# The Economics of Airport Expansion

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# Summary


## Introduction

Over the years there have been numerous debates on the expansion of London's airports. The Davies Commission is currently examining 'the scale and timing of any requirement for additional capacity to maintain the UK's position as Europe's most important aviation hub'. The RSPB, WWF-UK and HACAN want to engage in the process, ensuring that a proper methodological framework is used for assessing the different options.

They have asked CE Delft to propose a general framework for assessing airport expansion and new airport development projects, based on best practices and academic research. Special attention is paid to one of the least understood elements in such a framework: connectivity.

## Social cost benefit framework

A social cost benefit analysis (SCBA) is the most appropriate way to evaluate airport investment plans. It provides an overview of current and future pros and cons of a particular project for society as a whole (public, private sector and government) as objectively as possible. SCBA therefore differs fundamentally from a financial analysis or business case, which identifies the costs and benefits solely for a particular party.

The use of SCBAs is common practice in the UK and many other countries. The *Transport Assessment Guideline (TAG)* specifies how an SCBA of an airport investment project should be conducted. The main items are transport efficiency, time savings, investment costs and noise. Most of the effects are direct (i.e. accruing to the providers and users of airport infrastructure) or external (i.e. not included in the cost price of airports). In well-functioning markets, indirect effects (e.g. effects on suppliers of airports) should not be counted, as they are passed through by either the producers or the consumers as part of their costs and benefits.

Although economically incorrect, indirect costs are often included in commonly used frameworks, which inevitably leads to double counting by adding direct, indirect, induced and catalytic effects of aviation.

SCBAs should take into account any risks and uncertainties that might occur. A major source of uncertainty in airport projects is the forecast of future demand for aviation. Past experience has shown that these forecasts have been systematically too high, their use consequently leading to overestimation of the main benefits of aviation (transport efficiency and time savings).

## The benefits of connectivity

Among the wider economic benefits of airport expansion are the impacts on productivity: agglomeration effects, output change, changes in labour market supply and the move to more or less productive jobs. These are often captured under the term 'benefits of connectivity'. They provide one of the main arguments employed in the public debate on airport expansion, and studies have been published which claim the benefits of expanding London's airports will be very large for the capital as well as for the country as a whole.

Connectivity is defined as the degree to which a country or city is linked to other destinations and the ease or speed with which those destinations can be reached. All modes of transport are relevant in this regard, as well as transport replacement options.

A comparative analysis of the aviation network of the main European hubs (Heathrow, Paris, Frankfurt, Amsterdam) reveals that Heathrow has fewer destinations than other hubs and that the number of destinations is not rising as fast as at other airports. However, Heathrow offers a high frequency of flights to the destinations it serves. It appears that Heathrow's network is much more specialised on the most profitable routes.

The relationship between connectivity and GDP has not been studied in much detail in the academic literature. Even less is known about the possible existence of a causal relation between connectivity and economic growth, trade or other relevant economic parameters. The available empirical evidence suggests there is a weak correlation, mostly for less developed economies, but there is no evidence of causation.

The relation between aviation activity and economic performance has attracted more attention. A review of the academic literature suggests there is a two-way causal relation between aviation activity and regional economic performance, with an increase in aviation activity causing an increase in GDP, and vice versa. This relation appears to be stronger for remote regions and stronger for poorer regions and countries than for well-developed ones. When reviewing this evidence, one should be aware that the method used to establish a causal relation cannot establish whether airports cause additional economic activity per se, or whether regions with airports grow at the expense or surrounding regions without airports.

## Conclusion

This study provides a transparent framework for (social) cost benefit analysis of airport expansion and new airport development projects. It is extremely important that all types of effects are included in the CBA and to avoid any double counting by including indirect effects. This means that considerable effort is needed to evaluate the type of effects that can be expected to occur and to appropriately include them in the CBA.

Many studies find a positive correlation between aviation and economic growth, but no causal relationship between connectivity and economic growth was found. The positive effect of aviation on economic growth appears to be stronger for remote and poor regions than for central, well-developed ones. It is not clear whether this effect is truly additional, or whether regions with airports grow at the expense of other regions.

# 1 Introduction

## 1.1 Background

For many years there has been discussion on the capacity and expansion of London's airports. The current debate is on whether or not capacity should be increased at these airports, and if so, where this additional capacity should be placed. The main options for expansion are to build a third runway at Heathrow airport, an additional runway at another London airport or a new airport in the Thames Estuary. Proponents of airport expansion claim that current capacity is insufficient and that expansion is needed for economic growth. Opponents, on the other hand, question the lack of capacity and the presumed large benefits to the economy. They argue that expansion is unnecessary, will lead to major costs and result in more noise and environmental pollution.

The UK government has therefore established an Airport Commission to "examine the scale and timing of any requirement for additional capacity to maintain the UK's position as Europe's most important aviation hub". The Commission is to report in two stages. By the end of 2013 it will report on the steps needed to maintain the UK's hub status and how to improve use of existing capacity over the next five years, and by 2015 it will report on its assessment of the options for meeting the UK's international connectivity needs. For its work, the commission will seek stakeholder input.

The RSPB, WWF-UK and HACAN want to engage with the Commission, ensuring that a proper methodological framework is used for assessing the different options. Based on best practices and academic research, this report proposes such a framework. Furthermore, it investigates the relationship between expansion, connectivity and economic growth.

## 1.2 Objective

The aim of the study is to propose a general framework for assessing airport expansion and new airport development projects, and to propose a methodology to analyse the impact of one of the least understood and often neglected elements of such a framework: connectivity.

## 1.3 Research question

The two main questions that this study aims to answer are as follows:

1. What framework should be used to assess the economic impacts of airport investment projects?
   - Which of the costs and benefits that are included in current cost benefit analysis (CBA) frameworks should be taken into account in airport investment projects?
   - What are the likely differences in costs and benefits between airport expansion and new airport development?

2. Does airport expansion lead to increased capacity, more connectivity and more economic growth?
   - What is the relationship between capacity and connectivity?
   - What is the relationship between connectivity and economic growth?

## 1.4 Scope

This study focuses on potential airport investment projects in South-East England, considering two types of airport project: expansion of existing airports and new airport development. This report is not an investment analysis, but rather an analysis of the costs and benefits that need to be taken into account to estimate the impact of airport expansion or new airport development for society as a whole.

The research carried out for this study is based primarily on existing literature and includes little new data analysis. An analysis of optimisation of airport capacity is therefore beyond the scope of the present project. Nevertheless, the report contains many elements that could be useful for such an analysis.

## 1.5 Outline

Chapter 2 provides an answer to the question of what framework should be used to conduct a proper CBA of airport investment projects. Chapter 3 studies the relation between airport capacity, connectivity and growth. Chapter 4 concludes with the findings of the study.

# 2 Assessment of the economic impacts of airport investments

## 2.1 Introduction

This chapter analyses how the impacts of airport investment projects can be assessed. A (social) cost benefit analysis (CBA) is the most appropriate way to do so and is common practice in the UK and many other countries. We compare the UK guidelines for CBAs with two other guidelines and apply the methodology to airport expansion and new airport development projects.

## 2.2 Assessing economic impacts of airport investments: cost benefit analysis

A CBA is defined as 'an evaluation method that can be used to consider the impact of policy decisions'. It provides an overview of current and future pros and cons of a particular investment or policy project for society as a whole as objectively as possible. It is based on a broad definition of the term welfare and includes public, private and government benefits and costs[1]. CBA therefore differs fundamentally from a financial analysis (business case), which reveals the costs and benefits solely for a particular party.

