

Expanding Airport Capacity under Constraints in Large Urban Areas

Summary and Conclusions

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International Transport Forum
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1. OVERVIEW OF MAIN THEMES AND EMERGING CONCLUSIONS

1.1. Introduction

Expanding airport capacity is difficult in large urban areas. Expansion of existing airports is usually constrained by community agreements on noise and local air pollution and by a shortage of land. Finding sufficient land, at feasible prices, to develop or relocate major airports on green-field sites within a reasonable distance of city centres is often very difficult. Creating land for airports in locations less sensitive to noise and land-use conflicts, for example through offshore or estuarine land reclamation, is expensive and most new sites will require extensive investments in surface transport links to city centres. Furthermore, moving an airport imposes costs on airlines and their users as well as on activities located close to and dependent on proximity to the existing one. In multi-airport regions, options for expansion at one airport will impact the others and airlines, operating in increasingly competitive markets, may respond differently to alternative ways in which the region's airport capacity might be increased.

Many major airports are hubs for network carriers at the same time as serving a large local market. The complementarity between these functions is often seen as a prerequisite for viable network operations, suggesting that regulatory controls to distribute services over multiple airports can be costly in terms of connectivity for the local market, as well as the competitive position of the hub carrier(s). Hubbing operations also face competition from network carriers based at other hub airports, often in neighbouring countries. The strategies of network carriers and alliances need to be taken into account in assessing future demand for airport capacity. The requirements of other carriers are also important, but may differ. All parts of the market are experiencing change that will affect the pattern of demand for airport capacity in the future. This includes legacy carriers establishing low cost operations and the development of links between some low cost carriers and network carriers, code-sharing in some cases.

Decisions on expanding capacity for traffic through London's airports exemplify these interactions and constraints, and the UK Airports Commission has been established to examine the options for meeting capacity needs in the short, medium and long term.¹ The Roundtable was convened to review international experience in reconciling planning and environmental constraints with market demand for airport capacity, setting this in the context of the potential benefits – particularly in terms of productivity and economic growth – which flow from an increase in international airline services. In simple schematic terms, the main options for London might be characterised as: expanding capacity at Heathrow (the largest of the London airports); developing a large replacement hub airport in the Thames Estuary (or elsewhere) to minimise noise and land use conflicts, accompanied by the closure of Heathrow; or expanding capacity organically, where most feasible, in some or all of the existing main airports serving London.

1. See Airports Commission website: <https://www.gov.uk/government/organisations/airports-commission>.

The input papers prepared for the Roundtable track planning decisions and operational outcomes in Sydney, and in the multi-airport systems of New York, Tokyo, and Osaka and in Germany. The papers also examine the economics of hub operations and the expansion of airports in relation to multi-hub airline operations and review the way separate airport planning decisions in Germany, along with airline acquisitions, have resulted in Lufthansa becoming a multi-hub carrier. In addition to these case studies, the Roundtable – and this report – benefitted from the emerging findings from an extensive programme of research and analysis which is being taken forward by the UK Airports Commission (see Airports Commission Discussion Papers 1-5). These various lines of evidence are instructive as London now contemplates whether, and how, to best expand its increasingly congested airport capacity.

The case studies considered at the Roundtable show that expanding airport capacity in major urban areas is characterized by a fundamental trade-off between economic and environmental goals. On the one hand, providing additional capacity so that it is highly accessible to central business districts will usually best serve the community's economic goals. On the other hand, environmental goals will (in broad terms) usually be best served by airport capacity which is sited well away from centres of population. The outward spread of major urban areas over the last fifty years, combined with similarly rapid growth in air transport over that period, has only served to sharpen the importance of this trade-off.

Each of the case studies exemplifies this trade-off in different, and distinctive, locations. The studies show that a range of different solutions have been adopted, including:

- Newly established, and distant, airport capacity (in Osaka, Tokyo and, to some degree, Berlin or, prospectively, Sydney);
- Innovative development of existing capacity (for example, at Tokyo Haneda);
- Split development across two hubs (for example, Frankfurt and Munich).

Maximising the utilization of existing assets (in New York).

Consideration of the various case studies (and, more broadly, of developments in similar urban areas) does not suggest that any particular one of these solutions is clearly preferable to the others. This is not surprising. The central public policy issues at stake involve complex trade-offs whose nature and value will be shaped differently in each location by the interaction of local geography and the structure of the local economy, by local institutional structures and policy preferences (between various economic and environmental goals), and also by the history of previous capacity and the locational decisions which have been made in response to these (with some degree of path dependence). In consequence, different solutions are likely to be preferred at different locations at different points in time.

Accordingly, the main lessons from the Roundtable are not so much about identifying a generalisable, clearly preferred solution to the airport capacity problem (e.g. "always/never invest in new out-of-town capacity as suggested by experience in Osaka/Montreal"). Rather the main lessons are about what might constitute a successful framework for the development, phasing and co-ordination of airport expansion; a framework that recognizes the distinctive features of individual locations and uses evidence on these features to develop successful solutions.

These main lessons are drawn together in part 7 of this synthesis report (and are summarised in section 1.7 below). The preceding parts consider the key building blocks. The structure of the report is as follows:

- This first part provides an overview and summary of the report;
- part 2 considers future demand growth, the key driver of congestion and pressures on capacity;
- part 3 considers hub economies, which shape the increased connectivity – and the associated economic benefits – delivered by additional capacity at congested airports;
- part 4 considers the valuation of increased connectivity, particularly in terms of its impact on productivity and economic growth;
- part 5 considers different methods for comparing these benefits of additional airport capacity with the associated costs, particularly negative environmental impacts;
- part 6 considers environmental constraints in more detail, discussing in particular the issues that arise when (relatively) small numbers of people face (relatively) large negative impacts in ways which may result in a more general sense of unfairness;
- and part 7 considers, on the basis of all of this, a framework for the development, phasing and co-ordination of airport expansion.

1.2. Forecasting future airport demand

Growth in air travel signals the importance of the connectivity provided by aviation but also drives increasing congestion and pressures on capacity. Because assets are often long lived, often also with long lead times for planning and construction, forecasts of future demand (and the implications for congestion) are the first essential building block for the consideration of the need for additional capacity.

There is a wealth of high quality research evidence on which to draw to produce robust forecasts (see, for example, the review in Oum, Fu and Zhang (2009)) but significant uncertainties remain, in particular in relation to:

- Understanding fully the drivers of past growth (particularly the relative importance of past regulatory reform, developments in technologies and airline business models, and the longer term trends in incomes, trade, and key prices);
- Understanding how some long term trends – income, trade (including the role of trade barriers), and oil and carbon prices – will develop in the period following the present economic downturn;
- Understanding the effects of future innovations on supply – including developments in high speed rail - and associated changes to airline network structures;
- Understanding whether, and if so when, the strong historic link between income growth and air travel demand might start to weaken (as some argue is now happening for car travel – see OECD/ITF (2013) and Goodwin (2012)).

In addition to these uncertainties, there are also well recognized risks of institutional biases in forecasts (as outlined by Flyvbjerg (2009)). Given these uncertainties and risks, it is important that forecasts:

- Make the best use of high quality, relevant research;
- Are carried out impartially, validated by independent expert peer review, are discussed with key stakeholders and thereby command broad acceptance;
- Recognize uncertainties through using a realistic range of scenarios against which proposed investments can be tested (see e.g. Transportation Research Board (2012)).

1.3. Hub Economies

Hub economies have been central to the economic benefits delivered by increasingly competitive airline networks. Essentially, hub and spoke networks facilitate higher density, and hence less costly, flows of passengers. This also enables broader levels of air service to be provided in less dense markets, which would not be supported by local traffic alone. And it also means that the hub airport benefits from a particularly favourable array of connections.

Looking forwards this has two particularly important implications for investment in additional airport capacity:

- First, hubbing introduces an additional uncertainty into the forecasts of future demand at individual airports – because this will be shaped in part by the development of airline networks, although this uncertainty is likely to be less great in locations, such as London, where local demand is particularly strong.
- Second, hub economies will be a key shaper of the degree of connectivity – and economic benefit – provided by additional airport capacity.

1.4. Valuing connectivity

Improved connectivity is the key benefit from adding to capacity at congested airports, through the provision of enhanced airline services. Valuing connectivity is therefore of central importance in comparing the merits of alternative options for expansion.

Different methods of valuation have been used in practice. For small increases in capacity, a market measure of incremental revenues often gives a reasonable valuation (subject to reasonably competitive aviation markets and the nature of any regulatory controls on prices). In these circumstances, decisions to expand capacity can essentially be driven by commercial considerations, and there will be advantages in leaving this to market decision making (subject to appropriate public policies on negative environmental impacts – see Starkie (2008) for a discussion)

However, for more substantial investments, at airports serving major urban centres, a market measure is less likely to capture the full benefits of connectivity (particularly also if there are regulatory controls on airport charges). And in major urban centres the potential negative environmental consequences of airport expansion are likely to be particularly important. For both these reasons, there will usually be a greater public policy interest in comparing the positive impacts (particularly for productivity and economic growth) with the negative impacts (particularly environmental) of airport expansion.

1.5. Comparing the positive and negative impacts of airport expansion

As far as the positive impacts are concerned, there is an extensive body of research evidence which demonstrates the key importance of transport (and good transport infrastructure) for productivity and economic growth (see Crafts (2009) for an overview). The critical – and more challenging – question, in the present context, is to work out what this contribution might look like for particular airport infrastructure investments. The papers discussed at the Roundtable show that a number of different approaches have been used in practice.

The first approach, impact (or input-output) analysis essentially aims to measure the economic activity which results from airport expansion – both in the aviation sector and in sectors which are customers or suppliers. This approach can be useful for understanding how the impact of an airport investment might ripple through the economy. But it carries significant risks of overstating (perhaps substantially so) the overall benefits to the economy of additional airport capacity; essentially this is because this approach usually assumes that all of the resources shifted into aviation-related activities provide an additional benefit to the economy, rather than recognizing that in practice much of the resource will be diverted from productive activities in other sectors of the economy. It doesn't test whether resources deployed for capacity expansion could be used more productively elsewhere and, more generally, it ignores the cost side of the equation.

A second approach, cost-benefit analysis (CBA), avoids this weakness. It also helps in comparing the benefits to the economy with some of the negative environmental impacts. Cost-benefit analysis is well established in several areas of public policy, with a particularly strong foundation of research evidence and practical application in transport policy (see, for example, HEATCO (2006), an EU project which developed harmonised guidelines for the assessment of trans-national transport projects in Europe). There are two main limitations to CBA in the present context. The first is that it doesn't always capture the full impact of transport improvements upon productivity and economic growth. Essentially this is because CBA measures these benefits on the basis of the improvement in the prices and quality of transport services provided to travellers and shippers; these improvements then spread across the economy as reduced business costs and improved productivity. Whilst the research evidence suggests that this is usually a reasonable measure of the overall benefit to the economy, this isn't always the case (see HEATCO (2006) or Eddington (2006) for a discussion). In particular, recent research shows that investments that improve the transport links serving the central business districts (CBDs) of major urban areas may show significant additional productivity benefits. This is due to three considerations – agglomeration economies (that is, the advantages that firms might realise from being located closer together), more effective product market competition, and improved labour supply (see Crafts (2009) for a discussion). In one case – London's Crossrail – these three considerations together added broadly 50% to the estimated economic benefits of the project. Although this is very probably an exceptional (but important) example, it is interesting to note that the recognition of the existence of agglomeration economies in this case has helped the introduction of an additional tax – of broadly equivalent value – on businesses in the CBD (see Worsley (2011) for a discussion). However, not all of these three considerations will be of direct relevance to airport investment (not, for example, the labour supply aspects). Whilst some additional benefits might be expected, for example the benefits of reduced international trade costs, the available research evidence is at present inconclusive; it does not provide an accepted empirical view from which to judge whether there are any additional productivity benefits of this kind and, if so, how significant these

might be. This issue is an important, and active, area of on-going research (see, for example, GARS – IATA (2013)).

The second main problem with cost-benefit analysis is that it doesn't track the way in which the benefits of connectivity ripple through the economy (including a full understanding of the benefits to the tourist industry of additional visitors).

A third approach, computable general equilibrium modelling (CGE), deals with the latter problem. It may sometimes help with the first, although like CBA it is likely to be limited by the lack of good research evidence on the additional productivity benefits of (very) long distance/international connectivity. And in addition, just like input-output models, CGE models will not provide direct evidence on the negative environmental impacts of airport expansion. CGE models can also sometimes be resource intensive and the results are sometimes quite aggregated.

Overall, this discussion suggests that cost-benefit analysis provides an approach which is both well-grounded in the extensive research evidence available on transport infrastructure investment, and in the practical application of this evidence. But it is important to use realistic scenarios to reflect uncertainties in the evidence. This is particularly the case for benefits to productivity and economic growth, where it will be important to look at scenarios which consider the possibility of the kinds of additional productivity benefits discussed above (both by drawing on evidence from other transport sectors, together with any emerging evidence on aviation, and where it may also be useful to draw on CGE analysis, where this is feasible – an approach consistent with the HEATCO guidelines (see HEATCO (2006)).

