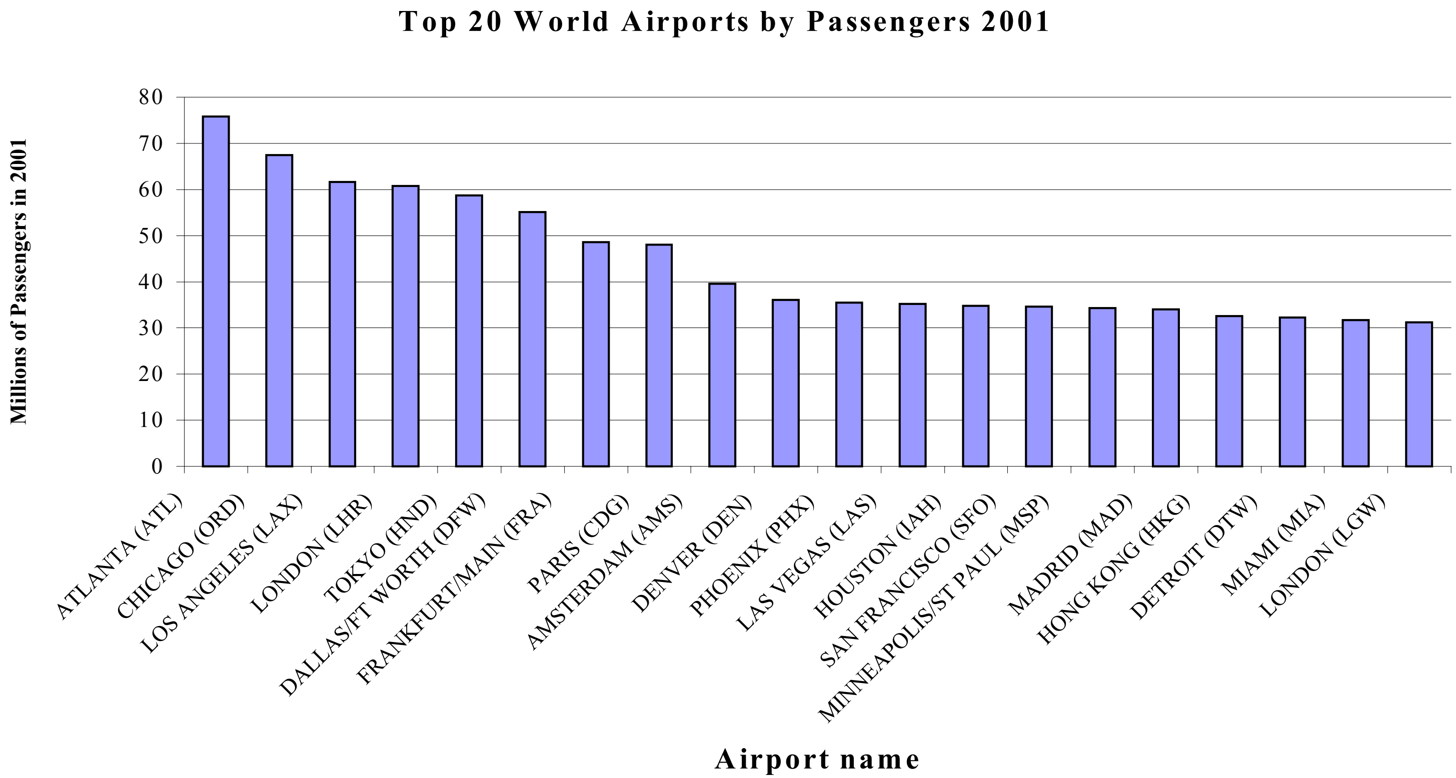
Source: Derived using Spreadsheet Costs and Benefits (SCAB) software supplied by Department for Transport, in conjunction with various estimates regarding costs and phasing of a Central Scotland Airport. Assumes South East constrained scenario and uses passenger and air transport movements as estimated in DfT SPASM forecasting software.