A CBA typically comprises of four steps:
1. The project and the baseline scenarios are defined. If project alternatives exist, all relevant alternatives are defined.
2. The effects of the project are identified.
3. Each effect is quantified.
4. Where possible, effects are monetised.

### Monetised CBA

Whereas some effects, like increased employment, are usually expressed in monetary terms, others are not. Impacts such as: noise, biodiversity or regional inequality are more difficult to express in monetary values because they are not commonly traded in markets. In a monetised CBA, only monetised effects are included – meaning non-monetised impacts have an implied price of zero. In order to correct for bias against non-market goods, and because non-monetised effects are certainly of importance, several accepted methodologies have been developed to monetise these effects.

### Role of CBA in the decision making process

A CBA is an important tool in the decision making process in order to prioritise the allocation of public spending. CBA is used regularly for national and regional policy making, for example in the fields of infrastructural investments (such as rail, road or aviation), river basin management, flood risk management and spatial development.

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[1] Besides goods and services, CBA takes into account intangible effects and expresses them in monetary terms. These include effects on the environment, landscape, nature and spatial quality.

The method of CBA is widely used in transport investment appraisals and other ex-ante policy evaluations both in the UK and in many other countries. They are recommended by the European Union for appraisal of infrastructure investments. In the UK, they are recommended by the UK Department for Transport (DfT) for transport appraisal.[2] Apart form CBA, there are also other inputs that play a role in the decision making process, such as distributional effects, legal aspects, public opinion, equity, fairness, employment effects.

## 2.3 CBA: Which costs and benefits are included?

CBA in UK has to be carried out according to the 'Transport Analysis Guidance', abbreviated TAG, which is published by the DfT. TAG has a separate unit for aviation appraisal (TAG Unit 3.18), which is developed for government interventions especially in the aviation industry. It sets out how aviation policies can impact national welfare and how these impacts can be appraised (DfT, 2012). This section will study the aviation appraisal in more detail and investigate which elements should be included in CBA.

Table 1 gives an overview of the different impacts that are included in the CBA for aviation investment projects by TAG. Also, a comparison is made with two other CBA guidelines that are often used abroad for (aviation) investment projects:
- OEI manual (CBP and NEI, 2000);
- Guide to CBA of the European Commission (EC, 2008).

**Table 1 Impacts included in cost benefit analysis for aviation appraisal (TAG)**

| | Economic impacts | Social impacts | Environmental impacts | Other |
|---|---|---|---|---|
| TAG | – Transport economic efficiency<br>– Time savings from delay reduction<br>– Wider economic impacts*<br>– Surface access impacts<br>– Costs<br>• Investment<br>• Maintenance<br>• Operational | – Accidents<br>– Security*<br>– Accessibility*<br>– Integration* | – Noise<br>– Air quality<br>– GHG emissions<br><br>*Non-monetised impacts:*<br>– Biodiversity*<br>– Landscape*<br>– Water*<br>– Historic heritage* | Impact on public accounts |
| **Additional effects in other CBA (but excluded from TAG)** | | | | |
| Other CBA guidelines | – Impact on property and land values<br>– Impact on other transport modalities<br>– Indirect effects on other markets<br>– Strategic effects | – Regional inequality<br>– Congestion | | |

Source: DfT (2012).
Costs and benefits marked by * are not included in monetised CBA. These impacts are regularly not expressed in monetary terms and are included in the Appraisal Summary Table (Annex C).

[2] http://www.dft.gov.uk/webtag/documents/overview/unit1.1.php.

For a more detailed comparison of the CBA guidelines, see Annex B.

The impacts of investment in aviation projects that are distinguished are economic, social, environmental, and public account. In general, the rule is to include only direct effects in CBA, unless market failures exist. In perfect markets indirect effects are internalised in the market prices and included in producer and consumer surplus. Indirect effects, catalytic and induced effects should therefore not be included in CBA. Nevertheless, these effects are often important in the public debate. More about these effects and why they should not be included in CBA will be further discussed in Section 2.7. In Annex A an overview is presented of the direct, indirect and external effects.

In the following sections, the cost benefit impacts from Table 1 are explained in more detail.

## 2.4 Economic impact

The economic impact of an airport project consists of many aspects. The CBA for aviation appraisal of TAG includes the effects on transport economic efficiency, time savings, wider economic impacts and surface access impacts. These impacts are further explained in detail below.

### Transport economic efficiency

Transport economic efficiency includes the costs and benefits to passengers, airports and airlines, such as changes in business and non-business travellers' journey time, impacts on private sector providers' revenues and costs, changes in fares and other changes in revenues. It is the change in welfare for passengers due to decreased travel time and for operators and airports due to higher net revenues from more flights.

Transport economic efficiency only changes when there is unmet demand for airport capacity[3]. Estimating unmet demand is by no means straightforward, what also appears from UK aviation forecasts of DfT, which have been continuously downgraded. Apart from uncertainty in determinants such as economic growth, oil prices and carbon prices, demand for flights and value of time varies between business and leisure travellers. It is therefore important to estimate the change in transport economic efficiency for different groups of users.[4] The topic of unmet demand is a key point in CBA for aviation investment projects, and will be further discussed in Chapter 3.

### Time savings

Expansion of an airport and hence more capacity offers more possibilities to divert to another runway when there are sudden changes in the flight schedules thereby avoiding delays. Expansion can therefore lead to time savings from delay reductions (in travelling journey time).

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[3] In case of unmet demand (demand for air travel is larger than supply), additional capacity will lead to more profits and increased welfare. In case of no unmet demand (demand is equal or lower than supply), additional capacity will nit lead to additional welfare.

[4] About 75% of passengers at Heathrow are leisure travellers yet expansion proposals are being driven by perceived business demand.

TAG prescribes the inclusion of the effects of better transport interchange on traveller journey times in monetised CBA, but excludes other transport interchange quality factors (such as waiting environment, level of facilities, level of information, etc.). Furthermore, it currently excludes reliability impacts, as the method for calculating these is still undergoing further study.

## Wider economic impacts

Wider economic impacts include the impact on agglomeration, output change, labour market supply and the move to more or less productive jobs. They are not estimated as part of the direct effects (transport user benefit) but are estimated separately. Since these effects are often large compared to other effects, but very difficult to quantify and monetise, they require careful attention.

TAG excludes wider economic impacts in the analysis of monetised CBA. The reason for this is that in perfect markets, all costs are internalised in market prices and only direct effects should be included in CBA. Indirect economic benefits (but also catalytic and induced effects) should therefore not be included in CBA, unless market failures exist.

**Wider Economic Impacts**

**Agglomeration impact**

Agglomeration refers to the concentration of economic activity in an area. Transport investments can improve the accessibility of an area for firms and workers, which affects the level of agglomeration. A higher agglomeration level affects the productivity of firms and workers in an area. Through its impact on productivity, agglomeration has an impact on welfare and Gross Domestic Product (GDP).

**Output change**

In imperfect competitive markets, production can be lower and prices can be higher compared to a competitive market. A reduction in transport costs (to business and/or freight) allows for an increase in production or output in the goods or service markets that use transport. Better transport provision may result in less congestion and enable a firm to carry out more deliveries in a day (i.e. increase output). A transport intervention that leads to an expansion of output will deliver a welfare gain as consumers of the goods and services will value any increases in production by more than the cost of the additional units of production.