In addition, cost-benefit analysis has the advantage of taking a wide ranging consideration of both the positive and negative impacts of airport expansion. In this way it helps draw together the available research evidence on the various different impacts of airport investment.

1.6. Environmental constraints

The environmental consequences are usually the biggest cost of an airport expansion (apart, of course, from the costs of construction and operation). These environmental impacts can include noise, local air pollution, loss of wildlife habitats or valued landscapes, and greenhouse gas emissions. The potential significance of these impacts has several implications for airport expansion. First, it will be important to carry out an environmental assessment of the different options for expansion. And it is also important to try to value the cost of these impacts, both so that their significance is understood and recognised and so that these costs can be weighed alongside the economic benefits of expansion in a cost-benefit analysis, as discussed in the previous section. There is now extensive research evidence which suggests a basis for valuing the different types of environmental impact arising from transport (see, for example, HEATCO (2006)). But the significant uncertainties in some of this evidence will need to be reflected by considering scenarios. And the ethical concerns which arise when natural and man-made capital cannot easily be substituted also need to be recognised (see, for example, Helm and Hepburn (2011) for a discussion).

But perhaps the most important characteristic of the negative environmental impacts, in the present context, is that they are often (but not always) concentrated on relatively small numbers of people (in contrast to the benefits of expansion, which are more usually spread wide and thin). Where, as a result, the costs are large for the individuals concerned

- and where in addition they are difficult to avoid - this often leads to intense opposition. And this opposition often arises even in circumstances where, in aggregate terms, the impacts are perhaps not that large (when set in the context of the other costs and benefits of airport expansion). That there is opposition from those affected is not surprising. But the papers considered at the Roundtable also suggest that there is often a far wider perception of a lack of fairness; and that this often, in turn, drives more widespread opposition to airport expansion. Developing acceptable solutions to this perceived unfairness is often a key requirement for expansion to move ahead successfully.

Noise is usually the most controversial environmental impact and conforms to this pattern. Valuation evidence on noise impacts is increasingly available, but when this is included in a cost-benefit analysis the impacts are often found to be a relatively minor factor when compared with the other costs and economic benefits of expansion (see, for example, Peter Forsyth's paper for the Roundtable). Rather, the key issue is the impact on those who may face more noise. The basic problem is that households and businesses have made location decisions on the basis of existing noise profiles (with perhaps some expectation of their future path). In these circumstances, a (significant) unexpected increase is regarded as unfair, given that there are often significant costs – both financial and non-financial – of re-location. This has sometimes led to an approach in which airport expansion is constrained to pre-existing noise levels, with air transport growth provided for by the introduction of quieter aircraft and changes in operating methods. In practice, there has been considerable scope to achieve this through measures such as:

- limiting or banning evening and night time flights, or restricting their use for ultra-quiet aircraft;
- negotiating with airlines to withdraw old, relatively noisy aircraft;
- differentiating landing fees by type of aircraft according to noise characteristics;
- establishing flight paths for aircraft taking off and descending which aim to reduce noise footprints;
- introducing new practices for aircraft whilst on taxiways and aprons to reduce ground running noise.

Developing an acceptable solution to the noise problem will often be critically important to the successful expansion of airport capacity. The key issue here is how best to frame a solution which, on the one hand, is generally perceived to be fair, whilst at the same time getting the best economic value out of the utilisation of the airport (that is, getting the most out of environmental capacity). The potential conflicts between these twin objectives mean that solutions will often be complex and controversial.

Framing a solution which is generally regarded as fair will require addressing a range of issues (see Airports Commission 2013e); these include:

- Establishing what is regarded as a fair noise level. For example, a ceiling at pre-existing levels or one providing for some reduction in noise? This latter might reflect rising expectations, or the possibility of health impacts identified in recent research which are not easily recognised by households and not, for this reason, reflected in their locational decisions.
- Establishing how noise levels should be measured (particularly differentiation by time of day/night).

- Considering what role might be played by amelioration (e.g. provision of noise insulation).
- And, similarly, consideration of what is the best role for compensation in striking an acceptable balance, and how this can best be framed to avoid excessive claims and disputes.

Getting the best value out of environmental capacity – the second half of the twin objective – is likely to require a mix of measures. In some circumstances – for example, relatively noisy aircraft at night – there may be tipping points at which the dis-benefit to households of additional noise rises sharply. In these cases, quantity restrictions – limitations based on aircraft movements – may be the best approach (see Hepburn (2006) for a more general discussion of situations where quantity controls might be expected to work more efficiently than pricing measures and vice versa). But in circumstances where the costs of additional noise are more incremental, then limitations based on noise budgets will usually be more effective at striking the right balance (see the paper to the Roundtable by Hans-Martin Niemeier for a discussion and a practical example). All of this means that, to work effectively, noise policies will usually involve a package of measures, and that these will need to be tailored to the particular local circumstances at the airport. Co-ordination between airlines, the airport and air-traffic control will often be required.

Local air pollution is also an issue. In some cases (for example in the EU) there are established regulatory standards for local air quality and plans for airport expansion must conform to these. This may involve actions affecting both airport and airline operations, as well as surface access traffic, to constrain emissions to the required levels.

Impacts on wildlife habitats are often a relatively minor issue, but can be important where rare or endangered species are at risk. An environmental assessment will be an important input to site selection in these circumstances. In some cases, it may also be possible to effectively internalize these impacts through the construction of a replacement habitat – an approach which has been successfully adopted in container port development in the UK and for waterways development more widely in Europe.

Greenhouse gas emissions obviously have a global rather than local impact but policies towards climate change may influence airport expansion in the future. The importance of greenhouse emissions from aviation looks set to increase for two reasons. First, demand growth is forecast to be greater than in many other sectors of the economy. And, second, the prospective contribution of low carbon technologies looks less promising than in many other sectors. Taken together, this means that greenhouse emissions look very likely to assume a greater importance in the global totals than hitherto (see Sentance (2009) and Airports Commission 2013c for a discussion).

There are two implications of this as far as the consideration of additional airport capacity is concerned. First, potential carbon prices and taxes, or the impact of non-price controls, need to be factored into future forecasts of aviation demand. The impact could be potentially significant if progress on low carbon technologies proves to be slow. Second, a perception that the development of effective climate policies for aviation has not been commensurate with its rising importance has led some to argue that the best way to curb greenhouse emissions from aviation is to stop the expansion of airport capacity. This would be a less efficient approach toward reducing aviation's greenhouse emissions than many other measures, such as including aviation in emissions trading schemes (see Sentance (2009) and Airports Commission 2013c for a discussion). But it is sometimes also argued that stopping airport expansion is a way for governments to signal policy commitment to

environmental goals. Public concern over aviation's role in climate change may also bear upon public support or opposition to airport development. In these circumstances the key question is then whether there are credible ways to demonstrate that additional airport capacity is meeting its climate change costs, for example through an effective emissions trading scheme or through a specific aviation levy – see Keen and Strand (2006 and 2007) for a more general discussion of aviation taxes.

1.7. A framework for developing, phasing and co-ordinating expansion

The case studies discussed at the Roundtable (together with broader experience of airport expansion) suggest advantages in an approach which involves the following steps:

- (a) **Getting the most out of existing capacity**, in terms of utilization, economic value and environmental impact, which is particularly important in times of austerity. Where regulatory frameworks allow use of all potential pricing and slot trading options, the approach can be summarised as follows:
 - Squeeze more out of existing runway capacity through improved air traffic management and optimised landing and take-off patterns;
 - Price general aviation at an appropriate cost for scarce runway space at congested commercial airports, so that only users who value the high costs of access remain;
 - Use differentiated (e.g. time-of-day) pricing for air-side services, or slot auctioning and trading, both to manage demand at the peaks and to get the best economic value out of scarce airport capacity. It has also to be recognized that slots carry the risk of anti-competitive hoarding unless they are time-limited.
- (b) **Undertaking a wide ranging review of where and how capacity could be added**. For example, a review of options for expanding airport capacity could include some or all of the following:
 - Develop secondary airports (or share military runways) for operations by low cost carriers, with airport development tailored to the needs of this market segment;
 - Add short runways, at the main airport or close by, to free capacity on existing runways for long-haul traffic;
 - Add long runway(s) at the main airport(s);
 - Develop an additional, or replacement, main airport.

As the experience of Sydney illustrates, the process is cyclical and ideal options rarely exist.

In circumstances where a replacement airport is proposed there will also be questions of co-ordination between old and new airports. The case studies illustrate the considerable uncertainties in such a step change, both in relation to the patterns of demand which emerge and in relation to future development possibilities. And the case study experience illustrates the value of keeping options open, where feasible, to provide for a flexible response to changing circumstances.

- (c) **Evidence based comparison of the likely impacts (economic, environmental and social) of the most promising options** – using cost-benefit analysis (perhaps supplemented by CGE modelling). Validating the provenance of the analytical evidence is important whilst also recognizing the ranges of uncertainty in the evidence by using a set of realistic scenarios.
- (d) **Adopting flexible (or option based) planning of preferred solutions** to reflect the uncertainties in the evidence, as suggested in Burghouwt (2007). The basic aim is to adopt plans which will work reasonably well over a range of scenarios (even if not necessarily being the best solution on the central forecast) and which have sufficient built-in flexibility in relation to the scale and timing of investment, such that plans can be adjusted if/when the future doesn't match the forecast.
- (e) **Protecting the interests of those most at risk of significant (negative) environmental impacts.** As noted, taking steps to resolve a perceived lack of fairness to those on the receiving end of localized environmental impacts, particularly noise, may be important to securing more widespread public support for airport investment.
- (f) **Providing the right investment incentives** – in particular:
- By enhancing competition in the provision of airport capacity (where feasible) – both to stimulate the right levels of investment and to incentivize the development of innovative solutions. Liberalisation of competition in airline services is generally considered to have been of significant benefit (see, for example, Morrison and Winston (1986)) and is valuable in the airports sector where feasible. The separation of the ownership of the main London airports is in part aimed at benefiting from opportunities for competition (although it needs to be recognized that London offers more opportunities for competition than some other major conurbations);
 - By greater alignment of public and private interests; as noted, there may be scope to internalize some environmental impacts. And the Crossrail project in London illustrates a case where the recognition of agglomeration economies – not captured in project revenues – has helped the introduction of an additional tax on businesses in the CBD, providing a source of funding from the prospective beneficiaries;
 - By providing co-ordination, so that any required expansion of surface access capacity, or of Air Traffic Control, is implemented in parallel;
 - By ensuring that, in cases where effective airport competition is not feasible, any regulatory price controls on airports provide appropriate signals for investment. This can be done, for example, through a periodically revised price cap based on a regulatory asset base (perhaps using a split rate of return, as suggested by Helm (2009), with the rate allowed on established assets indexed to the market and a higher rate of return allowed on new investment);
- (g) **Providing for legitimacy and stability of planning decisions** – in particular through consultation and transparency, through assuring the provenance and credibility of the evidence and analysis underpinning decisions, and through protecting the interests of those at risk of material environmental damage.

2. ESTIMATING FUTURE DEMAND FOR AIRPORT CAPACITY

Airport capacity investments can often be lumpy and long-lived, meaning that decisions on how much capacity to provide frequently require a view on the development of demand over the long run. Such views can be informed by expert opinion and by systematic projections, where the latter have the advantage of rigour and transparency. In order to project demand for travel at specific airports, a projection is needed of the overall volume of air travel and of its distribution over available airport capacity.

Systematic projection tools usually come in the form of econometrically estimated models of air passenger demand. Econometric estimation requires data on past trends that relate demand to explanatory variables. Econometric projections are vulnerable to error from changes in the relationships between such explanatory variables and air travel demand. If relationships evolve to differ significantly from the past, the projections will be off target. The problem cannot be avoided entirely but can be mitigated, firstly by including a full range of key explanatory variables (GDP and relative prices matter but so do regulation, market structure, availability of other modes, etc.) and second by allowing flexibility in the relation between explanatory and outcome variables (e.g. a declining income effect, so that GDP-growth leads to smaller travel demand increases when GDP is already high). Such a rich econometric model has the benefit of allowing construction of meaningful scenarios on the basis of potential developments in the explanatory variables, including the regulatory environment, fuel prices, growth in various global regions, airport capacity, etc.

Scenario-analysis is likely to prove superior to projections that only consider high and low bounds, without any real understanding of the likelihood of experiencing those bounds. If probabilities can be attached to the different scenarios, projections become more meaningful but achieving this is far from straightforward (see Transportation Research Board (2012) for a discussion).