Figure 1



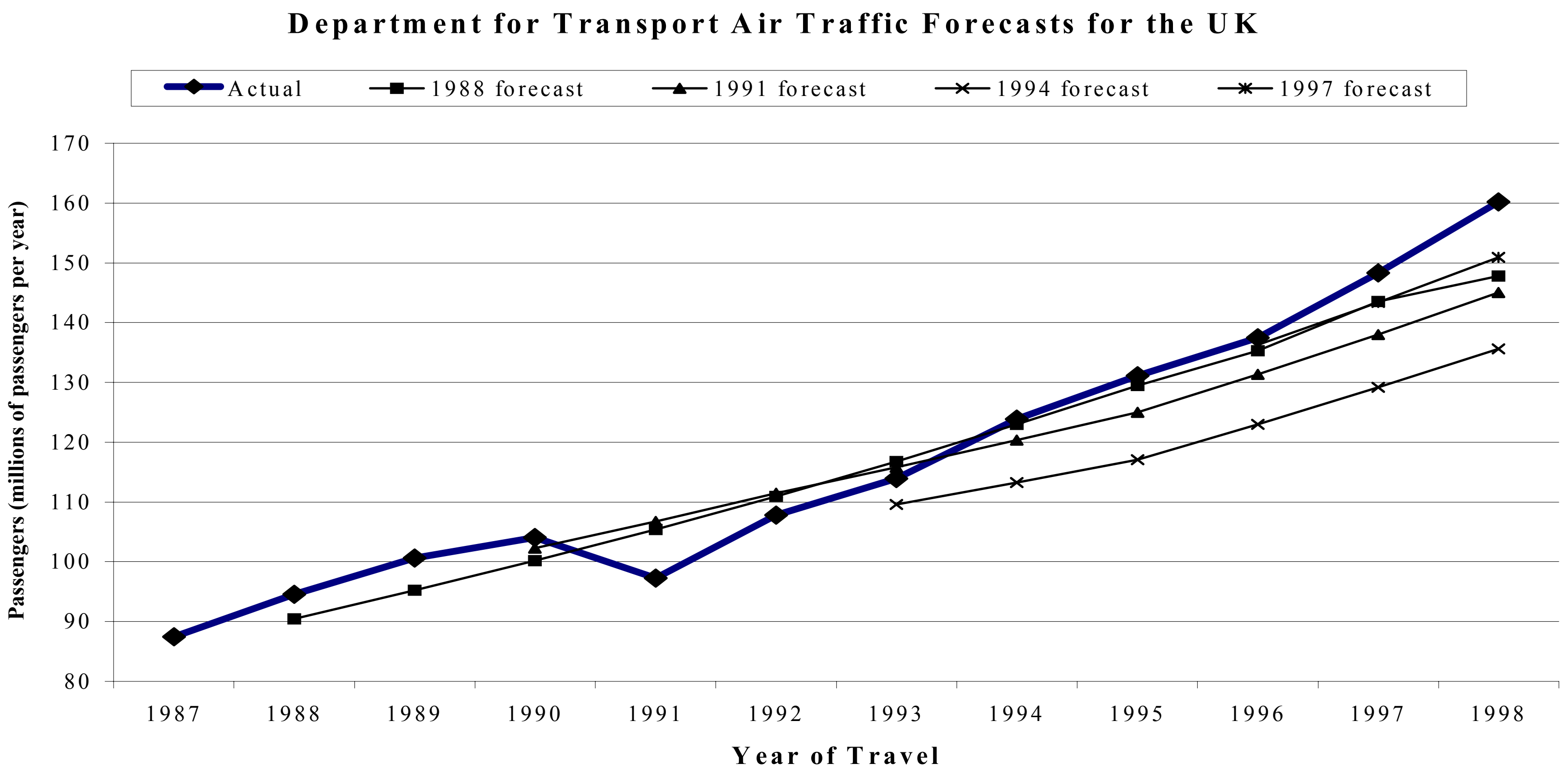
Source: CAA Statistics for 2001

Figure 2



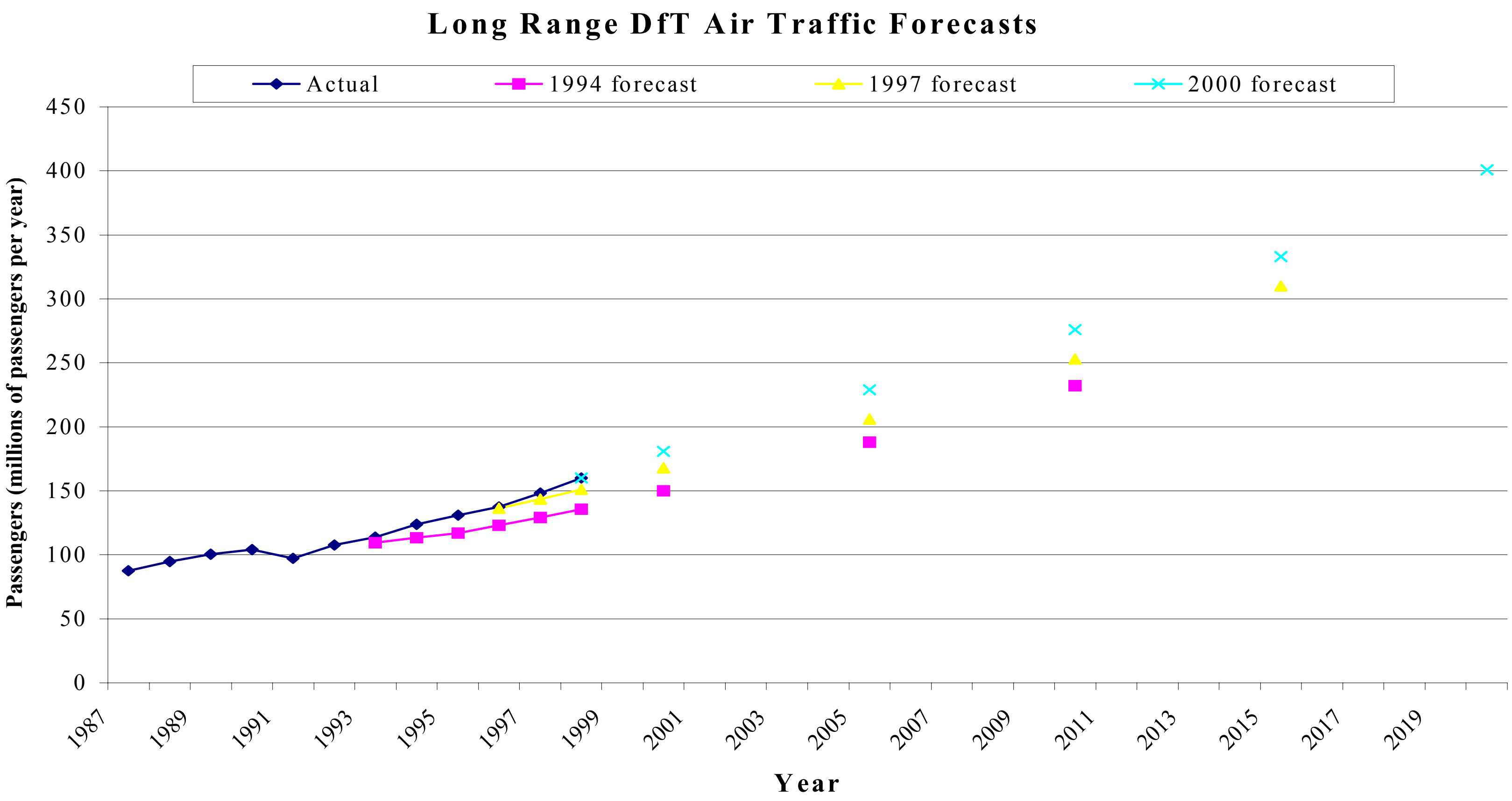
Source: ACI Traffic Data: World airports ranking by total passengers - 2001