**Impact on labour market supply**

Transport costs are likely to affect the overall costs and benefits to an individual from working. In deciding whether or not to work, an individual will weigh travel costs against the wage rate of the job travelled to. A change in transport costs is therefore likely to affect the incentives of individuals to work and hence the overall level of labour supplied in the economy. The level of labour supply can impact on welfare through GDP but also through benefits and disbenefits to individuals depending upon whether they like or dislike working.

**Move to more or less productive jobs**

Investment in transportation projects, such as building a new airport, can affect the incentives for firms and workers to locate and work in different locations. Employment growth or decline in different areas is likely to have implications for productivity, as workers are often more or less productive in different locations. This may have implications for UK productivity which, in turn, will impact on UK welfare.

### Surface access impacts

Surface access impacts are the effects of an investment project on new levels of traffic on contingent surface access schemes as well as the existing network. When an airport is increasing its capacity by building a new runway, it is likely that the increased capacity will lead to more flights and more passengers who need to reach the airport. This will also increase pressure on the capacity of public transportation and existing road infrastructure. This could lead to more emissions, more congestion and more accidents. Any airport development which would impact on surface access would be likely to require an appraisal. So far, however, only a surface access impact for housing development has been developed, not for aviation investment projects

### Treatment of benefits to non-UK residents

Some benefits of expansion will accrue to non-UK residents. For example, a reduction in travel costs to a foreign businessman travelling to the UK may benefit the businessman and/or his employer. Regarding the treatment of benefits to non-UK residents, TAG follows the HM Treasury's green book guidance (2003), which states that appraisals should take account of all benefits to both UK and non-UK residents[5]. It states that proposals should not proceed if, despite a net overall benefit, there is a net cost to the UK.

### Additional economic impacts included in other CBA guidelines

In contrast to other CBA guidelines, TAG does not mention the impacts on property and land values (EC DG Regional Policy, 2012). They can be positive, e.g. because office space near an airport commands a higher rent, or negative, e.g. because zoning laws prohibit using certain areas for residential buildings. Since the impact on property and land values can be substantial it would be informative to include them.

Furthermore, it appears that TAG does not include indirect effects on other markets, such as the costs and benefits to businesses in the supply chain (backward linkages), or the effects on other transport modalities (effect on rail and road transport). Other (indirect) effects which are not included are strategic effects (locational/settling factors). The welfare gain of these effects is, however, difficult to determine, and should only be included when they result in additional welfare (CBP and NEI, 2000) Including these effects requires careful attention, since there is substantial risk of double counting and overestimation of the positive effects.

## 2.4.1 Project costs

Aviation investment projects usually involve large costs. The costs that are included in CBA are investment costs, maintenance costs and operating costs:

- *Investment costs* (often referred to as capital costs) include construction costs, land and property costs and compensation, preparation and administration costs, and on-site supervision and testing.
- *Maintenance costs* are traffic related costs and include costs for reconstruction, resurfacing, surface dressing, etcetera.
- *Operating costs* are non-traffic related costs and include for example landside costs or airside costs. Landside costs are those incurred by processing passengers and cargo through terminals. Airside costs are those attributable to processing aircraft through aprons, taxiways and runways.

[5] An exception is made for international transfer passengers who simply changes planes at a UK airport.

Other costs that are included in the CBA are for risk adjustments and optimism bias. The former implies costs for risks that might occur during a project and the latter reflects the bias for estimated costs that are often too low and delivery times that are too short. See Section 2.6 for more details of how TAG copes with risk and uncertainties.

### 2.4.2 Social effects

Social impacts invoked by the introduction of a transport intervention includes the effects on communities such as cohesion, stability and services, people's way of life (how they live, work and play). TAG mentions several social effects such as accidents, security, accessibility and integration. In monetised CBA, TAG only includes the changes in numbers of accidents, excludes impacts on (personal and freight) security and integration, and subsumes the accessibility impacts to the extent that the cost benefit analysis takes account of all significant behavioural responses. These impacts appear in the Appraisal Summary Table (included in Annex C).

#### Accidents

TAG provides guidance on appraisal of accident impacts of transport interventions, since they may alter the risk of individuals being killed or injured as a result of accidents. It prescribes for monetised CBA to include changes in the numbers of accidents, but to exclude impacts on personal and freight security.

#### Security

Investment projects may affect the level of security for road users, public transport passengers and freight (all modes). The changes in security and the likely numbers of users affected are taken into account. Security indicators that are used for public transport passengers are site perimeters, entrances and exits, surveillance, lighting and visibility. However, these effects are not included in monetised CBA.

#### Accessibility

With a new airport being developed, accessibility is an important factor. The accessibility objective in TAG however, is focused on accessibility of public transportation and does not address accessibility benefits or costs from airport expansion or new airport development.

#### Integration

TAG considers the interchange of transport (modal transfers for passengers and freight from air to road, rail or sea). Furthermore, it takes into account how the investment proposal is integrated with land use proposals and policies and with proposals and policies concerning other transport modes.

#### Additional social impacts included in other CBA guidelines (but not in TAG)

Other CBA guidelines explicitly mention the impacts of airport projects on regional inequality and congestion.

The construction of a new airport may increase or decrease *regional inequality*, depending on the location of the new airport (remote region or core region). For example, airport development in a remote region may reduce the inequality gap between remote and core regions. Since the impact on regional inequality only affects redistribution of total wealth, it should be mentioned, but not included in CBA analysis (CBP and NEI, 2000).

The impact of investments in transport development on *congestion* can be direct (in terms of reduction in delays) and indirect (with respect to increased/decreased congestion in other modalities). Although in other CBA, congestion is treated as a separate category, TAG includes the direct effect of congestion within the economic effect of 'time savings' and includes the indirect effect within the category of 'surface access impacts'. Remarkably, congestion effects during the construction phase of the investment project (detour, leaving and approaching trucks, roadblocks, etc.) are not mentioned in any of the CBA guidelines.

While regional inequality is probably very hard to establish, congestion can be important, especially if the airport is accessed through landside infrastructure that is also used for other purposes.

### 2.4.3 Environmental effects

In monetised CBA, TAG includes environmental impacts on noise, greenhouse gases and local air quality. Although these environmental effects are indirect, they should be included since the costs of negative externalities are not included in market price due to market failures. Since they are not traded in markets their costs are not incurred by anyone, leading to over- or under-production, otherwise known as market failure.

TAG currently excludes impacts on the landscape, townscape, heritage of historic resources, biodiversity, and water environment and so some market failure exists within the CBA as well. These impacts are excluded in monetised CBA, as no monetary values for these have yet been established by the Department.

#### Noise

Noise can be defined as the unwanted sound or sounds of duration, intensity, or other quality that causes physiological or psychological harm to humans (CE, 2008). In general, two types of negative impacts of transport noise can be distinguished, namely health effects and annoyance effects:

- Annoyance effects reflect the cost of the disturbance which individuals experience when exposed to noise, ranging from sleep disturbance to discomfort, inconvenience and restrictions on enjoyment of desired leisure activities.
- Health effects relate to the long term exposure to noise and are often stress related, such as hypertension and myocardial infarction. Hearing damage can be caused by noise levels above 85 dB(A). The negative impact of noise on human health results in various types of costs - medical, the impact of lost productivity, and the costs of increased mortality. TAG does not take the impact of noise on health into account, but only investigates the annoyance effects (up to 81 dB).