The UK Airports Commission has published an overview of projection tools relevant to the UK (Airports Commission 2013a). The UK Department for Transport produces air travel demand forecasts based on an econometric model that distinguishes several market segments (business and leisure, UK and foreign and 5 geographic zones). The model is fed with exogenous forecasts for the explanatory variables. The most recent projections are that air travel demand will grow by between 1% and 3% per annum from 2010 through 2050. Projected traffic volumes remain below expectations formed before the great recession, throughout the period.

The allocation of demand to airports is projected with a separate model. This model aims to allow for the choices of passengers among UK airports but not for competition for transfer passengers between UK and non-UK airports. Given the intensity of such competition, and given that transfer passenger levels are not only of direct interest in themselves but also of interest in terms of their impact on connectivity, this is a relevant shortcoming. More generally, uncertainty about airline responses to capacity changes is large and needs to be accounted for in airport-specific responses.

Projections are inherently uncertain; it is not certain that the model will continue to apply in the future, even if initially well specified, and the future values of the exogenous variables needed for projections are uncertain. The task is to limit uncertainty as much as possible and to make explicit what remains. Sensitivity and scenario-analysis help do that, and clarify the effects of policy choices, e.g. on capacity expansion, in various possible future states of the world. Such analysis aims to reveal which policies are more or less robust to alternative states of the world.

Scenario analysis combined with judgment on the likelihood of different scenarios is useful in considering the impact of changes in the timing of adding capacity. For example, if tepid growth in demand is thought to be a persistent rather than temporary condition, delays to building capacity are less costly in the long run, even if there is a shortage of capacity now. Uncertainty then affects decisions on when to expand, rather than whether to expand at all. An approach to decision-making on capacity expansion along these lines, focused on the timing of expansion, is advocated in Jeffrey Zupan's Roundtable paper.

3. HUB ECONOMIES

Hubbing generates connectivity through its effects on route density of demand. Coordinating flights at a central airport allows higher frequencies of flights, larger planes, or better occupancy rates on busy routes and also allows more long distance destinations to be served by direct flights. How large the effect is, and just how important it is where local demand is very high (as in London), is a subject of debate (see, for example, Airports Commission 2013d for a discussion).

Empirical analysis by Burghouwt (2013), where hub connectivity is measured as quality-weighted² transfer opportunities, shows that:

- a. Splitting hubs reduces connectivity;
- b. Hubs are particularly important for generating long haul direct connections;
- c. Liberalisation increases the number of hubs, at least initially, whilst consolidation reduces it;
- d. Heathrow shows very strong overlap (80%) in the destinations it serves in the connecting market with Frankfurt, Paris Charles-de-Gaulle and Amsterdam Schiphol.

Without additional runway capacity, Heathrow has few opportunities to add long haul destinations to those already served (except at the expense of short-haul routes, which could then prejudice traffic feed). This limits expansion of British Airways at its core base and denies some of the benefits of hub economies to passengers and businesses in the London area. Equally, it needs to be recognized that the majority of the passengers at the London airports fly point-to-point, and that this is very likely to continue to be the case in the future. Nevertheless, in the absence of additional capacity, frequencies of service will

2. According to transfer and detour time.

develop more slowly and direct routes to new destinations will be added more slowly than they otherwise would. Valuing the potential benefits foregone is a key issue in determining airport policy.

Beyond a certain hub size, there will be decreasing willingness to pay per passenger as spokes are added, though spokes are not all of equal value and their relative value can change over time. Hub diseconomies also exist, perhaps particularly in the logistics and convenience of passenger transfer (for transfer passengers) and, to some degree, in ground access to the airport for origin/destination (O/D) passengers. Such diseconomies appear less likely at Heathrow, however, with redevelopment of old terminals underway. The improvements to the environment for transfer and access to terminals should outweigh any likely hub diseconomies. In any event, London has a strong O/D market, and this may be one reason why the hub function at Heathrow is less important than, say, in Frankfurt.

Where airlines decide to operate hubs is not determined only by size of the local market. Los Angeles is a very large origin and destination market and sees a lot of transfer traffic but has only limited hubbing functions. Outside of the very large US market, national flag carriers naturally tend to hub out of the largest national airport. Airport capacity and prospects for expansion are important factors for the location of primary hubs. Lufthansa developed a second hub in its home market, at Munich, as a result of restrictions on expansion at its main base, at Frankfurt, that were subsequently eased. Secondary hubs, such as the hubs operated by United, Delta and American Airlines at New York's airports, are more frequent in the US because of the size of the market and its geography.

Markets and the organisation of the airline industry are dynamic and can change rapidly. A rationalization of US hubs is underway as airlines merge and the industry consolidates, with the number of hubs declining and average inter-hub distances increasing. Mergers have resulted in some European airlines operating multiple hubs. Lufthansa has thus accumulated hubs in Zurich and Vienna in addition to Frankfurt and Munich. For a time it also ran a hub in the UK after acquiring BMI but subsequently sold the airline to IAG (British Airways-Iberia). Rationalisation or specialization is likely to follow. The Air France-KLM group operates out of two hubs in Paris and Amsterdam but has concentrated on serving different sets of markets from each; only where markets are large enough do both airports serve them (Burghouwt 2013). IAG is expected to similarly differentiate services between Heathrow and Madrid, with the latter focusing on Latin America and southern Europe. Historically, SAS operated more than one hub, reflecting its multi-national ownership.

Some low cost carriers, have begun to provide network type services with through ticketing via their bases and code sharing agreements with network carriers, for example JetBlue's operations through its New York and Boston hubs and its agreements with Aer Lingus, Lufthansa and Star Alliance partners. Airline businesses are in constant evolution. Air Berlin began as a low cost carrier, has become a network service operator, is a member of Oneworld and has an alliance with Etihad, which now holds 29% of its shares. It operates more services out of Berlin than Lufthansa. It is not entirely inconceivable that EasyJet, the UK's largest airline by volume of passengers carried, could develop network services out of the largest of its 23 bases, Gatwick, and evolve into a second UK based hub carrier if Gatwick were to expand (although this would require the development by the airline of both baggage transfer and inter-continental services).

As airline business models change it may be more useful to distinguish between network carriers and point-to-point carriers than between full service carriers and low cost

carriers. Some network carriers are beginning to use point-to-point carriers for feeder traffic, through alliances and other business arrangements. If this trend continues, distinguishing between full service carrier airports and low cost, secondary airports will make increasingly less sense.

Multi-hub operations sometimes work. Air France-KLM's twin hubbing out of Schiphol and Charles-de-Gaulle was underpinned by State assurances³ (between the Dutch government and Air France-KLM) to help safeguard Schiphol's role as an international hub. The arrangements appear to be durable both because of the size of the local markets and because there is sufficient difference in the largest origin-destination markets between the two cities, influenced by language, colonial history and specialization of local industry. There is thus scope for specialization without foregoing too many of the benefits of centralizing at a single hub. It is not clear this would work in London as it is a single, if very large, local market.

The number of discontinued hubs is large and growing. Hubs do not always work and losing hub status is often irreversible, although London faces a negligible risk in this respect. In practice, London has a very strong foundation of O/D traffic and the current hub operator competes with another airline on most of the destinations that it serves, a situation which is likely to persist whatever decisions are made on additional capacity at the London airports.

4. MEASURING AND VALUING CONNECTIVITY

The contribution of aviation to connectivity for a region or a country is determined by what destinations can be reached and under what conditions, both for passengers and for freight. More destinations, more direct flights, higher frequency and better reliability all contribute to improved connectivity. It is straightforward that additional capacity can enable better connectivity, at least at congested airports where capacity constraints inhibit the development of airline networks. The more difficult question is whether the benefit is worth the cost of the additional capacity.

In highly competitive air travel markets it is reasonable to assume that airlines more or less make the best use of available capacity, given prevailing demand and that fares are in line with marginal (and average) costs. Under these conditions fares are a good indicator of the marginal benefit of connectivity and standard approaches to estimating economic surplus can be applied. The marginal costs of capacity expansion can be compared to willingness to pay to evaluate the desirability of adding capacity; and the decision on how to use any new capacity can be left to the airlines. The practical challenges in predicting the effect of capacity constraints on future fare levels in different markets need to be recognized.

3. These assurances included the guarantee that Air France-KLM would continue to operate 42 intercontinental 'key destinations' out of Amsterdam for a period of five years.

Airline decisions on capacity allocation will be guided by passengers' or shippers' valuation of different ways of using the capacity. Customers pay for a service, of which the quality depends on several dimensions. Some of these relate directly to connectivity in the sense of increasing the supply of air services for existing destinations or adding new destinations. In order to understand the value of connectivity, it is useful to consider customers' valuation of these separate aspects.

For example, in a model for the USA, Israel, Keating, Rubinfeld and Willig (2012), analyse passengers' valuation of 'route level inconvenience' (the time it takes to get from an origin to a destination relative to the preferred departure time) and 'airport-level network breadth' (the number of direct and one-stop destinations from an airport on a particular airline). The estimates suggest that halving inconvenience (from, say, 6 to 3 hours) is equivalent in value to the passenger to a 7% reduction of the average fare. Adding 25 more destinations has a similar value. The analysis found that the willingness-to-pay for improved connectivity is high enough that quality adjusted fares often are lower at hub airports (where quality dimensions like airport-level network breadth are high) than at airports offering lower quality. Thus hub premiums sometimes reflect a situation where a large hub offers a superior product at a higher price.

There are several reasons why in practice the simple rule of inferring marginal social benefits from fares may not apply. For example, fares can deviate from marginal costs because there is market power, or because there is capacity dumping, or because slots are not put to best possible use for strategic reasons. Careful cost-benefit analysis will attempt to include corrections for these issues where needed. A broader question, however, is whether direct benefits (accruing to airlines and airports and fully or partially passed through to customers via ticket prices) reflect the full benefit to productivity and economic growth of improved connectivity or whether, to the contrary, there are additional benefits. If such wider benefits exist, and are of significant size, then it is possible that more capacity is justifiable than is suggested by direct benefits.

An extensive body of research evidence demonstrates the critical importance of transport (and good transport infrastructure) for productivity and growth (see Crafts (2009) for an overview). The research suggests that, in many cases, the benefits to productivity and growth from better transport links can be measured reasonably well on the basis of the improved prices and service quality to travellers and shippers (see Crafts (2009), Eddington (2006) and HEATCO (2006) for a discussion). But this is not always the case; in particular the research evidence shows that investments in transport links to the central business districts of major cities may show significant additional productivity benefits due to:

- Agglomeration economies. That is, the benefits of knowledge spill overs, access to a wider labour market and access to a wider range of suppliers which firms might realize from being located closer together. In some sense, these benefits might be seen as analogous to the kinds of network externalities seen in the telecoms industry.
- More effective product market competition.
- Improved labour supply (where there will be the benefits of an increased tax take, as well as benefits to the individuals concerned).

In one case, London's Crossrail, these additional productivity impacts were estimated to add broadly 50% to the economic benefits of the project (within a range, reflecting

uncertainties in the evidence, of between broadly 25% and 75%). This is very probably an exceptional, although important, example (see Worsley (2011)).

Not all of the above factors will be relevant in the case of aviation, not for example, improved labour supply. But it is possible that some additional productivity benefits might be expected, for example the economic benefit of reduced international trade costs. However, there is not, at present, a body of accepted research evidence to suggest whether these additional productivity benefits might be significant, or how large they might be, see again Crafts (2009) and HEATCO (2006).

A recent report by the Airports Commission (2013b) looks at the evidence on connectivity for the UK. A report by NERA (2010) looks at additional benefits. The NERA study identifies the potential productivity gain associated with exporting as a potentially important channel through which improved connectivity can generate economic benefits but expresses doubt on the extent to which such benefits are additional. If firms take account of the gains in decisions to start exporting, the benefits are not additional to direct user benefits. If they do not take these into account, then there are wider benefits. Combined with (scarce) evidence on the size of the productivity effects, estimates of the wider economic benefits range from zero to moderately small (around 10% of the direct benefits).

Arguably, even the high end estimates of wider economic benefits from connectivity are below the implicit valuation put on connectivity at the strategic level by some governments. At some airports, airlines may not be in a position to sustain the existing level of connectivity in a context of strong and heavily price-oriented competition. In such circumstances, if government continues to view connectivity as a strategic asset it will need to be funded through non-fare channels. Interestingly, the London Crossrail project (discussed above) is being partly funded through a supplementary tax levied on businesses in London's CBD. The projected tax receipts are of a broadly similar scale to some of the estimates of agglomeration benefits (see Worsley (2011)). There is a need for more evidence on what the value of such additional productivity benefits might be in the case of additional airport capacity and this is currently an active field of research (see, for example, the workshop organized by GARS-IATA in 2013).