Figure 3



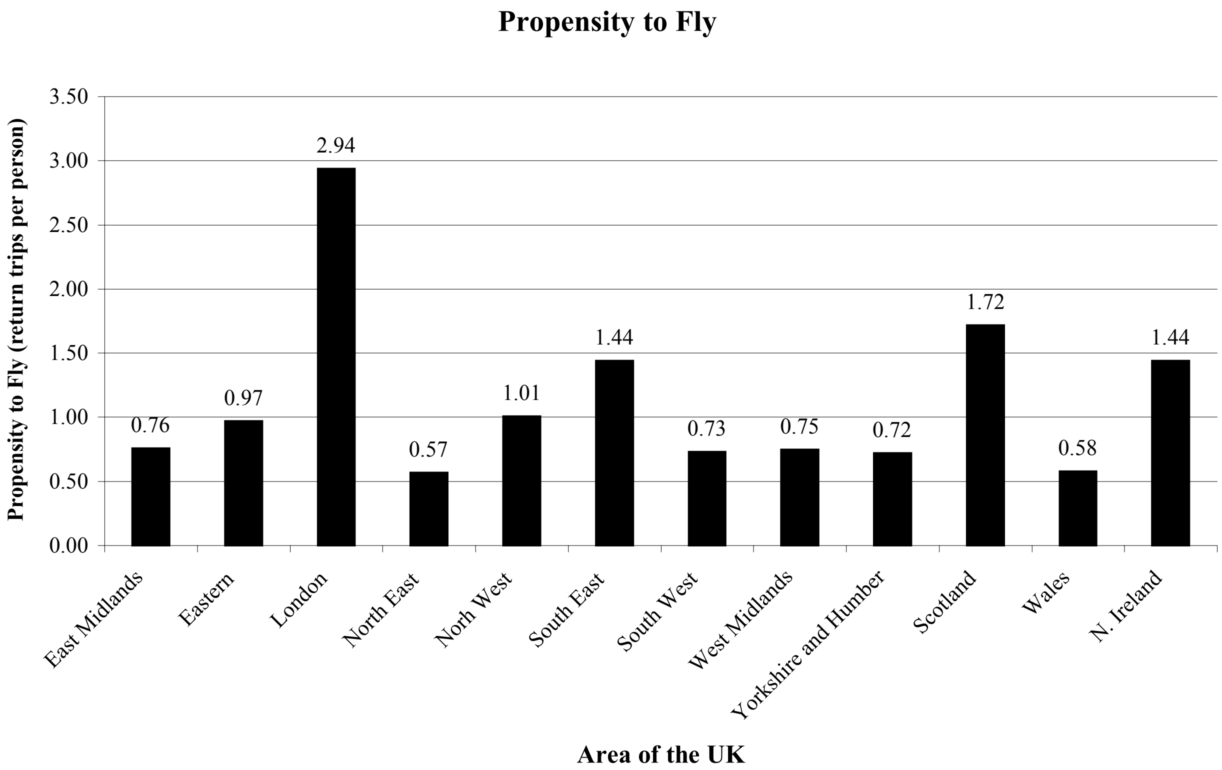
Source: Table 8.1 'Air Traffic Forecasts for the United Kingdom 2000' (DfT) http://www.aviation.dft.gov.uk/atfuk2000/index.htm

Figure 4



Source: Table 8.1 'Air Traffic Forecasts for the United Kingdom 2000' (DfT) http://www.aviation.dft.gov.uk/atfuk2000/index.htm

Figure 5



Source Table 2.2 'The Future Development of Air Transport in The United Kingdom: Scotland (DfT)

Figure 6

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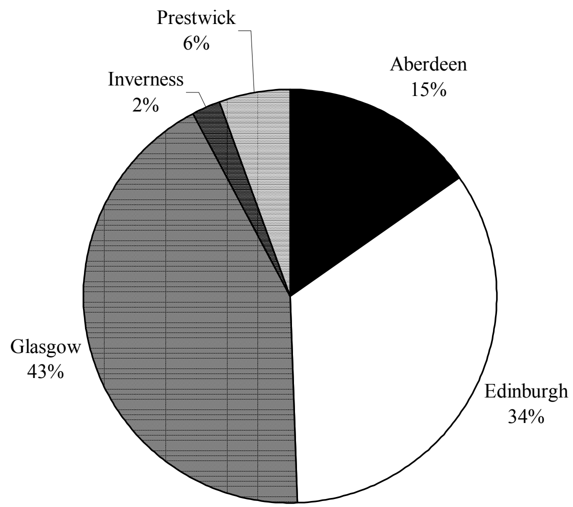
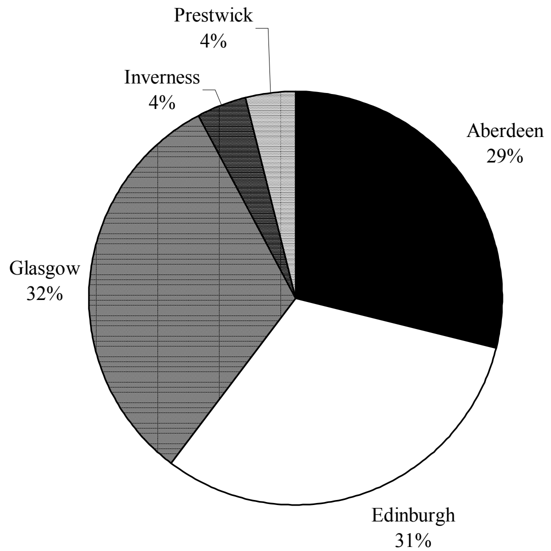
Share of Passengers (% of mppa) in Largest Five Scottish Airports



Source pp32 and 43 'The Future Development of Air Transport in The United Kingdom: Scotland (DfT)