The UK has well established procedures for assessing noise annoyance effects to people caused by road and rail traffic-related noise and vibration. But, there is no specific procedure for aviation related noise annoyance. The noise impact assessment in TAG involves two methods. The first, based on the concept of noise annoyance, involves calculating the difference in the estimated population who would be annoyed by noise from alternative sources, comparing the do-minimum and do-something scenarios. The second is based on the effect of noise on house prices and involves calculating the present value of households' willingness to pay to avoid transport related noise over the whole appraisal period for each scenario.

For road and rail, monetary valuation of noise is established by determining annoyance response relationships (which percentage is annoyed at certain levels of dB ranging from 45 to 81 dB) and then determining the £ per household per dB change (DfT, 2012: TAG Unit 3.2) However, in the case of aviation, noise impacts are more severe than compared to road or rail traffic. TAG does not include noise impacts from aviation, nor does it include impacts above 81 dB. A recent study by the World Health Organisation (2011) on noise effects points out that there is much uncertainty about valuation of noise from aviation at night time. Furthermore, it must be noted that there is no mention in the any of the CBA guidelines about noise impacts during the construction phase of the transport development. This is likely to result in a significant underestimate of the disbenefits to the local population, since noise nuisance during construction is likely to take place.

### Air quality (local and regional)

TAG provides guidance on assessing the impact of transport options on local and regional air quality. It focuses mainly on transportation by road and rail, and not on air transport. Emissions that are included in TAG are $NO_x$, CO, VOCs, and fine particulate matter (such as $PM_{10}$). The impact of $CO_2$ and other greenhouse gas emissions are included in the category 'Greenhouse gases/Emissions' (below). Monetary valuation of changes in air quality is carried out by calculating the marginal abatement costs (MAC) or damage cost values. The damage cost values reflect the cost of health impacts associated with exposure to air pollution. In the guideline for CBA of the European Commission, health impacts are measured by life expectancy or quality of life (quality-adjusted-life year, QALY) or by the willingness to pay for prevention of fatalities/injuries (EC, 2008).

### Emissions ($CO_2$ and other GHG)

TAG takes into account the impact of $CO_2$ and other greenhouse gas (GHG) emissions. These emissions are not only limited to emissions from fuel consumption and electricity generation, but can also include those resulting from the production of materials used in any infrastructure as well as those resulting from changes to the use of transport fuels. All changes in greenhouse gas emissions are prescribed to be presented in tonnes of carbon dioxide equivalent ($CO_2e$).

In TAG, assumptions are made that the majority of the embedded emissions would be covered by the EU ETS and would therefore already be internalised. TAG's analysis is therefore limited to emissions from fuel consumption and electricity generation only. However, since aviation ETS is temporarily halted for non-EU flights, a different method should be applied to include emissions in a proper way in CBA.

The monetary value of a change in $CO_2$ emissions is calculated by converting the estimated total number of litres of fuel burnt or the number of kWh of electricity used, to $CO_2$ emissions per litre fuel burnt or per kWh electricity used. Then, multiplied by $CO_2$ prices gives the $CO_2$ emissions in monetary terms.

### Biodiversity, landscape and water (non-monetised effects)

The costs and benefits of transport project investment on biodiversity, landscape, water, townscape and heritage of historic resources are difficult to estimate and express in monetary values. The development of a new airport in the Thames Estuary, for example, is likely to have a large impact on the landscape and local flora and fauna, but the question is how to express the loss of biodiversity in monetary terms. In the last decade, the valuation and monetisation of nature has become popular, and as a result the valuation methods are now more developed.

Regarding the aviation appraisal of TAG, these environmental effects are excluded in the monetised CBA, but included in the Appraisal Summary Table (included in Annex C). The reason for this is that no monetary values for these have been established yet by the Department for Transport (DfT, 2012: TAG Unit 3.5.4). When these effects are not taken into consideration, it could lead to a large under-estimation of the costs of an airport investment project. Environmental values should not be underestimated. Costs can add up to a large scale, as was the case with the Exxon Valdez oil spill (1989, Alaska).

In addition to CBA, there also exists an Environmental Impact Assessment (EIA), For large infrastructural investment projects, developers must carry out an EIA, which assesses all possible positive and negative impacts that a proposed project may have on the environment (EC, 2012).

### 2.4.4 Public account

An aviation intervention can affect the public account directly, by changing the tax receipts from taxes directly levied on aviation, such as the air passenger duty (APD). It can also affect the public accounts indirectly, by altering indirect taxation receipts from goods consumed across the rest of the economy. However, in a first order approach the effect on the public account should not be included in cost benefit analysis since it concerns transfers to the government and subsidies and pure transfers should not be included according to the CBA of the European Commission (EC, 2008).

## 2.5 CBA: Airport expansion versus new airport development

Differences in costs and benefits between expansion and new airport development will appear in the costs for construction, infrastructure, land values and travel time:

- Costs for construction are expected to be higher for new airport development than for expansion, since new runways and terminals have to be built.
- Costs for infrastructure are expected to be higher for new airport development since a new infrastructure network (roads, public transport) has to be built.
- Land value: in the case of new airport development, the former land on which the airport was built can be sold. However, new land also has to be bought, which might include compensation for people who have to leave their houses in the area where the new airport will be built.
- Travelling time or time savings for employees working at the airport might increase or decrease with the establishment of a new airport. Usually, airports relocate due to capacity constraints and/or noise issues. They therefore relocate to more remote places with enough space to expand and less noise annoyance to local residents. Therefore, travel time is likely to increase for employees at the airport.

- Effects on biodiversity (although not included in monetised CBA) are likely to be more severe in the case of development of a new airport since these take place in remote areas often with more natural value, landscape and biodiversity.
- Noise effects are likely to be more severe in the case of expansion of an airport, since existing airports are often located in a built environment, while new airport development often takes place in a more remote location.
- Closure costs of the existing airport and associated compensation costs to airlines, equity investors, bondholders and air traffic control could lead to significant increase in total costs for a new airport development. For Heathrow these costs are estimated at £ 20 billion (Oxera, 2013).

## 2.6 Risk and uncertainties

In order to estimate the costs and benefits of the different effects, many uncertainties may arise, such as uncertainty regarding:
- physical effects;
- statistical analysis;
- and future projections.

Each will be explained in more detail below.

### Physical effects

Risk and uncertainty about project costs may turn into risks when, for example, investment or operational costs overrun due to unexpected circumstances. Other project risks might occur due to uncertainty surrounding planning and land issues as well as timing and delivery. In TAG, for transport projects with a cost greater than £ 5m a Quantified Risk Assessment (QRA) is required. Furthermore, risks around project costs are taken into account by adjusting the baseline costs for risk and optimism bias:
- Risk: identifiable future situations that could cause an overspend or underspend to occur.
- Optimism bias: demonstrated systematic tendency to be overly optimistic (underestimation of costs).

### Statistical analysis

Regarding statistical analysis, uncertainties may arise due to model specification and measurement errors. These can be taken into account by means of probability analysis and standard error.
- Probability analysis measures the probability that an event may occur.
- Standard errors are a common statistical measure of risk and measure the accuracy with which a sample represents a population. The smaller the standard error the higher the accuracy. If the standard deviation is greater, the variability and thus risk is also greater.

TAG does not require specific measures for standard errors, but only requires sensitivity tests and alternative scenarios.

### Future projections and model forecasting

In order to estimate future costs and benefits, uncertainty arises about future parameters such as future transport demand, economic growth, oil prices, environmental policies and regulations. These future demand projections play a large role since the economic benefits rely heavily on the number of flights and flight tickets sold. In case future projections are not carried out well and demand is overestimated, it might lead to the risk that a ghost airport is built, like the airport Ciudad Real in Madrid. Here, investments of £ 1.1 billion were made for the development of an overflow airport that wasn't needed (Daily Mail, 2012).