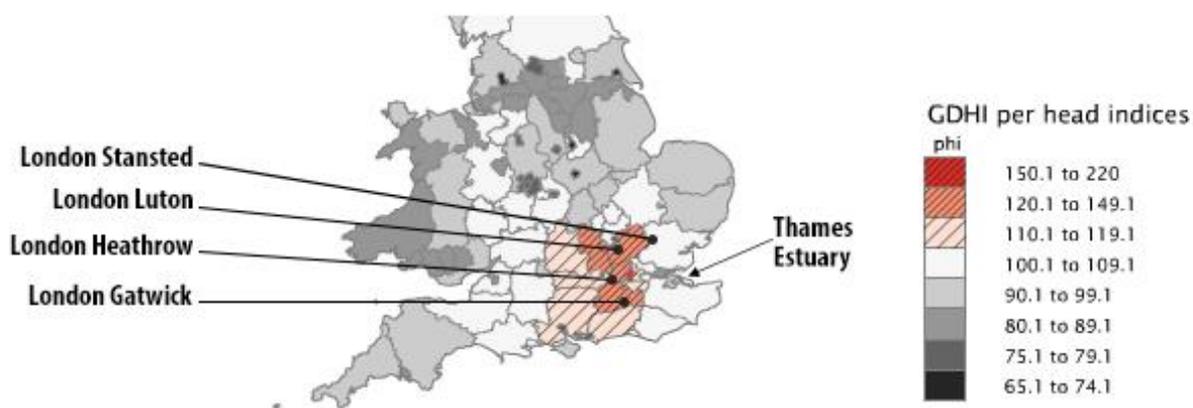
The main network carrier operating out of Heathrow, British Airways determines which destinations to serve with the slots available to it according to profitability. Profitability is a good indicator that the direct connections are worthwhile to the London economy as well as to BA as long as connectivity benefits are internalised in ticket prices to a broadly similar degree and the quasi-market in slots works reasonably well. If adding to the frequency of flights to destinations already served is more profitable than adding a new destination for direct flights, this is likely to be the better outcome for London (as well as BA).

A large expansion at Heathrow would probably result in the addition of new O/D services whose viability is dependent on hub economies, and which might therefore not arise as a result of expansion of a secondary airport. Because of hubbing economies, BA (and its alliance partners) can add services to new destinations at lower O/D demand levels than other airlines operating out of London airports. The scale of its Heathrow operations makes BA more competitive than network carriers operating secondary hubs in Heathrow. If a third runway is built at Heathrow, this advantage will be maintained (subject to any possible diseconomies of scale of the kind discussed in the preceding section). If capacity were to be doubled in Gatwick, Luton or Stansted, with no third runway at Heathrow, a rival hub operation might be able to compete with BA, especially if airport charges were

lower than at Heathrow. It would need to reach critical hubbing mass by competing for traffic in the most profitable existing markets and only then would it be able to support services to new O/D markets that depend on hubbing economies to be viable. Any such new hub would have to compete for traffic not only with Heathrow, but also with other major European hubs (particularly Paris, Frankfurt and Amsterdam).

One way a second hub airport at an existing or new airport location might emerge is if surface access links were better for a significant part of the local O/D market than Heathrow. This would be analogous to the division of the New York market between Newark airport on the west side of the Hudson River, which has much better accessibility from New Jersey, and JFK and La Guardia airports to the east. However, the London area is not marked by any such physical divide, and accessibility depends on the main road network across the south-east region and connection with London's surface and underground rail network. Heathrow's location may give it some advantages over other sites (depending on surface access costs) in terms of accessibility to centres of economic activity and to higher income households, as Figure 3 illustrates.

Figure 3. **Principal London Airports and Geographic Distribution of Gross Disposable Household Income in 2011** (GDHI indices, UK average = 100)



Source: ONS Regional Accounts.

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5. COMPARING THE POSITIVE AND NEGATIVE IMPACTS OF AIRPORT EXPANSION

Evaluating economic impacts and gauging net benefits facilitates making good public policy decisions on how much, where, and when to invest in airport capacity. Producing such evaluations is challenging and care needs to be taken that the tools used are fit for purpose and address key concerns in the decision-making process. The case studies considered at the Roundtable show that three main methods have been used in practice.

The first method, Impact Analysis, is based on input-output analysis and aims to describe the likely effects of an investment on broader economic activity. Input-output models sketch linkages between different sectors of the economy, and so provide insight into the changes in activity levels in these sectors when there is an exogenous change to supply or costs in a particular sector. In their simplest form, input-output models assume that all activity triggered by the exogenous change is additional, i.e. if the change does not take place the resources used would be idle and have no opportunity cost. This is a tenuous assumption at best and although it does not necessarily mean input-output analysis cannot be used for describing impacts, it does indicate that the method is not suited for analysing economic benefits. In the extreme, if resources have no alternative use, then using more inputs is always better (see Niemeier, 2013) and all forthcoming demand is worth serving, which is clearly not a useful principle for decisions on infrastructure capacity or any other project. Other concerns with simple input-output analysis include the use of linear models which tend to inflate multiplier effects⁴ and, typically, a regional focus which tends to ignore the importance of displacement of economic activity.

The second approach, Cost-Benefit Analysis (CBA), is specifically designed to estimate a project's net benefits, by comparing costs and benefits now and in the future. The approach is routinely used in the context of transport infrastructure decisions and is particularly suitable for comparing alternative projects, e.g. alternative ways of increasing infrastructure capacity. The evaluation of benefits focuses on 'direct impacts', i.e. the value to transport users of the improvement in services which is facilitated by the investment. These direct impacts are not limited to time savings, but in many cases these constitute the bulk of the direct benefits. Apart from continuing refinements in the evaluation of direct benefits, recent developments in cost-benefit analysis focus on 'wider economic benefits', i.e. benefits that are additional to those occurring directly in transport markets. Within these wider benefits, productivity gains associated with increased accessibility of economic mass (that are not already captured in the direct benefits) are of key interest. For example, estimates for Crossrail and for the Grand Paris metro project find that these productivity benefits increase the direct benefits by around a half (within a range of uncertainty of between broadly 25% and 75%).⁵ However, although the consideration of such wider economic benefits is recognised in the HEATCO (2006) and also in the UK guidelines it is

4. Cf. e.g. Grady P. and R.A. Muller, 1988,

5. This increase of more than 50% is found by adding the pure agglomeration benefits and the tax revenue impact of the move to more productive jobs (see Worsley, 2011).

not always recognised in the cost benefit guidelines for other countries (see Mackie and Worsley (2013)).

Applying cost-benefit analysis (with evaluation of any wider economic benefits) is likely to differentiate between the various alternatives for airport capacity expansion, including the do-nothing scenario, and will therefore be useful. Limits to the method obviously exist, but they are well understood (if not easy to overcome). Including the wider economic benefits is relevant, because the potential for agglomeration economies can differ between the different options. If relocating an airport is difficult, relocating the economic fabric around it is even more so, and the potential productivity impacts should not be ignored. Cost-benefit analysis for airport expansion will need to address the impacts of the various options on connectivity. This is largely uncharted terrain but is a central concern and necessitates an expansion of the standard toolkit for cost-benefit analysis when examining the expansion of major airports.

Cost-benefit analysis starts from and focuses on the transport project itself, although the technique is being extended to cover broader economic effects. Other tools have complementary functions, notably, computable general equilibrium (CGE) models. This is the third relevant approach to evaluation. These models typically work with more stylized representations of transport supply but are better suited to analysing the transmission of changes in transport conditions throughout the economy at large. They work in a framework that is compatible with the logic of cost-benefit assessment (in contrast to input-output models). Forsyth (2013) advocates combined use of CGE and CBA to establish a comprehensive picture of the economic costs and benefits of various options for airport expansion as, more generally, does HEATCO (2006).

The use of CBA in preparing investment decisions is sometimes questioned: why are decisions on, for example, major industrial infrastructure subject to only financial and environmental appraisal and not to broader CBA? A simple answer would be that planning requires CBA for public investment decisions. But this raises the question is there any good reason to introduce this requirement? The answer is yes. If government is to take a decision it should do so based on information relevant to its role, which is to enhance overall welfare and this is precisely what CBA sets out to test. Commercial feasibility may be compatible with a welfare perspective, but does not have to be, so commercial evaluation (combined with assessment of environmental impacts) is not necessarily sufficient.

6. ENVIRONMENTAL CONSTRAINTS AND ENVIRONMENTAL ASSESSMENT

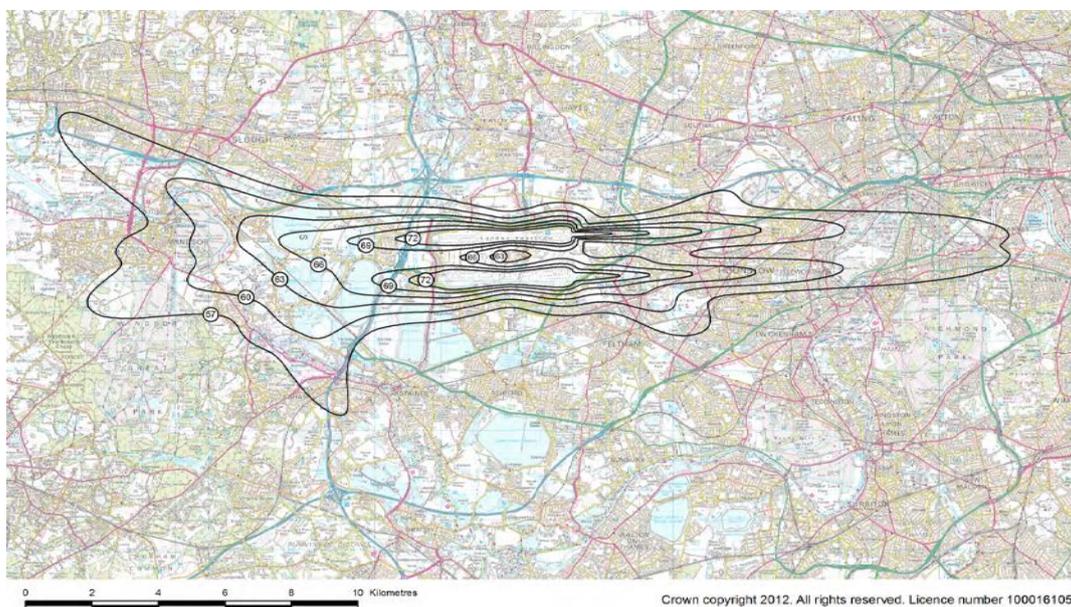
The environmental impacts are usually the main cost of airport expansion (apart, of course, from the costs of construction and operation). These impacts include noise, local air pollution, loss of wildlife habitats and landscapes, and greenhouse gas emissions. Each of these has their individual characteristics and they each raise different issues for airport expansion. Accordingly, we will consider each in turn. But more generally, the potential significance of these impacts means that it will usually be important to carry out an environmental assessment of the different options for expansion. It will also be important to include valuations of the environmental impacts in a cost-benefit analysis – recognizing the uncertainties in the research evidence and in its utilization. And it will be important to understand the consequences for those people, often relatively small in number in comparison with the numbers using the airport, who might face significant environmental costs.

Noise nuisance is the key constraint on expansion for most airports. National practice varies as to the metrics used to measure noise nuisance and on the levels used as benchmarks (see Airports Commission 2013e for a discussion of different metrics and of the different types of dis-benefit which might result from aircraft noise).

In some circumstances – for example, in relation to relatively noisy aircraft at night – quantity restrictions will often be a preferable approach to limiting noise nuisance, see Hepburn (2006) for a discussion of the situations where quantity restrictions might be expected to be more efficient than pricing measures, and vice versa. In more general circumstances, recent research evidence suggests that households typically experience some, small, dis-benefits at quite low levels of noise exposure and that this dis-benefit rises incrementally at increasing levels of noise exposure – but with no evidence of any particular tipping points, see MVA (2007). In these circumstances, restrictions based on noise budgets will usually be more efficient than restrictions based on air traffic movements, see the Roundtable paper from Hans-Martin Niemeier.

At Heathrow, exposure to aircraft noise is usually measured by the number people living and working in the footprint determined by the 57 dBA Leq contour for noise under typical flight patterns (Figure 1). Careful management of flight paths on the approach to airports can reduce the footprint. Where prevailing winds require the use of two sets of runways along different axes, or reversal of the direction of take-off and landing, noise nuisance patterns vary with the weather.

Figure 1. **Noise Exposure Contours for Heathrow Airport 2011**
(57-72 dBA Leq contours)



Source: ERCD 2012.