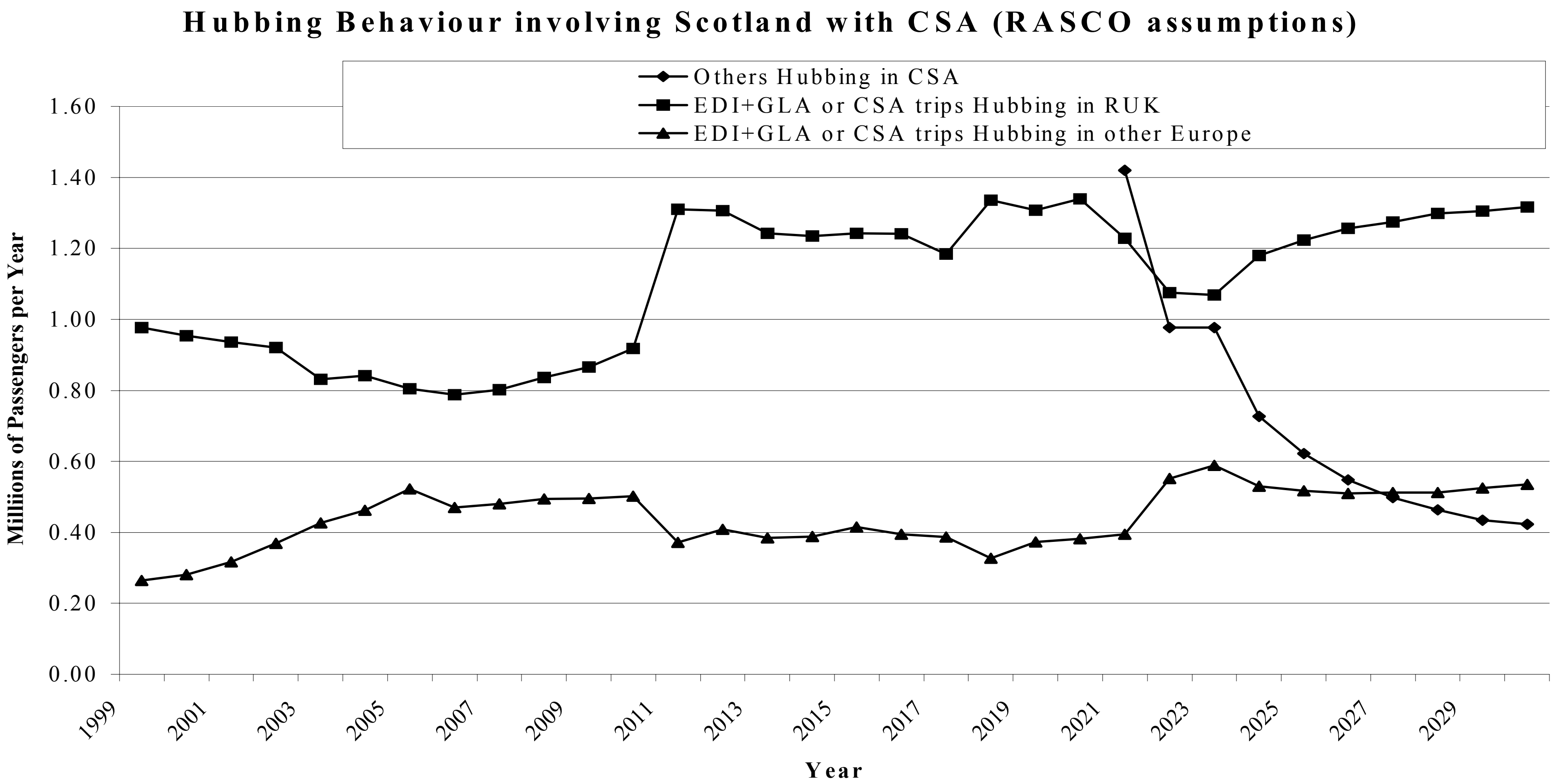
Figure 7

Share of Air Transport Movements (%) in Largest Five Scottish Airports



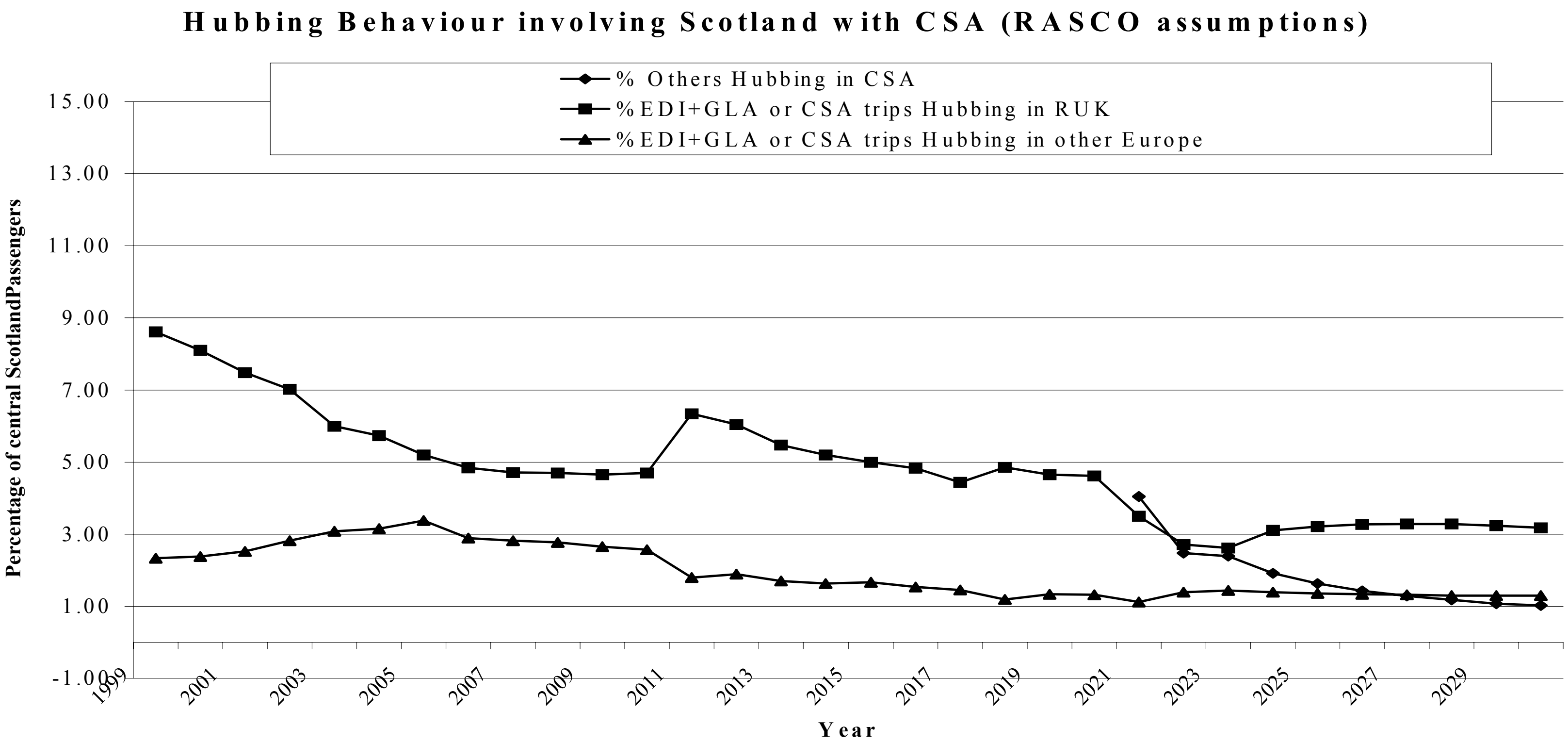
Source pp32 and 43 'The Future Development of Air Transport in The United Kingdom: Scotland (DfT)