TAG (DfT, 2012: Unit 3.15.5) provides a systematic analysis method for dealing with uncertainty in model forecasting by developing scenarios and sensitivity tests. Scenarios are used to combine the impact of different variables and to show the different outcomes under different assumptions. It often includes three scenarios: optimistic, baseline and pessimistic. A sensitivity test analyses the influence of different variables on the project's financial and economic performance. Regarding the uncertainties over demographic, economic and behavioural trends, TAG states that reported national data should be used.

In order to analyse uncertainties, TAG prescribes that the appraisal must consider at least two alternative scenarios or two sensitivity tests. To forecast transport demand, the Trip End Model Presentation Program (TREMPO)[6] is used, however, this model only includes data on trips on foot, by bicycle, motor vehicle, rail and bus, but not for aviation.

## 2.7 Commonly made mistakes in CBA

Cost benefit analysis has a scope to include all the impacts on the economy, the environment, and social effects. However, too often proponents and opponents stress only parts of the CBA that show results in their favour. This section discusses commonly made mistakes in CBA.

### Ignoring negative effects

Templates often omit the external effects and ignore the negative impacts on, for example, the environment, noise and pollution, even though these have well documented economic impacts. Noise depresses property values and has negative impacts on health, including an increase in the risk of high blood pressure and consequences for myocardial infarction and cerebrovascular accident, in cognitive impairment in children, and sleep disturbance (WHO, 2011). These impacts not only lower the wellbeing of the affected individuals but may also reduce their productivity (CE, 2012). Other negative impacts that are often omitted are the expenditures of UK inhabitants abroad and investments abroad. The aviation industry does not facilitate just inward investments, but also outward investments. Ignoring these negative effects will result in an underestimate of the net impact of the investment project.

### Overestimation of positive effects

On the other hand, there is a tendency in the aviation industry to overestimate the positive impacts of aviation. Many studies are based on the ACI-Europe study kit which has been developed by York Aviation and is widely used by airports and organisations like the Air Transport Action Group (York Aviation, 2004; ATAG, 2005).

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6 http://www.dft.gov.uk/tempro/intro.php.

The ACI framework includes directs effects, indirect, induced and catalytic effects.

- Direct effects are measured by the economic activity (value added and/or jobs) at the airport.
- Indirect effects denote economic activity in the aviation sector's supply chain (backward linkages).
- Induced impacts are second order effects and can be described as the expenses of people employed at the airport on goods and services (forward linkages).
- Catalytic impact is economic activity created in other industries caused by the existence of an airport. It is the employment and income generated by the role of the airport as a facilitator of economic growth, also called spin-off benefits.

Summing these direct, indirect, induced and catalytic value-added leads to double counting and an overestimation of the positive effects. The method fails to recognise that aviation is a supplier and a client of other sectors. For example, indirect and induced employment includes spending on goods produced abroad, so the effect on domestic employment is likely to be overestimated. Secondly, tourism jobs impacts should also include the loss of income through money that local residents spend abroad. The same argument holds for inward and outward investment (CE, 2012). According to the CBA guideline of the EC, indirect impacts in secondary markets should not be included in the economic appraisal whenever an appropriate shadow price has been given for the benefits and costs (EC, 2008).

### Employment as a benefit

Another commonly made mistake is that employment is often counted as a benefit. Investment projects and politicians often mention the number of jobs created by the project as a benefit. Employment is however an indirect effect, and should not be included assuming that the labour market functions well. Only in the case of a market failure (structural unemployment) additional welfare could be created. Only in this situation is it correct to fully count the on-site job creation of the project as a benefit. This requires the vacancies to be filled by long-term unemployed who would be unable to find employment now or in the future. Due to the economic recession and increased unemployment in the UK, jobs are an important subject in the public debate. When considering the inclusion of employment effects in CBA, this should be carried out with caution because of double counting. Wages are part of the cost of the project, not the benefits. The social benefits of employment are already given by using shadow wages. Including these effects in CBA might lead to double counting, which should at all times be prevented.

## 2.8 Conclusion

In this chapter we analysed the impacts that are included in CBA in order to get a complete overview of all costs and benefits of an airport investment project. A CBA should - besides economic impacts- also include external effects, such as social and environmental impacts, that are not internalised in market prices. At first sight TAG seems to be an adequate guideline to analyse costs and benefits of aviation investment projects. It compares well with other CBA in some aspects, but could still be improved.

Comparing TAG to other CBA, it appears that several important effects have been excluded, such as:

- impacts on property and land values;
- impacts on other markets, such as the costs and benefits to businesses in the supply chain (backward linkages);
- impacts on other transport modalities (effect on rail and road transport);
- strategic effects (locational advantages);
- regional inequality.

Furthermore, there are several non-monetised impacts of transport project investment, such as biodiversity, landscape, water, townscape and heritage of historic resources, which are not included in the CBA. The reason for this is that there have not yet been developed any monetary tools to value these impacts to the satisfaction of those designing the TAG. In consequence, omitting non-monetised impacts will result in an underestimation of the net impact.

This chapter also considered the uncertainties and risks which may arise when estimating costs and benefits of the different effects. Examples are the uncertainties about physical effects, statistical analysis and future projections. TAG takes these risks and uncertainties into account by including risk and optimism bias, developing scenarios and sensitivity tests.

Last, we discussed commonly made mistakes in CBA. In general, there is a tendency to ignore the negative effects (such as noise and pollution) and to overestimate the positive economic effects (by including induced and catalytic effects). This again leads to an overestimation of the net results in favour of the investment project.

# 3 Airport capacity, connectivity, economic growth?

## 3.1 Introduction

In CBA, a major part of the total benefits is determined by the economic benefits of an investment project. In aviation development projects, these economic benefits are largely dependent on the wider impact of connectivity. Connecting buyers with suppliers, investors with ideas and businesses to sit cheek-by-jowl with their competitors - connectivity - may be a key to economic growth. Although this statement is often taken for granted, there is still large uncertainty about the (causal) relationship between connectivity and economic growth.

In the UK, there have been discussions for many years on the expansion or new airport development around Heathrow and other airports in the South-East. Proponents of aviation expansion argue that expansion of the airport increases the airport's capacity and improves the connectivity of London and the UK in general, which would boost economic growth and employment. Opponents claim that the impact on economic growth is overstated.

In this chapter we study the relationship between capacity, connectivity and economic growth. Section 3.2 explains the concept of capacity and constraints. Section 3.2 discusses the relationship between airport capacity and connectivity. Section 3.4 examines the relationship between connectivity and economic growth.

## 3.2 Airport capacity and demand

Airport capacity and demand are crucial factors to determine transport economic efficiency, which is one of the largest benefits in CBA. First, we discuss the concept of capacity and demand and to what extent there is unmet demand, followed by the impact of capacity constraints on connectivity.

### 3.2.1 Airport capacity

Capacity refers to the ability of an airport to handle a given volume or magnitude of traffic (demand) within a specific period of time, often expressed as a maximum number of aircrafts that an airport is able to process per unit of time (Senguttuvan, 2006). The determination of airport capacity is, however, complex. Capacity constraints may arrive at landside or airside areas of the airport and may occur due to operational, economic, environmental constraints. [7] Other factors affecting capacity are administrative constraints, meteorological conditions, runway configurations, arrival/departure ratio, and fleet mix (DLR, 2009).