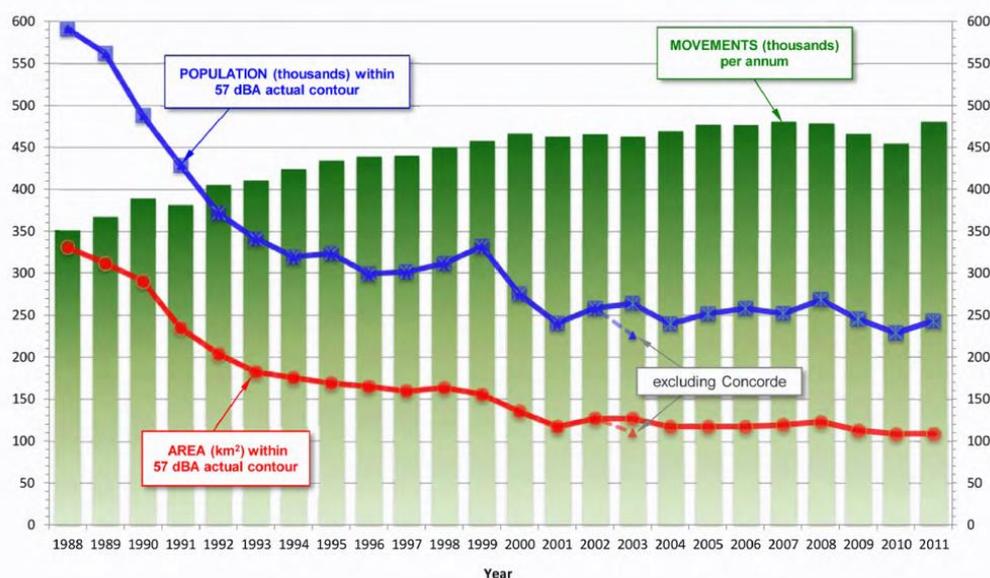
Table 1. **Population Living within Key Aircraft Noise Contours, 2006**

	Noise level	Area km ²	Dwellings	Population
Heathrow	>55 Lden	244.7	314,350	725,500
	57 Leq	117.4	109,700	258,500
Gatwick	>55 Lden	94.5	4,700	11,900
	57 Leq	44.0	1,550	3,700

Sources: Heathrow 2011; Gatwick 2010.

Aircraft have become substantially quieter over time as a result of technological improvement and regulation. Figure 2 illustrates the change in exposure to noise around Heathrow over a period of time during which the number of aircraft movements increased by 35%. In 1980, as many as 2 million people were exposed to 57 dBA Leq or more (see Heathrow 2011). This suggests that noise levels for many people around Heathrow are lower than 20 or 30 years ago (although with little change during the last ten years, during which time a number of those concerned will have re-located to the area). The European Union requires airports to develop noise action plans and requires noise monitoring using 55 dBA 'Lden' noise contours. These measure noise over a 24 hour period, weighting noise occurring during the more sensitive evenings and night periods more heavily in the calculation. Table 1 summarises noise exposure around two of London's airports, illustrating the extent to which location determines noise nuisance; Heathrow sees around 1.85 times the aircraft movements of Gatwick but noise nuisance affects 60 times as many people.

Figure 2. **Heathrow traffic, noise contour area and population affected (1988-2011)**



Source: ERCD 2012.

Noise action plans can cover a range of measures to reduce or ameliorate noise impacts (see Airports Commission 2013e for a discussion):

- Limiting or banning evening and night-time flights, or restricting them to ultra-quiet aircraft;
- Negotiating with airlines to withdraw old, relatively noisy aircraft;
- Differentiating landing fees by type of aircraft according to noise characteristics;
- Aligning flight paths for take-off and landing to avoid densely populated zones;
- Establishing flight paths for aircraft taking off so that they climb to reduce noise at ground level as quickly as possible – fining airlines when individual aircraft exceed departure noise limits at monitoring stations located under flight paths;
- Exploring steeper descents and take-offs to minimise noise footprints;
- Introducing new practices for aircraft whilst on taxiways/aprons to reduce ground running noise, e.g. wheel tugs (the pilot can shut off the engines and an inbuilt electric motor powers the aircraft to/from the stand).

Measures taken at one airport can affect others. Withdrawing old, noisy planes from one airport might lead them to be used at other airports. But to some extent other airports will benefit from measures at a major airport that incentivise the use of quieter aircraft. Widespread adoption of noise-differentiated landing fees will incentivise airlines to buy quieter aircraft, and stimulate manufacturers to improve aircraft and engine design.

Local air pollution is also a factor in decisions over expansion for major airports. Many have agreed strategies to cut emissions from aircraft, airport operations and access traffic. A small number, including Zurich, have experimented with cap and trade emission bubble

systems, setting an absolute reduction target and distributing efforts to meet the target according to where mitigation is least costly. NO_x emissions are the main air quality issue for aircraft. Air quality standards for NO₂ are regularly breached in many large metropolitan areas. Chronic non-attainment of air quality standards could be a reason for airport expansion plans to be refused planning consent. A parallel might be drawn with the freeze on terminal development plans in the maritime ports of Long Beach and Los Angeles until levels of airborne particulate matter are reduced in the Los Angeles basin, see Giuliano and O'Brien (2008).

Policies towards climate change may also influence airport expansions in the future. Climate policies where they exist usually allow for an expansion of aviation. This is because aviation currently accounts for only a small fraction of overall transport emissions and an even smaller proportion of all greenhouse gas emissions from combustion. The rate of growth of aviation is relatively fast but greenhouse gas emissions from aviation are likely to continue to account for a smaller share of transport sector emissions in 2050 than those from vehicle traffic (see ITF/OECD (2012) and Airports Commission (2013c)). Adoption of widely recognised greenhouse gas mitigation policies for aviation, such as emissions trading systems, might make airport expansion less of an issue for climate change policy, although this is far from certain. The European Union's emissions trading system for aircraft using EU airports is currently suspended (for flights outside the EU) in the face of opposition from countries outside the Union. The use of air passenger taxes would usually be a less efficient way of limiting greenhouse gas emissions from aviation. Whilst a fixed tax per passenger will reduce overall demand for air travel somewhat, by making travel more expensive, such a tax would have no steering effect whatsoever in the market; it would provide no incentive to use more fuel efficient aircraft, optimise flight paths or carry more passengers per plane. Greenhouse gas mitigation measures, including taxes and charges, need to focus on achieving these technological and logistical responses if they are to be effective (see Keen and Strand (2006 and 2007) for a more general discussion of air passenger taxes). Indirect approaches to limiting greenhouse gas emissions, such as limiting capacity at major airports, will be less effective than many other potential measures (see Sentance (2009) and Airports Commission (2013c) for a discussion).

Environmental impacts on wildlife and landscapes are often a less important issue, but can be significant in cases where there are risks to rare or endangered species. Coastal sites, in particular, may encroach on significant birdlife habitat. The site initially chosen for a new Lisbon airport in 1971, Rio Frio 40 km south of the city, was rejected because it would have involved felling 50 000 cork oaks, a protected species and habitat (Partidario 2009).

The subsequent evolution of decisions for expanding airport capacity in Lisbon illustrates the potential value of an environmental assessment in determining locations for new airports. A site was selected in 1982 at Ota, 40 km north of the city, on the basis of land availability. The hydrology of the site, however, required expensive civil engineering works threatening the commercial case for the new airport. This prompted the business community to launch a strategic study of the region in 2007 to see if other sites might be identified on the basis of criteria of population, regional development, land transport access, environmental impact, and suitability as a location for commercial and industrial activity. This identified a military firing range, Campo de Tiro de Alcochete which is closer to the city, as the optimal location (subject to ending the military lease). The government commissioned its own environmental assessment, confirming the result. This then seems set to be the site for a new Lisbon airport although the financial crisis has postponed plans

for its development, with more efficient use of the existing airport at Portela as the current focus.

EU legislation requires environmental assessment of major transport projects, plans and programmes. Amongst other things, it requires project variants and intermodal alternatives to be assessed for economic and environmental impacts. In practice, the main impact of this has been to steer new transport infrastructure to locate along existing transport corridors wherever possible (ECMT 2004). This reduces “sprawl” of the inevitable negative impacts of transport infrastructure.

7. AN APPROACH TOWARD DEVELOPING, PHASING AND CO-ORDINATING AIRPORT EXPANSION

7.1. Getting the most out of existing airport capacity

Given that airport expansion is often so contentious and difficult to implement, there is potentially significant value, particularly in times of austerity, from measures which aim to get the most out of existing assets – in terms of utilization, economic value and environmental impact. The case studies not only suggest various possibilities but also indicate scope – sometimes prospectively significant scope – to do more.

Getting the most out of existing capacity is likely to involve both operational measures – to squeeze higher passenger throughput out of existing assets – and also pricing (or slot allocation) measures to get the best economic value (and sometimes environmental value) out of the feasible passenger throughput. The discussion which follows considers each of these kinds of measure in turn.

At 15 million passengers per year, London’s airports were close to capacity when the 1968 Roskill Inquiry into options for expansion was launched. It identified a potential site for a new airport at Cublington, 65 km NW of the centre of the city, with a minority report recommending an offshore site at Maplin Sands, 70 km east. Forty five years later the airports are still operating at the limits of capacity, but carry 115 million passengers a year (Kay 2012). Terminal buildings have been added, much larger planes introduced and seat occupancy rates enhanced. Patterns of runway use have been optimized and air traffic management improved. The role of hitherto smaller airports in the London region (particularly Stansted) has been significantly enhanced.

Trials of further modifications to the use of Heathrow’s twin runways are underway but the margins for further expansion without runway additions here and/or at Gatwick and/or Stansted are tight. Gatwick is the busiest single runway airport in the world. Airports elsewhere have seen similar patterns of getting more capacity out of existing runways. The next generation of air traffic control, with plane-to-plane communications technology, promises further gains although perhaps not as significant as once expected; the increment expected at New York from the introduction of the so-called Next Gen technology has recently been revised downwards (see Jeffrey Zupan’s paper for the Roundtable).

Runway capacity translates into the numbers of potential plane movements per hour. Capacity can be increased by optimizing the mix and grouping of different types of aircraft using the runway. Larger planes - carrying more passengers - increase the passenger capacity of the airport, although the largest planes require greater separation because of turbulence in their wake, with smaller aircraft being most affected by wake turbulence. General aviation (light aircraft and executive jets) consume many times more runway capacity per passenger than commercial aviation. Under many regulatory regimes, with weight-based charges, they pay much less than commercial aircraft per take-off. Where pricing has been reformed to charge in relation to the value of each aircraft movement to the airport (from landing charges and passenger charges), general aviation has been priced out of the main airports, for example at Heathrow and in New York.

New York's airports are served by much smaller planes on average than Europe's main airports (see the Roundtable paper from Jeffrey Zupan). This reflects the number of connections to domestic destinations with relatively low passenger densities. It might also suggest that there is greater potential to increase airport capacity in New York, through increasing plane sizes, than in Europe's hub airports (although any such conclusion needs to take account of the differences between the types of aircraft used in long-haul and in short-haul markets).

Runway capacity is often limited by agreements and regulations to limit noise. For example, these can impose a limit to the number of take-offs and landings per hour, or impose a noise budget, or a night time curfew, constraining usage well below technical capacity. At Frankfurt, for example, flight restrictions for the airport were introduced that limited the full utilisation of the recent expansion in airport capacity (see the Roundtable paper from Hans-Martin Niemeier). The benefit realized from the additional capacity was in handling aircraft movements in periods of peak demand during the day, reducing delays from congestion. Clearly restrictions could be relaxed in the future to expand capacity without further investment if, for example, aircraft become substantially quieter (or, whilst considered unlikely, if the local community were to change its attitude to the trade-off between noise and economic activity). Heathrow is subject to a night time curfew and to a noise management strategy that limits total capacity.

Whilst some of the various measures discussed above might act to increase utilization, and the numbers of flights accommodated, equally important is achieving good economic value from the flights that are handled. Key questions here concern how air-side services are priced and how slots for take-off and landing are allocated.

Pricing in relation to congestion is generally resisted by airlines as they see it as a way of extracting economic rent from them rather than managing demand. It has therefore not often been used. Heathrow airport experimented with several approaches to pricing, opposed in court by US airlines. Boston airport has been authorized by the Federal Aviation Authority (FAA) to use peak pricing, should delays exceed a pre-determined level, on condition that revenues would be spent on airport enhancements. For a significant impact on congestion, however, prices would have to be set so high that, short of constructing new runways, it might be difficult to spend the revenues. Sydney appears more likely than other airports to price demand as it is not only permitted under the regulatory regime applied to the airport but was employed prior to addition of its third runway.

Capacity can also be managed by trading slots. A market for trading slots would certainly be more efficient than rationing capacity through delays. At present, however, the use of trading at congested airports is patchy and embryonic - being better established in

the UK than elsewhere⁶. Slot trading, or more probably peak pricing, could be used under the regulatory framework in Sydney to manage excess demand efficiently.

The allocation of slots often determines capacity at busy airports. Allocation has usually been determined on the basis of the number of slots being used by each airline when rationing is introduced (grandfathering). Provision for new entrants is usually made when new capacity is added or an existing user withdraws from the airport or ceases to operate.⁷ Slots that go unused get re-allocated. Slots are valuable assets, particularly at congested airports. They can sometimes be sold by one airline to another⁸, but as noted above the use of trading at congested airports is still embryonic. The potential to get the most economic value out of available capacity through slot allocation hence is not exploited. Even where trading is possible, airlines holding slots may prefer not to give them up or sell them to competitors in order to protect their market position, even when demand falls. Thus the impact at New York's airports of Amtrak improving its services from New York to east coast cities, taking passengers from airlines, was the use of smaller aircraft rather than a reduction in aircraft movements, as airlines prioritized using slots to retain ownership, a practice sometimes referred to as 'baby-sitting' of slots (Zupan (2013)).