Figure 8



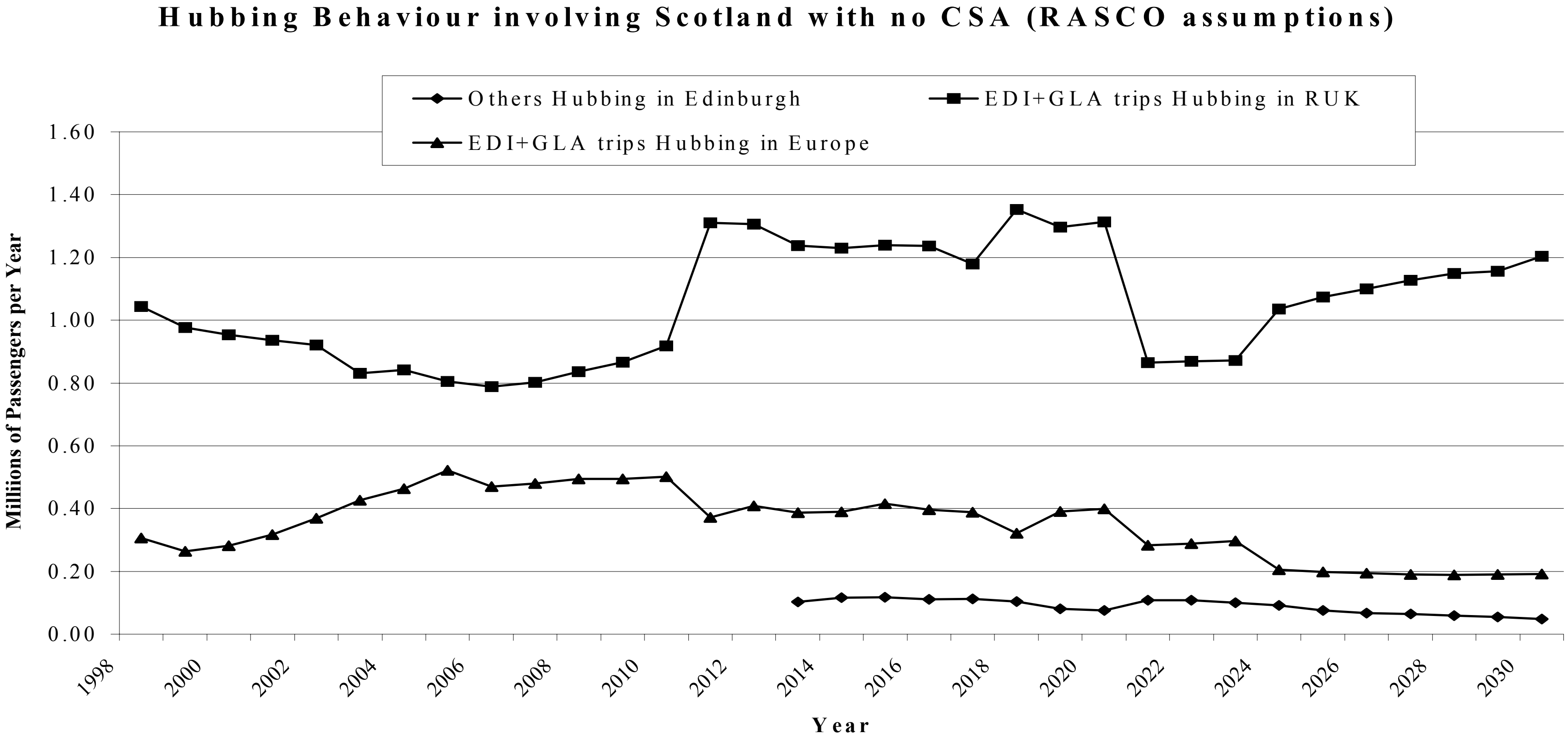
Source: Output of DfT SPASM Model, 15Nov_1CScotSum