[7] Landside area encompasses the surface-access systems connecting the airport to its catchment area and the terminal system. The airport airside consists of airspace around the airport (airport zone or terminal airspace, like runways, taxiways, and the apron and gate complex.

In the short term, airport economic capacity is determined by the airport service charges which regulate demand access, in the long run capacity is determined by availability of airport infrastructure (Janic, 2004).[8] The infrastructural supply is often related to the number of runways and terminals at an airport. Table 2 gives an overview of London's aviation operational capacity.

**Table 2 Airport capacity at London airports (2012)**

| Airport | Number of runways | Number of destinations | Number of passengers* | Air traffic movements* |
|---|---|---|---|---|
| Heathrow | 2 | 193 | 69.4 mln. | 480,906 |
| Gatwick | 1 | 200 | 33.6 mln. | 251,067 |
| Stansted | 1 | 150 | 18 mln. | 148,317 |
| Luton | 1 | 54 | 9.5 mln. | 104,000 |
| London City | 1 | 46 | 2.9 mln. | 68,792 |
| Southend | 1 | 16 | 0.4 mln. | 25,470 |

Source: Local airport websites and CAA (2012), *data for 2011.

### London's capacity versus other European airports

London has one hub airport (Heathrow) and 5 point-to-point airports. In total, London's capacity is determined by 7 runways, which is, together with Paris (Orly and Charles de Gaulle), the highest amount of runways compared to other European cities. Amsterdam (Schiphol) has 6 runways and the airports at Madrid (4) and Frankfurt (3) operate with substantially less runways. Heathrow (2012) states that it operates at almost full capacity. However, this refers to slots during the busiest period of the year. Heathrow does not run at full capacity outside the summer period and Eurostat data (2012) show that the load factor of airplanes is less than 75%. Regarding Heathrow's terminals, capacity can be expanded by another 20 million passengers. The new Terminal 5, opened in 2008, increased Heathrow's capacity up to 90 million passengers maximum.

### Seat capacity

Also regarding seat capacity, London is the largest airport system in Europe with 172 million to/from seats in 2012 (OAG data)[9]. It has 50% more seat capacity than the next largest European airport system, which is Paris. In 2012, Heathrow reached seat capacity of 94.5 million to/from seats retaining its position as the 3rd largest airport in the world.

## 3.2.2 Demand for air travel

The airport operational capacity mainly depends on factors such as air travel demand by passengers, safety constraints, and delays (Janic, 2004). Airports try to control the flow of air traffic such that the demand meets but does not exceed the operational capacity.

Table 4 shows the airport passenger demand forecasts of the Department of Transport for UK airports till 2050.

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8 Economic conditions may significantly influence the number of units of demand accommodated at an airport. In the short term, charges for airport services during the peak and off-peak capacity at Europe's largest airports (runways)hours regulate demand access.

9 http://www.oagaviation.com/OAG-FACTS/2012/December-Executive-Summary.

Table 3 UK terminal passenger forecasts, central estimates (mln. passengers per annum, mppa)

| | Unconstrained | | | | Constrained (maximum use) | | | |
|---|---|---|---|---|---|---|---|---|
| Forecast year | DfT (2007) | DfT (2009) | DfT (2011) | DfT (2013) | DfT (2007) | DfT (2009) | DfT (2011) | DfT (2013) |
| 2010 | 270 | 260 | 211 | 211 | 270 | 260 | 211 | 211 |
| 2020 | 385 | 365 | 275 | 260 | 355 | 345 | 270 | 255 |
| 2030 | 495 | 465 | 345 | 320 | 425 | 405 | 335 | 315 |
| 2040 | - | - | 425 | 390 | - | - | 405 | 370 |
| 2050 | - | - | 520 | 480 | - | - | 470 | 445 |

Source: DfT (2007), DfT (2009), DfT (2011), DfT(2013).

It shows that DfT's forecasts of UK terminal passengers have been routinely downgraded over the past years. For 2030, forecasted unconstrained passenger demand has been downgraded by 65% between 2007 and 2013. While in 2007 unconstrained passenger demand for 2030 was forecasted at 495 million passengers, in 2013 this amount was revised downwards to 320 million passengers. It appears that the 2011 estimate of 345 mmpa in 2030 did not even fall in the range forecast in 2009 (low growth scenario estimate was 415 mmpa).

Forecasts of air passenger demand are not straightforward, due to large uncertainties in oil prices, carbon prices, economic growth and many other factors. This is apparent from the DfT passenger forecasts. These uncertainties can be explained by the fact that scenarios and forecasts of aviation demand depend to a large extent on assumptions on:

- GDP per capita growth because demand for aviation is elastic.
- The income elasticity of demand or the propensity to fly. Often, these are assumed to be constant while cross sectional studies suggest a saturation of the demand for aviation and hence a decrease of the income elasticity over time.
- Costs of aviation, which in turn are driven by fuel price assumptions, assumptions on taxation, assumptions on environmental regulation, assumptions on the market share of low cost carriers, etc..
- Alternative technologies, such as other modes of communication.

Often, aviation demand forecasts tend to take an optimistic view on many assumptions, such as low oil prices and being too optimistic on technological development, an approach which results in an overestimation of the demand and the severity of the constraints (CE, 2008, 2009, 2012 and 2013).

### Does London's capacity meet future demand?

The question for London's airports is whether it can also meet demand for air travel in the future and to what extent there might be unmet demand caused by constraints in the future. Heathrow (2012) and DfT (2011) argue that capacity at London's airports is constrained. AEF/WWF (2011) however state that there is sufficient capacity available at the airports in South-East London and other regions to meet the level of aviation growth within the environmental limits recommended by the Committee on Climate Change, consistent with UK climate targets. Their analysis shows that a small shortfall is expected in the South East which is not sufficient to require a new runway, so long as the trend towards larger aircraft and higher passenger loading continues. AEF/WWF (2011) concluded that the shortfall in Air Traffic Movements in the South East by 2050 would be less than one per cent.

### 3.2.3 Environmental constraints

Apart from infrastructural constraints, there may also be environmental constraints, such as policies on noise and air pollution. These polices intend to protect local people from the damaging effects of airport operations, by means of night curfews or constraints on emissions.

According to Janic (2004), the environmental constraints that are present at Heathrow are related to noise and land use. They affect runway capacity by (a) restricting the use of runways to achieve maximal operational capacity and (b) restricting land use for physical (spatial) expansion of airport infrastructure outside of the existing airport area.

### 3.2.4 Expanding capacity

Regarding capacity, or actually the lack of it, the only solution that often seems to be considered is expansion in terms of building new infrastructure (new runways or terminals). However, there are different ways in which an airport's capacity can be expanded without building new infrastructure, such as by extending operating time, more efficient use of runways, use of larger aircrafts, or changing the fleet mix. Extending operating times and changes in the fleet mix will however have noise and environmental consequences.

AirportWatch (2011) argues that the key question is not the lack of capacity, but how that capacity is used. The study finds that the majority of flights from all European airports is intra-European, often covering relatively short distances. They state that European governments need to decide whether to continue to permit most of the capacity at Europe's airports to be taken up with short distance flights or whether to reduce the number of those flights – through fiscal measures and slot allocation – in order to free up capacity for more intercontinental flights from key business destinations.

This shows that there are many ways to address capacity constraints, which do not necessarily mean building a new runway, but instead achieve the same thing by more efficient use of runways, or freeing up capacity normally used for short haul destinations.