In the USA, the primary purpose of introducing slot controls, at a small number of congested airports, was to preserve the reliability of airport operations. US airports generally operate closer to the absolute capacity of the air traffic management system than European airports. They handle the congestion that inevitably results through unscheduled delays. Delays at a major airport have a knock-on effect in the destination airports served; thus delays in New York cause delays in Chicago later in the day and so on. The US FAA introduced slot limits to contain this knock-on effect. There are, however, unintended negative effects from slot allocation, including slot hoarding to prevent competition and unnecessary limitation of runway capacity at airports where delays are primarily the result of knock-on effects from other airports. Periodic review of US policy aims to mitigate such perverse effects but revisions are infrequent.

Slot allocation is also used outside the US to ration airport capacity in busy airports and similarly risks undermining efficiency by creating incentives to hoard underutilized slots. For an efficient outcome, both efficient slot allocation and an efficient price for landing are needed – the same price for all users (apart from terminal use prices) – see Forsyth and Niemeier (2008).

Differentiated pricing of airside services – reflecting the balance between demand and capacity – might, in principle, achieve finer tuning and a dynamic response to changes in the market. The issue it would raise, however, is how revenues should be spent, at least when investment in new runways is not possible because of physical or planning constraints. This is a more visible and therefore more contentious manifestation of the slot rents that exist today.

6 Airport Coordination Limited operates a web-based trading system for slots at Heathrow (slottrade.aero).

7 At Heathrow, 50% of new capacity is allocated to "new entrants" (i.e. airlines that operate on fewer than 4 flights a week from Heathrow).

8. In February 2013, for example, Jet Airways sold its three pairs of Heathrow slots for US\$70 million to Etihad Airways in a sale and lease back agreement, part of a wider commercial partnership including code sharing. Jet Airways will continue to use the slots for its flights from London to Mumbai and Delhi.

Slot rents complicate the incentives towards expansion of airport capacity in an environment where interests between airports, airlines and the users of airline service do not always coincide. As slots are allocated free of charge rather than sold or auctioned, rents accrue to airlines rather than airports. Expansion of runway capacity undermines the value of existing slots.

At hub airports, incentives towards expansion to cater for hubbing services are also complicated by differences in the way airports generate income and apply charges to airlines. Transit passengers generate somewhat less income for the airport than passengers originating or ending their trip at the airport since transit passengers are generally subject to lower air passenger charges. The extent to which such lower charges correspond to lower costs is unclear, as for example baggage processing costs are high for transferring passengers. They also do not generate car parking revenues, which account for a major share of total income for many airports. But on the other hand, transfer passengers are essential for airlines operating hub and spoke operations and enable higher frequencies or larger aircraft or higher occupancy rates on trunk routes, enhancing the competitive position of the both the carrier and the airport and potentially contributing to their profits. Hubbing airlines need to concentrate a large part of their flights on a single airport and the size of their investments in terminal facilities make it difficult to move. Airlines offering mainly point to point services, including most of today's low cost carriers, are more indifferent as to which airport they use. In cases where a city is served by several airports, these airlines can often credibly threaten to switch to where charges are lowest.

Incumbent airlines holding slots profit when airport capacity is short, as they can operate at high load factors where there is excess demand, raise fares and swap economy cabin space for business cabin capacity. The incentives for the airport in these circumstances will depend on the extent to which revenues are shared with the airline, over and above air passenger charges, and on the regulatory context. Airports and airlines make joint investments in terminals in some cases, resulting in more convergent incentives.

The framework for getting the most out of existing airport capacity, where the regulatory framework allows use of all potential pricing and slot trading options, can be summarized as follows:

- Squeeze more out of existing runway capacity through improved air traffic management and optimised landing and take-off patterns (see the Roundtable paper by Katsuhiko Yamaguchi for a discussion of continuous improvement or "KAIZEN") ;
- Price general aviation to reflect the cost of scarce capacity at congested commercial airports – rather than setting a lower price for smaller aircraft (for example, through using weight based charges) – so only those putting a high value on access remain;
- Use differentiated pricing for air-side services, or slot auctioning and trading, both so as to manage demand at the peaks, but also so as to get the best economic value out of scarce airport capacity; as noted, however, slots do carry risks of anti-competitive hoarding unless time limited.

7.2. Reviewing a wide range of possibilities for adding to capacity

Investments in airport runways and terminals are sometimes lumpy; and sometimes they are made infrequently in large indivisible units. This makes planning expansion

complicated and financially risky and can result in long periods of excess demand followed by periods of excess capacity. Failing to expand airport capacity can have a high cost in terms of lost economic opportunities for airlines and for the economy served by the airport but premature expansion can also have high costs (although perhaps not as great in some cases). Sequencing expansion can reduce these risks. And using pricing and regulatory instruments can (as described above) manage congestion ahead of the point at which a new runway is built or be used to optimize the use of existing airports before building a new airport. The instruments used to help get the best economic value out of existing capacity can also provide indications on the right timing of any expansion.

The development of Sydney airport illustrates the range of options in a regulatory environment that permits the use of pricing to manage demand (see Peter Forsyth's paper to the Roundtable). Locations for a second Sydney airport on a larger site, with fewer people living under flight paths, were examined in the 1970s. In 1986, the Australian Government announced that a location at Badgery Creek, about 45 km west of Sydney's CBD, had been chosen as the site for a second major airport for Sydney. A site of approximately 1 700 hectares was subsequently acquired between 1986 and 1991. However, it was eventually decided that the advantages of the existing airport, located approximately 10km south west of the CBD, outweighed the advantages of the selected new site, which was located substantially further from the CBD. As a result, a third runway was added to the existing airport in 1995. Demand has since grown to a point where there is some congestion at peak hours. Together with concern over noise, this has prompted another search for a site for a potential new airport, identified at Wilton, located considerably further from the CBD than the previous proposal – reflecting the outward spread of the suburbs in the intervening years.

Sydney airport is subject to a light-handed approach to regulation that permits a range of responses to congestion. The airport could simply allow delays to ration capacity but this is unlikely as the airport is free to set air-side charges as it sees fit, subject to monitoring by the competition authorities (the Productivity Commission and the ACCC). Airlines can also go to court if they believe they have a case to make against the airport for over-charging, using provisions of competition law relating to access to essential facilities. The Productivity Commission has recognized that it might be appropriate for airports to charge high prices if this is needed for efficiency (PC 2002). There are now insufficient slots in Sydney at peak times. Average delays increase from 6 to 12 minutes in the peaks and some airlines are unable to find slots at the preferred time. Pricing was used to manage congestion before the third runway was built, through minimum charges for all aircraft, thus discouraging smaller aircraft, ending when the new runway was commissioned. Pricing could be reintroduced.

There are some additional options for optimizing the use of Sydney airport with parallels elsewhere. Regional services using small aircraft enjoy privileged access to the airport through a quota of slots reserved for their use. This could be discontinued, auctioning the slots to carriers serving larger markets, with regional flights transferred to a nearby airport, Bankstown, currently serving general aviation. Surface access to Bankstown is poor despite the relatively short distance to the CBD and proximity to the main airport. Despite its limitations, some transfer of regional services appears likely in order to liberate capacity at the main airport. There is also an air force base with a moderately long runway at Richmond, further out from the CBD. This might provide a suitable site for a second airport, perhaps for low cost operations. At the main airport, runway capacity might conceivably be added through further land reclamation in the bay (although at present this seems unlikely).

In summary, a review of options for expanding airport capacity could include some or all of the following:

- Develop secondary airports, or share military runways, in the region for low cost airline operations, with airport development tailored to the needs of this market segment.
- Add short runways at the main airport, or close by, to free capacity on existing runways for long-haul traffic.
- Add long runway(s) at the main airport(s).
- Develop an additional, or replacement, main airport

As Sydney illustrates, the processes is cyclical and ideal options rarely exist. Unless the existing hub airport is closed when a new, larger airport is built coordination is difficult and outcomes unpredictable and unstable.

7.3. Coordinating Operations between Old and New Airports

Persuading airlines – and particularly network airlines – to switch operations to a new site is difficult if the existing, more conveniently located, airport is not closed. Slot pricing and trading might have some potential for coordinating the use of the existing airport with a second airport and lower landing charges at a new airport would encourage some carriers to transfer operations, although there is often pressure to recover investment quickly at a new airport through high charges. Policies on traffic allocation may in some countries be circumscribed by local regulatory rules. This is the case in the European Union, where the European Commission must be notified if a set of airports is to be treated as an airport system and, in the interests of preserving competition, certain conditions have to be met for coordination of traffic to be allowed. In Sydney, current thinking sees a second airport as a base for lower cost carriers rather than as a substitute hub for network service operators. Also prices tend to be lower at old airports – they tend not to cover their long run costs (including the opportunity cost of land).

There are strong reasons for airlines to prefer the existing airport if it is not closed when a larger airport is commissioned on a new site. Not only are they likely to have sunk investments at the existing airport but also invested in relations with a network of local suppliers. For air freight, the logistics companies established around the airport are a critical factor. Heathrow carries a third of UK exports by value and 63% of freight tonnes handled at UK airports. More generally, businesses generating passengers will have located around the airport and along the roads serving the airport. For an airport like Heathrow, large numbers of international companies have located headquarters in areas accessible to the airport. Airlines need to stay close to their customers. Closing the airport to force relocation can have severe effects on the economy of the districts most accessible to it, although it should be acknowledged that any such airport closure would necessarily need to be planned and implemented over a relatively long period of time.

A number of major cities have opened new hub airports and moved airline operations to the new site by largely closing the existing airport to international traffic. Tokyo, Osaka and Seoul all did this as noise nuisance made expanding the existing airports located close to the CBDs problematic. In the cases of Tokyo and Seoul, however, services to international destinations in the region have since resumed at the older airports, driven by the convenience of downtown locations for business travellers in particular. Using Gimpo

and Haneda instead of Incheon and Narita to travel from central Seoul to central Tokyo cuts the overall trip from five to three and a half hours for business travellers.

The redevelopment of Haneda airport for international flights has been particularly striking. In the 1970s the airport's small site at a river mouth on Tokyo Bay was constrained by port activity and noise nuisance from planes passing over the CBD. Narita airport was built 45 km away from the CBD and Haneda restricted to domestic flights. A decline in inner port activity and the use of the bay for landfill to dispose of refuse created a large area that could be reclaimed for expansion of the airport. Pressure from businesses to operate more flights from Haneda, and from the main domestic operator ANA to enter the international market from its base at Haneda, resulted in two new runways being built. Noise impacts on Tokyo have been limited by offsetting the runways from the standard orientation dictated by the direction of prevailing winds. A few degrees rotation towards the bay allows flights to take off and land largely over water (see Katsuhiko Yamaguchi's Roundtable paper). Slots for international flights have been awarded to Haneda, exploiting its night time availability in particular (Narita is subject to a curfew). Haneda has capacity to take many more international flights but expansion has been limited in response to concern on the part of local governments over potential loss of business at Narita.

There is relatively little transfer traffic in either of Tokyo's airports, partly because of high domestic and international point to point demand, partly because of high transfer prices and, until recently, generally high costs because of the strong Yen. Separating domestic from international flights also undermined connectivity in Tokyo and Osaka. Whilst Haneda served all domestic airports, Narita operated connecting flights to only a few major cities. Osaka's airports are in similar position. Perhaps in part because of this, some passengers have chosen routes through hubs outside Japan; for example, Korea's Incheon International airport provides international connections to regional airports in Japan. However, the numbers of passengers involved seem to have been quite small. There is, nevertheless, evidence that some of this transfer traffic has reverted to Haneda since the re-introduction of international scheduled operations there (Hayashi 2013; Sugitani and Tansai 2010).

Japan's two main airlines ANA and JAL base their hub operations at Haneda and Narita respectively. Allowing Haneda more international slots will improve the competitiveness of Haneda over rival hub airports in Asia and most likely benefit ANA. The return of international scheduled flights at Haneda has triggered a strategic response from Narita, leading to a fifty percent increase in annual landing slots by 2015 (see Katsuhiko Yamaguchi's Roundtable paper). Award of the 2020 Olympic Games to Tokyo in September 2013 prompted the government to examine options to add slots at both airports, including a possible fifth runway at Haneda⁹.

In most cases where cities have multiple airports they tend to serve different market segments, with one providing capacity for network service carriers to operate a hub and others catering mainly to low cost carriers, charter flights, regional aviation and other point to point services. Cities where two airports support hubs for network carriers are unusual. The New York region seems to be an exception, although it can be argued that the two main airports largely serve spatially separate markets on the landward side, east and west of the Hudson river (see Jeffrey Zupan's Roundtable paper).