Figure 9



Source: Output of DfT SPASM Model, 15Nov 1CScotSum

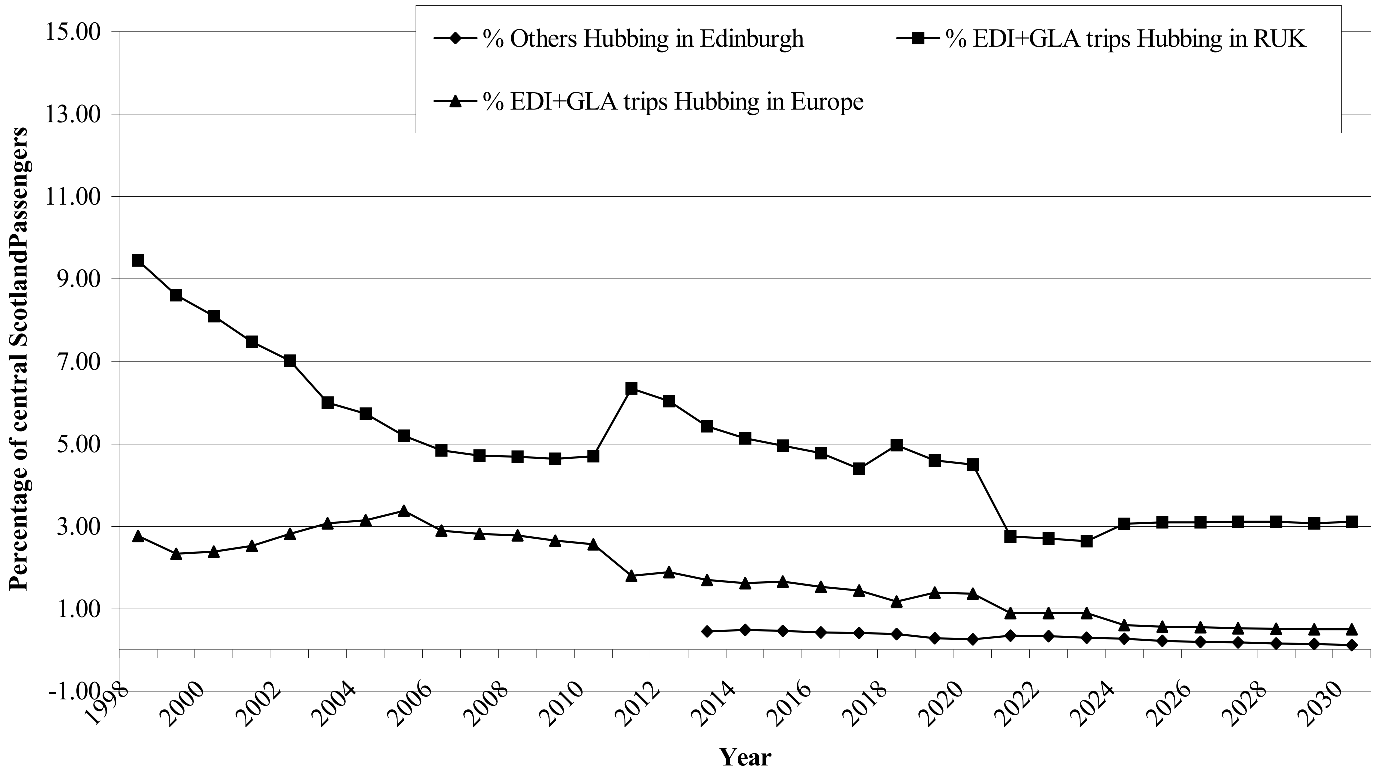
Figure 10



Source: Output of DfT SPASM Model, j62Sum

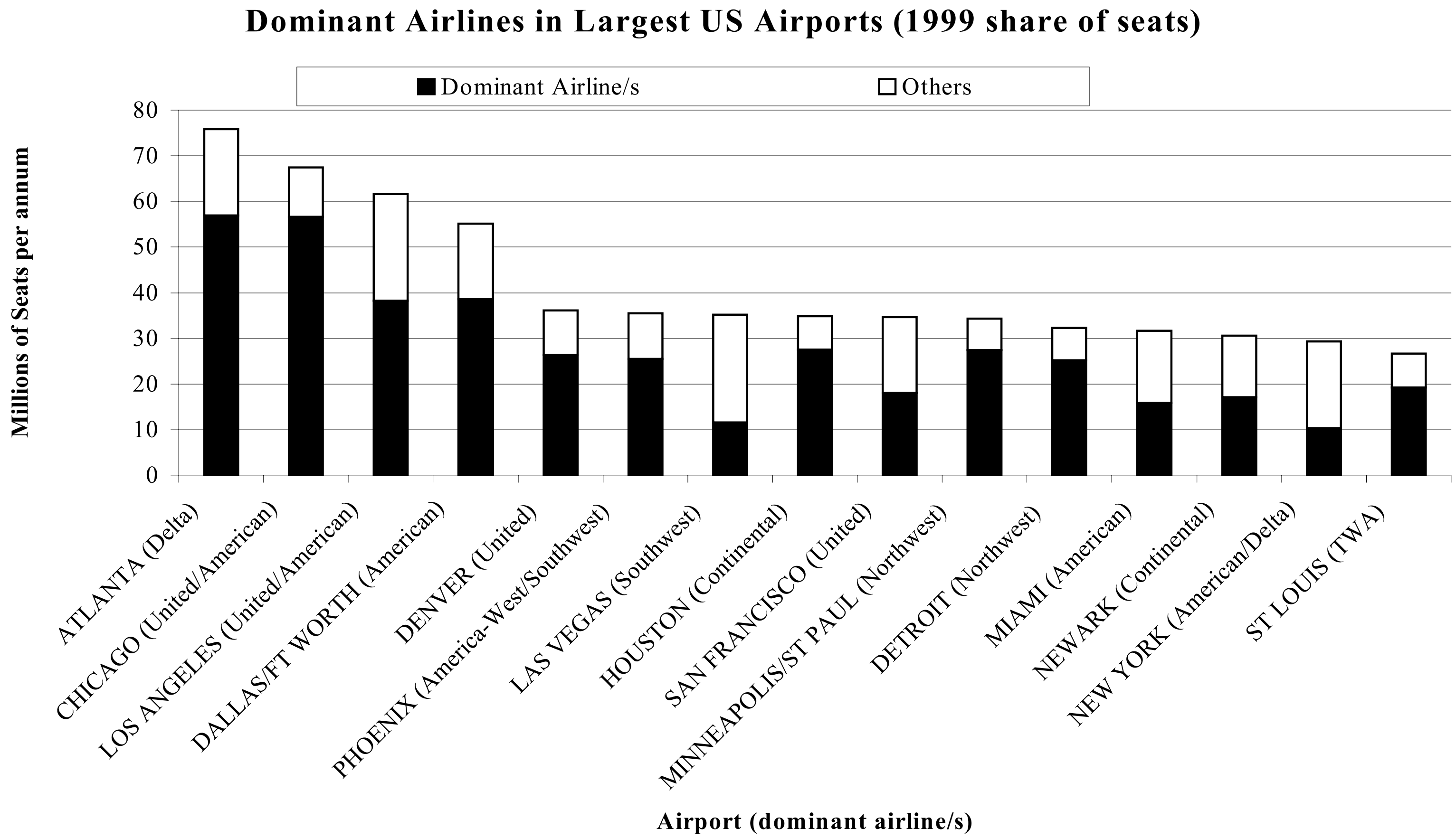
Figure 11

Hubbing Behaviour involving Scotland with no CSA (RASCO assumptions)