## 3.3 Connectivity

Although connectivity does not formally play a role in CBA, it is one of the main arguments used in the public debate on airport expansion. Therefore, we scrutinised the facts on connectivity and economic growth side by side. Prior to the discussion on whether and how airport capacity influences connectivity and economic growth, it is important to define the term connectivity.

### 3.3.1 Definition of connectivity

In its broadest context, connectivity refers to the density of connections of a country or city with the rest of the world and the directness of those links. Connectivity encompasses centrality, the degree to which a country or city is linked to other destinations. Connectivity further embodies the ease and speed in which those destinations can be reached. This includes all types of transport modes such as aviation and rail or transport replacement such as videoconferencing.

In the aviation context, connectivity is defined as "a combination of the range of destinations served and the frequency of flights" (DfT, 2012b).

The broader the range of destinations and the higher the frequency of flights, the better connected an airport, city or country is. This includes direct connections, but also indirect connections by transfer. Very often however, a very narrow definition of connectivity is used, implying that connectivity is only related to direct flights between two destinations. This also neglects the economic importance of the destination and omits the importance of key business centres.

### 3.3.2 Connectivity: in number of destinations

Based on Eurostat data (2012), we investigated the connectivity of Heathrow compared to the other main European airports. Table 4 shows the number of destinations between 2003 and 2010.

**Table 4 Number of direct destinations at the four main European airports**

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | % change (2003-2010) |
|---|---|---|---|---|---|---|---|---|---|
| Heathrow | 128 | 132 | 135 | 134 | 133 | 135 | 134 | 139 | 8.6% |
| Schiphol | 137 | 142 | 145 | 147 | 154 | 168 | 149 | 154 | 12.4% |
| Paris CDG | 141 | 150 | 152 | 163 | 167 | 167 | 167 | 177 | 25.5% |
| Frankfurt | 182 | 184 | 189 | 196 | 211 | 209 | 208 | 211 | 15.9% |

Source: Based on Eurostat data (Eurostat, 2012).

Between 2003 and 2010, Heathrow served the lowest number of (direct) destinations (139). It also had the smallest increase in new destinations (8.6%) between 2003 and 2010 compared to Schiphol (12.4%), Paris CDG (25.5%) and Frankfurt (15.9%).

It must be mentioned that these figures only show the total number of destinations and do not say anything about the importance of the destinations. Most of the destinations are domestic or minor destinations. What matters for economic growth and employment is the number of flights to the key business destinations. AirportWatch (2011) investigated the connectivity of Heathrow with the key business destinations in the world[10]. They found that Heathrow has more flights to these business destinations than any other airport in Europe. It has many more intercontinental flights than the other European airports, but flies to a smaller number of European and domestic destinations. Flaws of this report include that it did not look at the new emerging economies, such as Mexico, or Indonesia and that it only looked at departures during one week in July, 2011.

### 3.3.3 Connectivity: in frequency of flights

Although Heathrow had the lowest amount and smallest increase in destinations compared to the other main European airports, between 2003 and 2010 it had the highest frequency per destination, with an average of 3,467 flights in 2010. Table 5 shows the average frequency of flights per destination between 2003 and 2010.

[10] As key business destinations, Airportwatch (2011) included important business cities in the U.S., Canada, Japan, South Korea, the Gulf States, China, India, Brazil, Indonesia and South Africa.

Table 5 Frequency of flights (average per destination)

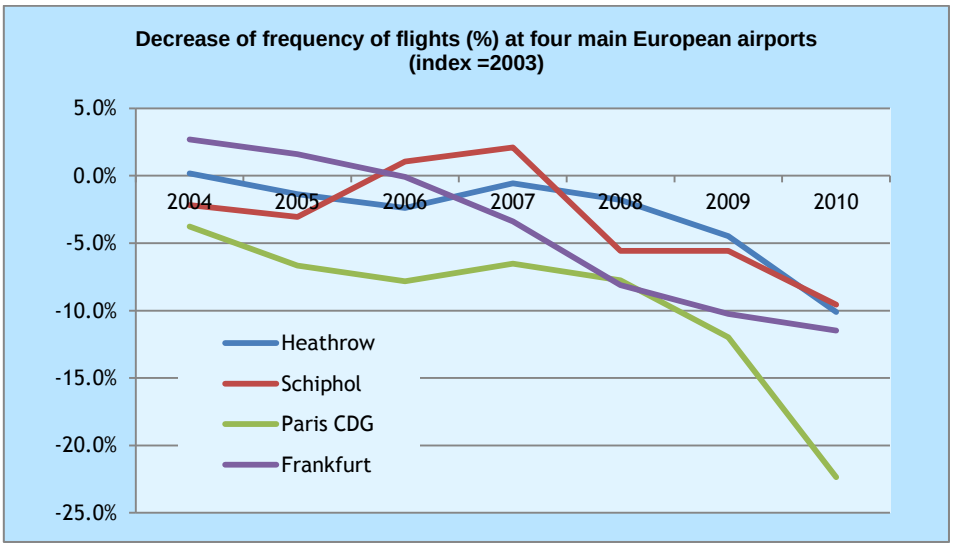
| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | % change (2003-2010) |
|---|---|---|---|---|---|---|---|---|---|
| Heathrow | 3,857 | 3,864 | 3,804 | 3,765 | 3,835 | 3,788 | 3,685 | 3,467 | -10.1% |
| Schiphol | 2,467 | 2,414 | 2,392 | 2,494 | 2,519 | 2,330 | 2,330 | 2,232 | -9.5% |
| Paris CDG | 3,152 | 3,033 | 2,941 | 2,905 | 2,946 | 2,907 | 2,774 | 2,447 | -22.3% |
| Frankfurt | 2,617 | 2,688 | 2,659 | 2,615 | 2,529 | 2,405 | 2,349 | 2,317 | -11.5% |

Source: Based on Eurostat (Eurostat, 2012).

In the observed time period, it appears that all four main European airports decreased the frequency of flights. Heathrow decreased its frequency of flights by 10.1% between 2003 and 2010. However, it did not decrease as much as Paris CDG (-22.3%) or Frankfurt (-11.5%) and still remains on top.

Research carried out by AirportWatch (2011) confirms that, compared to other European cities, London has the best connections to the key business centres of the world. London's airports had 1113 departure flights in one observed week, compared with Paris's 499, Frankfurt's 443, and Amsterdam's 228. This shows that London's strategy is to focus on a smaller number of important and profitable routes, while other airlines invested in a more widespread network.

Figure 1 Decrease of frequency of flights (%) at four main European airports (index =2003)




Source: Based on Eurostat (Eurostat, 2012).

## Load factor

The low number of destinations and the high frequency of flights at Heathrow, raises the question of whether the flights are fully booked or whether Heathrow is offering too many flights to the same destinations. Therefore, it is interesting to look at the load factor (what percentage of the seats is filled)[11]. This shows us how capacity is used at Heathrow.

[11] Load factor is measured by: total passengers carried/total seats available.

From our data analysis, it appears that seat capacity at Heathrow is similar to the other large European airports. The load factor is 74%, which indicates that 26% of seats are empty (Eurostat, 2012). Therefore, there is some scope for improvement.

**Table 6** **Load factor at four main European airports**

| | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|
| Heathrow | 74% | 72% | 73% | 74% |
| Paris CDG | NA | NA | 98% | 77% |
| Frankfurt | 75% | 75% | 74% | 76% |
| Amsterdam | 76% | 76% | 75% | 78% |

Source: Based on Eurostat (Eurostat, 2012).