9. <http://english.kyodonews.jp/news/2013/09/245573.html>

Haneda may be an exception because of the unforeseen benefits of its location – where the high cost of landfill for off-shore development was reduced by the city’s waste disposal policy – but it illustrates the unpredictability inherent in coordinating old and new airports when the old airport is not closed down entirely. In Montreal a new hub airport, Mirabel, was opened in 1975 fifty minutes’ drive from the CBD; the largest airport in the world at the time. Slots for international flights were withdrawn from the existing Dorval airport, 20 minutes’ drive from the CBD. Public pressure prevented the planned closure of Dorval, which was less expensive and more convenient to use for domestic flights. Passengers taking connecting flights between the two airports were faced with a long bus ride. Passenger numbers did not increase as forecast at Mirabel and international flights were reinstated at Dorval in 1997. Mirabel now only serves freight and general aviation.

In Hong Kong in contrast, the inner-city Kai Tak airport was completely closed when the new airport on Lantau Island was opened with its direct road and rail links to the CBD. The very central location of Kai Tak resulted in rapid redevelopment for prime real estate. In Berlin, the inner-city Tempelhof airport has been closed down and Tegel will close when the new, expanded Brandenburg International Airport on the site of Schoenefeld airport is opened (see the paper to the Roundtable by Niemeier). Berlin saw a drawn-out planning debate over alternative uses for the Tempelhof site but coordination in Berlin presents fewer problems than in London; Tegel is not a hub airport and access to the City centre will be no worse at the new airport than Tegel because of investment in road and rail links to the site, which is only 18 km from the CBD.

The process of building a consensus on development of transport infrastructure with the business community is illustrated by the GBP 15.9 billion Crossrail investment, linking west London to the city centre and the financial centres of the City and Docklands (located towards the east). The local business community agreed to the introduction of a supplementary tax on commercial property to cover a quarter of the cost. Reaching this agreement ended three decades of delay in finding finance for the project. Although the business community (represented by London First) is equally convinced that expansion of London’s airport capacity is needed, and financing is available for a third runway at Heathrow, aligning airport, airline and business interests on transferring hub operations to a new site at a cost of GBP 40-50 billion or higher would be far more difficult.

In Sydney, the airport’s owners have first right of refusal for developing a second airport. It is, however, far from clear that they would exercise this option if a second site were to be chosen as it is not clear that the government would require closure of the existing airport (and in practice this appears unlikely). The right was awarded when the airport was sold so as to protect the price from planning risk. The airport was sold for about five billion AUD whilst bids without the guarantee were expected to be considerably lower. It might be possible to align Heathrow’s interests with expansion on a new site through such an arrangement, although Heathrow’s owners were recently forced to sell Gatwick and Stansted by the competition authorities. Expansion at Stansted in the late 1980s was financed on the basis of profits at Heathrow while the two were both owned by BAA Plc. Closure of Heathrow would otherwise require compensation, with Heathrow currently valued at around £10 billion on the basis of its regulatory asset base.

Osaka’s airports face familiar problems of coordination. The Itami inner city airport, which is constrained by its noise footprint, saw flights restricted when the new, offshore Kansai International Airport was opened. Itami continues to serve as a major domestic airport at Osaka because of the convenience of its location while Kansai International provides a wide range of services, including LCC and global air cargo, taking advantage of

its 24-hour operability. Ownership of the two airports was integrated in 2013 to simplify coordination ahead of plans to lease the airports to a private operator. The effect of airport integration is already manifest. For instance, the airport company has reached an agreement with local government to allow Itami slots which were previously limited to turbo-props to be utilized by low-noise turbo jets. Coordination has been complicated, however, by the construction of a third airport in the region in the port of Kobe. The site had been considered as a location for Kansai International and rejected. The 1995 Kobe earthquake overturned regional planning decisions and the go-ahead was given for the airport as part of the reconstruction and economic stimulus package for the city.

Airport planning decisions can also be overtaken by changes in the airline business, including emerging business models like LCC as well as mergers and alliances. They could also be affected by the development of high-speed rail networks.

7.4. Evidence based comparison of the likely impacts – economic, environmental and social – of the most promising options

The case studies show that there are no universally applicable conclusions on which options for increasing capacity are likely to work best in practice; this will be shaped by the interplay of local geography, the structure of the local economy, and the structure of airline networks at individual locations.

This suggests that it will be important to carry out evidence based comparisons of the likely impacts (economic, environmental and social) of the most promising options. Different approaches used in practice were discussed in part 5 above. This discussion suggested that cost-benefit analysis (perhaps supplemented by CGE) provides an approach which is well grounded in the available research evidence, and its practical application, and which aims to cover the main positive and negative impacts of airport expansion. However, the significant uncertainties in some parts of the evidence base need to be reflected, and then tested, through a suitable range of realistic scenarios. Given these uncertainties, it is important that the analysis is transparent, impartial, validated by expert peer review and reviewed with key stakeholders – with the aim that, in this way, the findings command broad acceptance.

7.5. Flexible strategic planning

Decisions on investment in additional airport capacity face significant uncertainties – in relation both to demand and also to various components of costs and benefits – and this suggests there are likely to be benefits in a flexible approach to expansion. But additional capacity often involves large, long-lived, sunk investments and these characteristics – together with co-ordination issues, particularly with surface access and air traffic control – require detailed strategic planning. There is an obvious dilemma here – too much focus on detailed planning, with insufficient regard to the uncertainties, carries the risks of getting the level of capacity wrong (with either over-building or under-building, and additional costs either way). On the other hand too much focus on flexibility risks ineffective delivery (with time and/or cost over-runs) through failure to adequately plan through the complexities of construction and co-ordination. Burghouwt (2007) characterizes this as the three-fold dilemma of airport planning and suggests that flexible strategic planning provides an approach to resolving this dilemma (see Kay (2010) for a more general discussion of some of these issues). In essence flexible strategic planning involves four stages:

- looking at investment proposals across a range of scenarios for the key uncertainties;
- including proposals which are incremental and/or have flexibility to add/subtract capacity;
- comparing these proposals over the full range of scenarios;
- and reviewing plans as new information becomes available.

As far as scenarios are concerned, firstly, the earlier discussion noted key uncertainties in the demand forecasts and these should obviously be reflected in the scenarios. But there will often also be significant uncertainties in at least some of the benefits and costs. For example, in relation to environmental costs there may be uncertainties on valuations (e.g. in relation to greenhouse emissions) and/or in relation to impact (e.g. in relation to the future utilization of quieter aircraft). Or, in relation to productivity and economic growth there may, for example, be uncertainties in the development and impact of new communications technologies. Some of these risks might be managed, at least partially, through vertical contracts between airports and key customer airlines (see Starkie (2008) for a discussion) – although, to some degree, these will concern managing endogenous risks and risk-sharing, rather than managing exogenous risks.

Second, as far as flexible capacity is concerned, the basic idea is to include investment proposals which either are incremental and/or which provide options to expand or contract capacity as circumstances develop. See Burghouwt (2007) for a case study of Amsterdam airport.

Third, comparing the different investment proposals across the range of scenarios using cost-benefit analysis (and perhaps CGE) will help to establish the potential value of flexibility. Those investment proposals which have built-in flexibility – to expand or to contract a margin of capacity – will generally be more expensive; and so they will tend to perform less well on the central forecasting scenarios. The key question is then whether their flexibility helps them to perform sufficiently well on the less central scenarios so as to suggest that the extra costs of flexibility are worthwhile. Thus it may turn out that the best option is not the one that performs best on the central scenarios but rather the one which performs reasonably well across a range of scenarios (sometimes referred to as multi-future robustness). Formal techniques – such as real options analysis – may be useful to supplement cost-benefit analysis in answering this question, although these methods often have significant information requirements and may be difficult to implement in practice. Again see Burghouwt (2007) for a discussion and also Transportation Research Board (2012).

Finally, it can be expected that new, and better, information on many of the key uncertainties will become available over the timescales of planning and development. So it will usually be worthwhile to review and revise plans at key staging points. It will, however, be important to schedule these reviews for points when there are significant forks in the road, and/or significant new information, and not to unnecessarily exacerbate uncertainty through frequent, unscheduled re-consideration.

7.6. Protecting the interests of those most at risk of significant (negative) environmental impacts

The case studies show that the potential for negative environmental impacts often acts as a major constraint on airport expansion. Particularly important are circumstances where

there are some people, often small in number compared with the numbers using the airport, for whom the potential environmental costs are significant (for example, in terms of night time noise or the loss of valued wildlife habitats). Even where, in aggregate terms, these costs are relatively small in comparison with the other costs and benefits of airport expansion, these impacts can result in significant public opposition to expansion. It is understandable that those at risk will usually oppose expansion. But what the case studies suggest is that these circumstances often result in a more general sense of unfairness (to those at risk) and that this in turn can prompt more widespread opposition to expansion.

Resolving this problem in a satisfactory way will often be critically important to successfully implementing airport expansion. Solutions will need to provide for an outcome which is generally perceived to be fair, whilst at the same time seeking to achieve the best value utilisation of the airport's capacity; the potential conflict between these twin objectives means that this is far from straightforward.

As discussed in part 6, a solution regarded as fair is likely to involve some blend of:

- assuring present levels of environmental benefit and devising airport expansion around these (for example assuring pre-existing levels of noise or local air pollution);
- providing alternative – equivalent – benefit, where this is feasible (for example, replacement wildlife habitats);
- providing amelioration (for example noise insulation);
- and providing compensation (for example buying-out severely affected households).

Getting the best value utilisation of capacity – the second half of the twin objective – will likely involve (as discussed in part 6) some blend of restrictions on quantities (e.g. night flights by relatively noisy aircraft) and restrictions on prices (e.g. noise budgets or emissions budgets for local air pollution).

Solutions will need to be tailored to the distinctive local circumstances and, for this reason, will often be complex.

7.7. Providing the right investment incentives

Evidence on the pattern of airport investment shows a mixed picture. In many cases, there are examples of too much capacity being provided at some locations, coupled with too little capacity in other locations, often where it is most needed (see the discussion in the paper for the Roundtable by Professor Niemeier). This suggests scope for improving the efficiency of investment in additional airport capacity. Improved investment incentives should also help with the difficult public policy choices on new airport capacity, both by enhancing the range and quality of the solutions that are proposed and by enhancing the depth and robustness of their supporting evidence. Getting the right investment incentives is, however, far from straightforward. In particular, there may be problems associated with:

- the risks of stranded sunk assets, a risk which may in turn inhibit investment (the time-consistency problem);

- external costs (particularly environmental impacts) and/or benefits (particularly impacts on productivity and economic growth);
- monopoly, or market power, in circumstances where the urban geography and configuration of airline networks make the development of competing airport facilities problematic.

On the first problem – stranded assets - monopoly supply has sometimes been seen to be a solution – by providing greater certainty on prospective returns. In the UK, this was, to some degree, reflected in the approach to public ownership of the utilities in the second half of the 20th century (see Helm (2009) for a discussion). And it was similarly reflected, in part, in the decision to privatize the three main London airports under common ownership (an approach which it was thought would help facilitate investment in additional capacity).

In practice, this doesn't seem to have worked out as expected. The UK's competition authorities have concluded that the monopoly arrangements provided inadequate incentives for investment in additional capacity (Competition Commission (2009)). They concluded that, instead, the separation of the ownership of the main London airports, to provide the opportunity for competition between them, would provide more effective investment incentives. In the rest of the UK, competition between airports has been allowed to develop, where feasible, and this seems to have worked reasonably effectively, see Starkie (2008). In particular, investment in new capacity has generally been carried forward where there has been market demand; the time-consistency problem has been resolved through long term contracts between airports and key customer airlines (again see Starkie (2008)) whilst the incidence of over-provision is relatively low compared with many other European countries (on which see Professor Niemeier's Roundtable paper). Of course, long term vertical contracts may carry the risk of anti-competitive restrictions, although the risks are likely to be lower where an airport faces effective competition, which is also where, correspondingly, the risks of stranding are greatest. Nevertheless, competition authorities will need to be vigilant and transparency will be important.

On the second problem – the possibility that external benefits and/or costs may be important – there is at the least a role for a public planning framework to consider and resolve conflicting interests. Experience with the London Crossrail project suggests a route toward at least partially internalizing some of the impacts on productivity and growth which cannot be captured in commercial revenues. And experience in the ports and waterways sectors in Europe shows how internalisation might be approximated for some important environmental impacts, as do noise-related charges at some airports. However, it is likely that some of the relevant impacts will prove more difficult to internalize in the case of airports. Nevertheless, better alignment of interests has the prospective advantage of focusing resources on the creative development of shared solutions (again the ports and waterways experience is relevant, see for example ECMT 2006) rather than the development of competing, and inflated, claims of benefit or cost (as graphically outlined in Professor Niemeier's paper) which become both difficult and contentious for public policy makers to resolve.