Source: Output of DfT SPASM Model, j62Sum

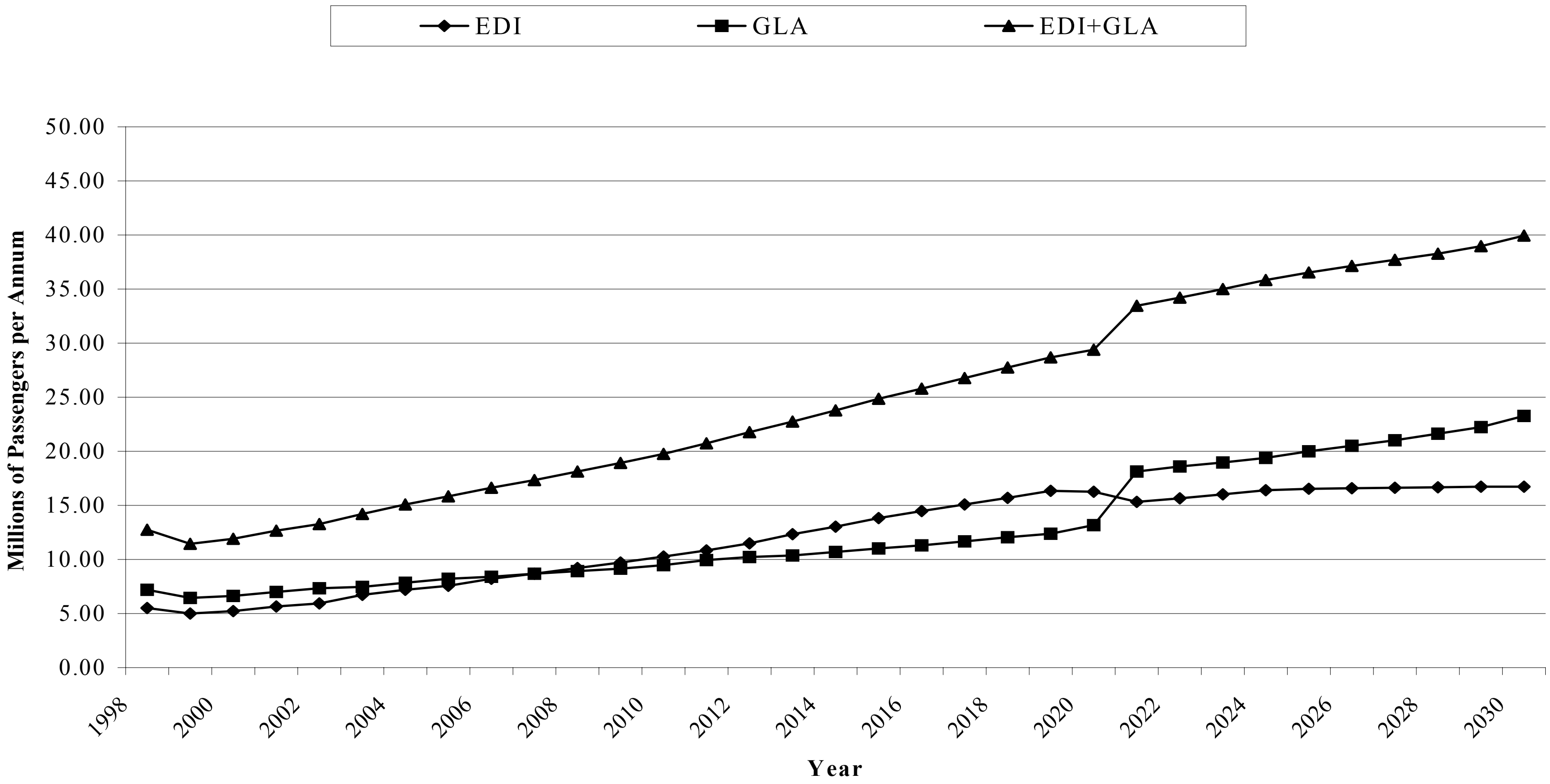
Figure 12



Source: Note uses 2000 passenger trips data in combination of data from Table 9.7 p 256 of Doganis (2002)

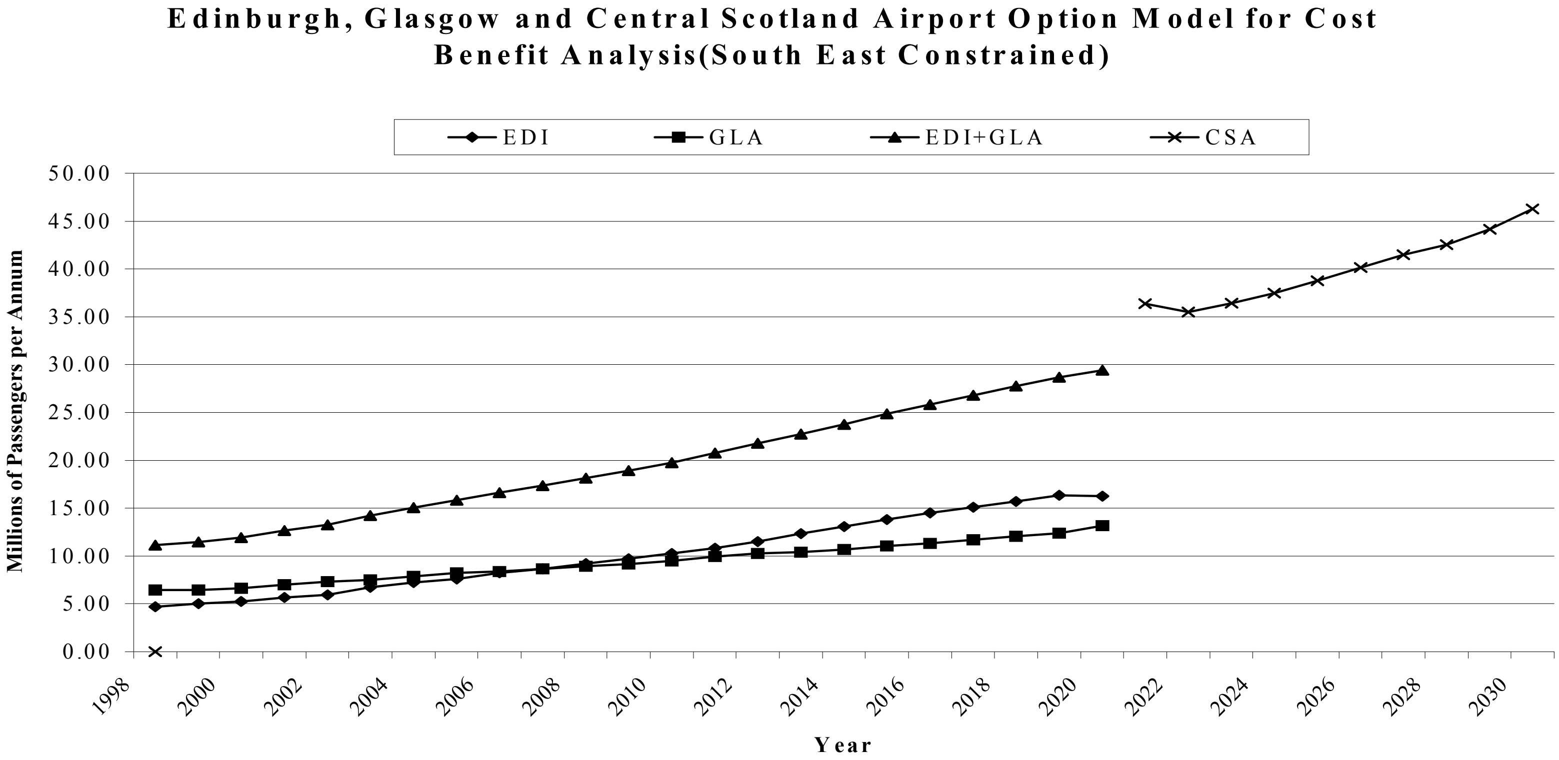
Figure 13

Base Model for Cost Benefit Analysis (South East Constrained)



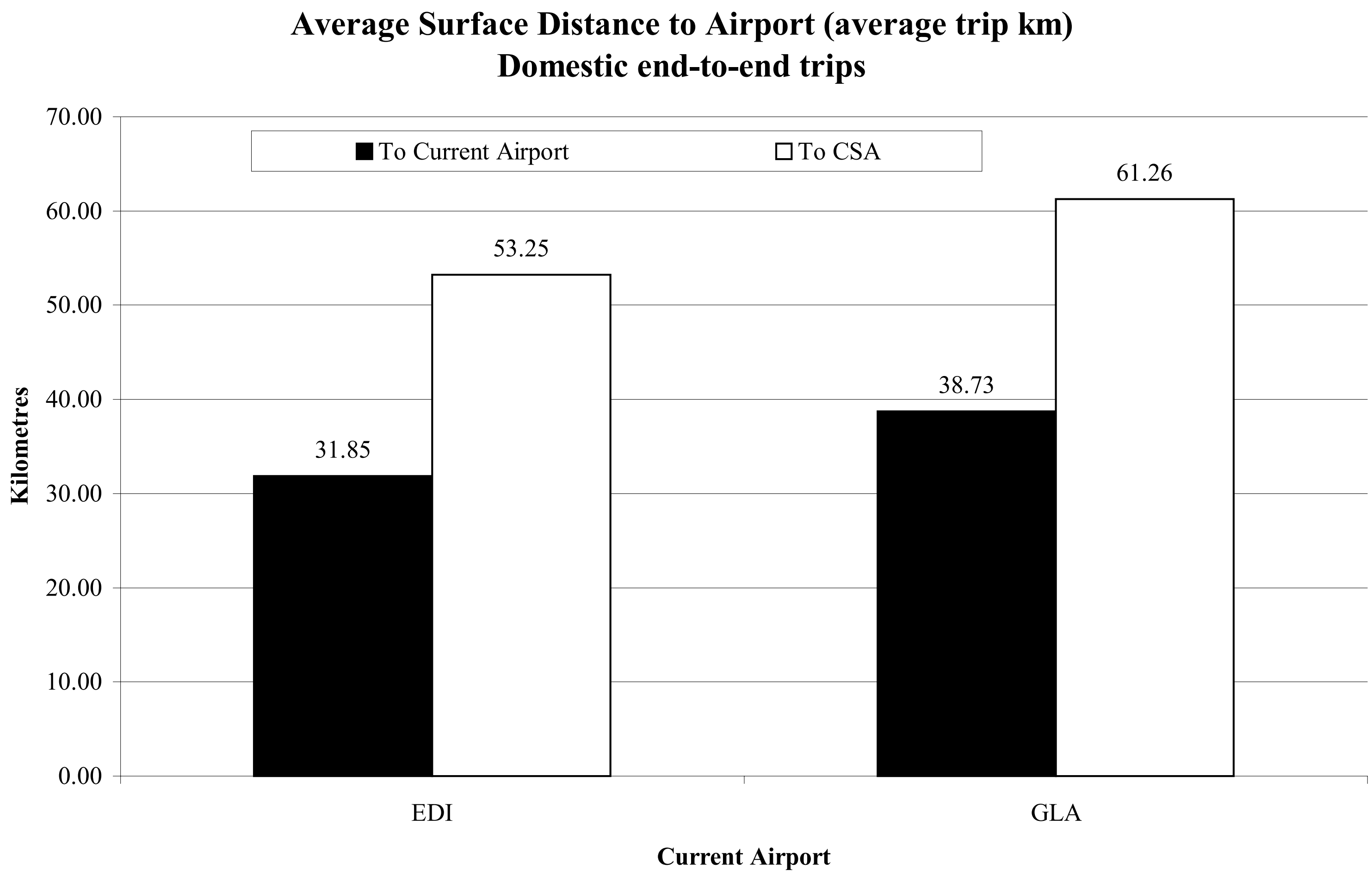
Source: Output of DfT Cost Benefit Analysis Model, 19 NOV SCAB_XX2

Figure 14



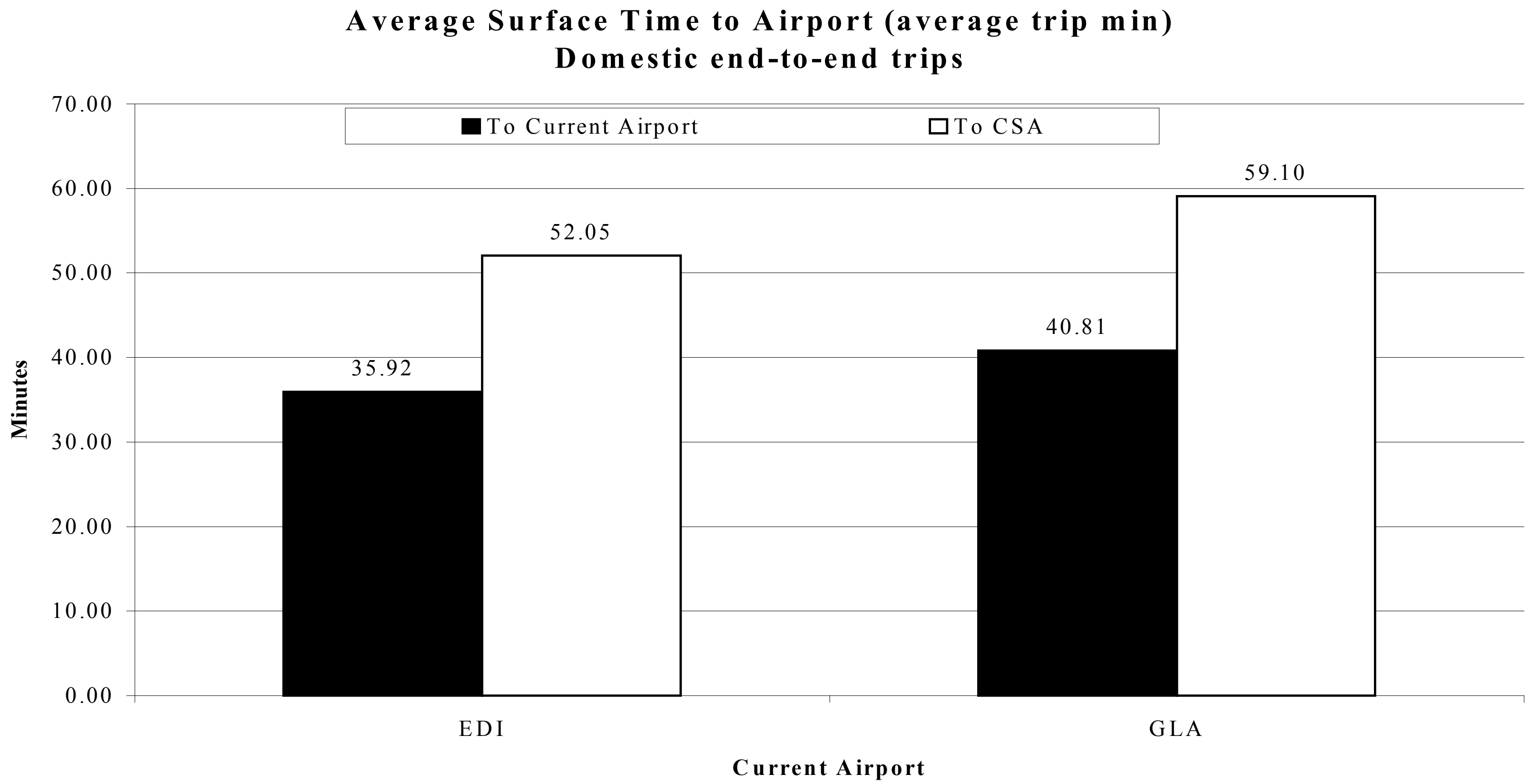
Source: Output of DfT Cost Benefit Analysis Model, 19 NOV SCAB_XX2

Figure 15



Source: DfT Surface Access District Files 2198, J62Dist and 15 1DomDist

Figure 16



Source: DfT Surface Access District Files 2198, J62Dist and 15 1DomDist