The third issue – monopoly or market power – is particularly relevant to airports in major urban areas. Even where feasible steps are taken to facilitate competition, this may be partly or largely precluded by the interface between the urban geography and airline networks at a particular location. In these circumstances, the regulatory controls hold the

key to investment incentives. In broad terms, there are three different models which have been used to regulate airports in cases where market power is an issue:

- Light-handed regulation,
- Rate-of-return regulation,
- Price-cap regulation.

Light handed regulation – as practiced at Sydney airport, for example – essentially involves allowing the airport to set its own structure of charges, subject to some scrutiny by the authorities (see the paper presented to the Roundtable by Peter Forsyth for a discussion). This approach is judged to have worked reasonably well in circumstances where there is a margin of spare capacity – by allowing the airport some flexibility to set the level and structure of prices so as to respond to developments in market demand. However, a key question is whether this approach will provide the right incentives to invest in additional infrastructure as capacity margins tighten. Or whether, alternatively, both the airport and the main incumbent airlines will see an advantage in delaying investment. There must be some doubt about whether light handed regulation will provide the right investment incentives in these circumstances (again see Forsyth (2013) for a discussion).

It is these concerns that have motivated the adoption of more prescriptive regulation of prices at many large airports. The second approach – rate-of-return regulation – provides strong incentives to invest, by warranting the returns to the investment through the price the airport is allowed to charge for its services. The concern here is that this risks excessive levels of investment (or of gold plating) and of promoting inefficient levels of costs.

The third approach – simple price-cap regulation – provides incentives for cost efficiency but at the risk of inadequate incentives to invest.

Research on the implementation of regulation in the airports sector confirms that these concerns have arisen in practice (see Oum, Zhang, and Zhang (2004)). In cases where rate-of-return regulation has been adopted, there is evidence of over-investment and higher costs. Price-cap regulation, on the other hand, tends to be associated with more efficient levels of costs, but also with under-investment. There was insufficient experience with light handed regulation at the time of the study to test its impact empirically.

The question this raises is whether it is possible to modify the application of price-cap regulation so as to provide adequate incentives to invest – an issue discussed by Helm (2009) who makes three suggestions:

- That the calculation of the periodic price cap is based on a regulatory asset base; this resolves the time-consistency (stranded asset) problem in a regulated setting and is becoming increasingly common practice in the implementation of price-cap regulation
- That the calculations of the price cap are based on a split rate of return – a higher (ex-ante) rate for prospective new investment (to reflect the project risks) and a lower rate for established assets. The basic idea here is to avoid the risk that a single rate will under-incentivise new investment whilst also over-rewarding established assets, and thereby encouraging financial engineering.

- That the rate provided on established assets is indexed to the market rather than pre-specified.

In addition, the study by Oum, Zhang and Zhang (2004) suggests that a dual-till approach – essentially accounting for airside and retailing activities separately – provides better incentives for investment and for productivity than a single till approach.

This discussion perhaps also suggests that once a major addition to capacity has taken place, followed by a period with a margin of spare capacity, then light-handed regulation would be preferred to enable the airport to structure its prices to make the best use of capacity; once, over time, capacity margins tighten a case could be made for re-introducing a price cap based on split rates of return.

7.8. Legitimacy of planning decisions and the costs of inconsistency

Many airports in large metropolitan areas suffer long planning delays when expansion is proposed. For example, the paper to the Roundtable on Germany (Niemeier 2013) notes periods of 13 years for Munich and 24 years for Dusseldorf. Deliberations often span decades and political commitments to add runways or to restrict flights are susceptible to being overturned in time. The legitimacy of decision is frequently challenged by protests. Nimbyism¹⁰ is inevitable, as while the benefits of air travel are broadly spread, the negative externalities are concentrated narrowly on the areas neighbouring airports. A sufficiently large number of political constituencies may be affected by noise from large airports close to city centres for opposition to expansion to become a sensitive national political issue. The more extreme, “build absolutely nothing anywhere near anything/anybody” (BANANA), view point gains ground when ineffective procedures undermine the legitimacy of decision making. Legitimacy rests on at least four factors:

- The credibility of demand forecasts. Forecasting with models which overstate demand, and over time tend to be unreliable and biased, will lose credibility if they are not improved.
- The corresponding credibility of financial and economic analysis. The commercial, financial case needs to be assessed as does cost-benefit analysis. Care needs to be taken in assessing wider economic effects to be accounted for in addition to the direct economic benefits included in CBA to identify the impacts on productivity at a sufficient level of detail to understand the mechanisms at play, so as not to overstate benefits.
- Environmental impact assessment is required so as to enable local impacts to be considered in a broader regional or even national context, with a thorough evaluation of alternative options.
- Public consultation is essential. It needs to start with the local community most affected and start early. The most successful consultations begin by involving the public in identifying a full range of alternative options so that to some extent they take ownership of the problems to be solved. Without a basis in early consultation, formal mediation and inquiry procedures in the final stages of the decision making process can suffer from the impression that the decision has already been taken barring revelation of some striking new evidence.

10. Not in my back yard.

Of course, over long time periods the political environment changes, including in relation to environmental concerns. Even the best environmental assessment and public consultation procedures cannot produce agreements that guarantee conditions for coordinated airport expansions over decades. Niemeier (2013), however, documents the costly effects of inconsistency. Plans for a third runway at Lufthansa's hub in Frankfurt were delayed 22 years and subject to violent protest, opening only in 1984. The difficulties led Lufthansa to develop a second hub at Munich when its new airport opened in 1992. The airport is located 28 km from Munich so that noise affects few people. Munich was originally planned for 4 runways, but this was reduced to 2 by the time it opened in 1992. Plans for a third runway were finally rejected by public referendum in 2012. Meanwhile Frankfurt airport launched an open ended consultation with the public and business interests on the future of the airport in 1998 that led to the opening of a fourth runway (and introduction of a strict night curfew) in 2011. Had the more inclusive planning environment been established earlier in Frankfurt, Lufthansa would probably have foregone a second German hub and the costs and dilution of hub economies associated with it. Had it been able to foresee the growth of opposition to airport operations in Munich it would surely have remained concentrated in Frankfurt.

BIBLIOGRAPHY

Note: Listed below are the references explicitly cited in this summary overview; a wider range of research evidence underpins the five input papers prepared for the Roundtable, and is referenced in each of these papers.

Airports Commission 2013a, Discussion Paper 01: Aviation Demand Forecasting, February 2013.

Airports Commission 2013b, Discussion Paper 02: Aviation Connectivity and the Economy, March 2013.

Airports Commission 2013c, Discussion Paper 03: Aviation and Climate Change, April 2013.

Airports Commission 2013d, Discussion Paper 04: Airport Operational Models, May 2013.

Airports Commission 2013e, Discussion Paper 05: Aviation Noise, July 2013.

Burghouwt, G., 2007, Airline Network Developments in Europe and Its Implications for Airport Planning, Ashgate.

Burghouwt, G., 2013, Airport Capacity Expansion Strategies in the Era of Airline Multi-hub Networks, Discussion Paper 2013-5, International Transport Forum, OECD Paris 2013.

Competition Commission, 2009, BAA Airports Market Investigation: Final Report, London, The Stationery Office.

Crafts, N. 2009, Transport Infrastructure Investment: Implications for Growth and Productivity, Oxford Review of Economic Policy 25(3) 327-43.

ECMT 2004, Assessment and Decision Making for Sustainable Transport, OECD Paris 2004.

ECMT 2006, Inland Waterways and Environmental Protection, OECD Paris 2006.

Eddington, R. 2006, The Eddington Transport Study, December, London, The Stationery Office.

ERCD 2012, ERCD report 1201, Noise Exposure Contours for Heathrow Airport, 2011, Lee, Edmonds, Patel and Rhodes, Prepared by the Civil Aviation Authority on behalf of the Department for Transport, September 2012.

Flyvbjerg, B. 2009, Survival of the Unfittest: Why the Worst Infrastructure Gets Built – and What We Can Do About It, Oxford Review of Economic Policy 25(3) 344-67.

Forsyth, P., 2013, Air Capacity for Sydney, Discussion Paper 2013-2, International Transport Forum, OECD Paris 2013.

- GARS – IATA 2013, German Aviation Research Society Workshop in co-operation with IATA “The Effects of Air Transport on the Economy – How can we Evaluate Them?” 20th June 2013, Amsterdam
- Gatwick 2010, Noise Action Plan 2010-2015, Gatwick Airport June 2010.
- Giuliano and O’Brien 2008, Responding to Increasing Port-Related Freight Volumes: Lessons from Los Angeles/Long Beach and other US Ports and Hinterlands, OECD/ITF Roundtable Discussion Paper No. 2008-12, March 2008.
- Goodwin, P. 2012, Peak Travel, Peak Car and the Future of Mobility, OECD/ITF Roundtable Discussion Paper No. 2012-13.
- Grady P. and R.A. Muller, 1988, On the use and misuse of input-output based impact analysis in evaluation, *The Canadian Journal of Program Evaluation*, 3, 2,49-61.
- HEATCO, 2006, Developing Harmonised European Approaches for Transport Costing and Project Assessment, IER, Germany.
- Heathrow 2011, Heathrow Noise Action Plan, Heathrow Airport May 2011.
- Helm, D. 2009, Infrastructure investment, the cost of capital and regulation: an assessment, *Oxford Review of Economic Policy* 25(3) 307-26.
- Helm, D and C. Hepburn 2011, The economic analysis of bio-diversity: an assessment, *Oxford Review of Economic Policy* 28 1-21.
- Hepburn, C. 2006, Regulation by Prices or Quantities or Both: A Review of Instrument Choice, *Oxford Review of Economic Policy* 22(2) 226-47.
- Hyashi, T., et al. 2013, Study on the Effect of Internationalization of Haneda Airport, *Transport Policy Studies* Vol.16 No.2 Summer 2013.
- Israel M., B. Keating, D. Rubinfeld, and R. Willig, 2012, Airline network effects & consumer welfare, mimeo.
- ITF/OECD 2013, Long run trends in travel demand.
- ITF/OECD 2012, Transport Outlook 2012: Seamless Transport for Greener Growth.
- Kay, J A. 2012, London’s new airport held to ransom by folly, *Financial Times*, 7 November 2012.
- Kay, J A. 2010, *Obliquity*, Profile Books.
- Keen, M and J Strand 2006, IMF Working Paper, Fiscal Affairs Department, Indirect Taxes on International Aviation.
- Keen, M and J. Strand 2007, Indirect Taxes on International Aviation, *Fiscal Studies*, 28.
- NERA 2010, Representing International Business Impacts in Transport Appraisal – Report for the Department for Transport, NERA Economic Consulting.

- Niemeier, H-M., Expanding Airport Capacity under Constraints in Large Urban Areas: the German Experience, Discussion Paper 2013-4, International Transport Forum, OECD Paris 2013.
- Mackie, P and T. Worsley (2013) International Comparisons of Transport Appraisal Practice: Overview Report. ITS Leeds.
- Morrison, S. A. and C Winston (1986), The economic effects of airline deregulation, Brookings Institution.
- MVA Consultancy. 2007, Attitudes to Noise from Aviation Sources in England; Final Report for the Department of Transport.
- Oum, T. H., X Fu and A Zhang. 2009, Air transport Liberalisation and its Impacts on Airline Competition and Air Passenger Traffic, ITF 2009 Forum, Forum Papers.
- Oum, T. H., A Zhang and Y Zhang 2004, Alternative Forms of Economic Regulation and their Efficiency Implications for Airports, Journal of Transport Economics and Policy, Volume 38, Part 2 217-246.
- Partidario 2009, Does SEA Change Outcomes?, Partidario, M., Instituto Superior Technico, Portugal, Discussion Paper 2009-31, International Transport Forum, OECD Paris 2009.
- Productivity Commission 2002, Price Regulation of Airport Services, Report No. 19, Ausfino Canberra.
- Sentance, A. 2009, Developing transport infrastructure for the Low Carbon Society, Oxford Review of Economic Policy 25(3) 391-410
- Starkie, D. 2008, The Airport Industry in a Competitive Environment: A United Kingdom Perspective, OECD/ITF JTRC Discussion Paper No 2008-15.
- Sugitani, A. and Tansei, K. 2010, Transition and Present Situation of International Routes and Passengers from Local Airports, Technical Note 603, National Institute for Land and Infrastructure Management, Ministry of Land, Infrastructure, Transport and Tourism, June 2010.
- Transportation Research Board, Washington DC, 2012, Addressing Uncertainty about Future Airport Activity Levels in Airport Decision Making, Airport Cooperative Research Programme Report 76.
- Worsley, T. 2011, The Evolution of London's Crossrail Scheme and the Development of the Department of Transport's Economic Appraisal Methods, OECD/ITF JTRC Discussion Paper 2011-27.
- Yamaguchi, K., Evolution of Metropolitan Airports in Japan, Discussion Paper 2013-3, International Transport Forum, OECD Paris 2013.
- Zupan, J., 2013, Upgrading to World Class: The Future of the New York Region's Airports, Discussion Paper 2013-1, International Transport Forum, OECD Paris 2013.

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