## Number of passengers

In order to get a complete view of the capacity and development of the four main European airports we also looked at the total number of passengers on board and the total annual (commercial) flights.

**Table 7** **Number of passengers (2003-2010) in millions**

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | % change (2003-2010) |
|---|---|---|---|---|---|---|---|---|---|
| Heathrow | 68.2 | 72.4 | 72.9 | 71.5 | 72.0 | 70.9 | 70.0 | 69.7 | 2.1% |
| Schiphol | 36.7 | 39.2 | 40.8 | 42.4 | 44.5 | 46.1 | 40.4 | 42.5 | 15.8% |
| Paris CDG | 44.6 | 47.4 | 49.9 | 53.5 | 56.6 | 56.8 | 54.8 | 57.1 | 28.1% |
| Frankfurt | 55.2 | 58.1 | 58.8 | 59.6 | 63.4 | 59.9 | 57.3 | 59.3 | 7.4% |

Source: Based on Eurostat data (Eurostat, 2012).

Table 8 shows that Heathrow is still the largest airport in terms of the total number of passengers However, the gap with the other airports shrank between 2003 and 2010. The increase in the number of passengers compared to 2003 was small at Heathrow (2.1%), while Paris CDG (28.1%), Schiphol (15.8%) and Frankfurt (7.4%) increased their passengers at higher rates.

## Total annual flights

**Table 8** **Total annual flights**

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | % change (2003-2010) |
|---|---|---|---|---|---|---|---|---|---|
| Heathrow | 493,704 | 510,069 | 513,605 | 504,461 | 510,113 | 511,356 | 493,737 | 481,894 | -2.4% |
| Schiphol | 338,032 | 342,734 | 346,882 | 366,546 | 387,935 | 391,467 | 347,140 | 343,690 | 1.7% |
| Paris CDG | 444,385 | 454,937 | 444,876 | 473,492 | 489,923 | 483,666 | 461,494 | 436,950 | -1.7% |
| Frankfurt | 476,337 | 494,520 | 502,621 | 512,484 | 533,554 | 502,586 | 488,611 | 488,855 | 2.6% |

Source: Based on Eurostat data (Eurostat, 2012).

In 2010 Heathrow had the second largest number of total flights, following Frankfurt. However, Heathrow had decreased its total flights by -2.4% compared to 2003 and Frankfurt increased its total flights by 2.6%.

**Summary**

In general, we see a trend in the period 2003-2010 among the four main European airports to increase the number of destinations and to reduce the frequency of flights.

With respect to Heathrow, the airport seems to develop at a slower rate than the other large European airports or even to decrease. The data show the following:

- Heathrow has lowest number of destinations (139) and smallest increase of new destinations (2.1%) compared to other main airports.
- Heathrow still has the highest frequency of flights, but decreased its frequency over time (-10.1%) compared to 2003.
- Heathrow has a load factor of 74% which indicates that 26% of the seat capacity is unused.
- Heathrow still has the highest number of passengers, but the gap with other main airports becomes smaller.
- Heathrow has the second largest number of total flights after Frankfurt, but Heathrow decreased its annual flights (-2.4%) and Frankfurt increased (7.4%) compared to 2003.

Concluding, it appears that Heathrow's strategy for the last decade has been to focus on a limited amount of destinations, but with a very high frequency. Where other airports focussed on a more widespread network, Heathrow focussed on a small number of destinations with a high frequency. Looking at load factor it appears that 26% of the seats is unused, which gives some scope for improvement. The question is whether Heathrow is constrained by capacity restrictions or whether UK demand for air travel has decreased over time.

### 3.3.4 Impact of capacity constraints on connectivity

Capacity constraints could in the intermediate term lead to congestion both in the air and on the ground, which in turn results in delays and reduced reliability. Furthermore, it might complicate the accommodation of hubbing 'waves' of landing and take-off to other connecting flights.

In the longer-term, any new destinations or increased frequencies come at the expense of another destination already being served. Furthermore, capacity constraints could influence the fleet mix and result in larger aircrafts.

The relationship between airport capacity and connectivity, and between connectivity and economic growth is complex. At a capacity constrained airport, the number of flights is less than it would be if the constraints were relaxed. If the airport were allowed to expand, the number of flights would increase. This can result in a number of changes in the flight network, such as:

- more frequent flights to the same destinations, increasing the number of seats available;
- more frequent flights to the same destinations, using smaller aircraft;
- flights to more destinations.

If the network were optimised in the constrained situation, the additional flights would have lower benefits than the other flights.

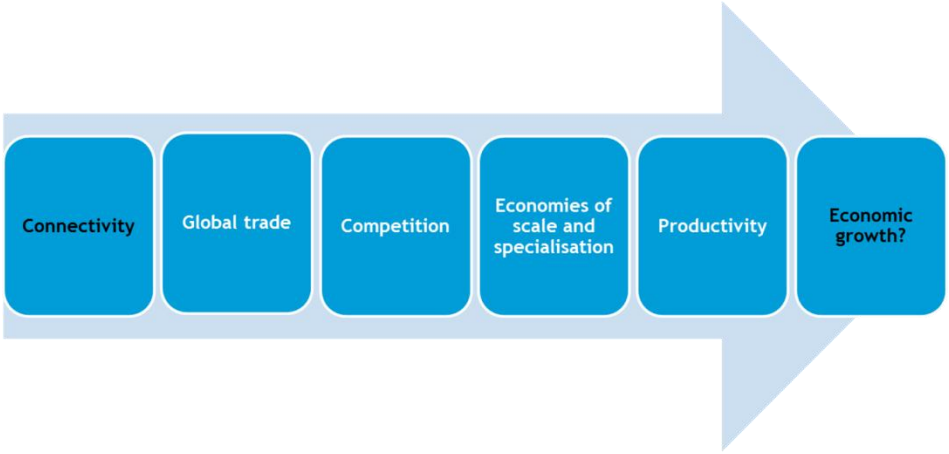
The relationship between connectivity and economic growth is less clear. As subsequent sections will show, there is a large body of literature on the relationship between aviation demand and economic growth, but very little on the causal relationship between connectivity and economic growth.

## 3.4 Economic growth

Many studies have investigated the economic benefits of aviation and its impact on economic growth. The relationship between connectivity and economic growth is, however, less investigated and there remains much uncertainty. We analysed the existing literature and tried to unravel the impact of connectivity on economic growth step by step.

The aviation industry often portrays connectivity as the driver of economic growth and innovation - it would generate wider economic benefits for businesses, increase global trade and productivity. Figure 2 shows the assumed linkage between connectivity and economic growth.

**Figure 2 Does connectivity lead to economic growth?**




We analysed the linkages between connectivity and economic growth step by step.

### 3.4.1 More global trade

Connectivity is defined as the range of destinations and/or the frequency of flights. When the number of destinations increases, this could open up new markets and lead to new trading partners. Trade with distant markets becomes easier and cheaper and goods and services can be marketed on a global basis. The export from UK companies to foreign countries and import from foreign business to UK increases.

More connectivity in terms of a higher frequency of flights, on the other hand, will lead to more reliability and a more frequent supply of goods or services. The question is however, whether more frequent flights will also increase global trade. Trade could increase by industries for whom frequency of supply is increasingly important (such as transport of flowers).

The relationship between connectivity and global trade assigns a large role to business passengers. And although they pay in general higher fares (business class, last minute booking) and hence contribute to a larger extent to the aviation revenues, their role should not be exaggerated. Only 25% of London's air travel demand is for business, and 75% for leisure travel (Prime, 2012).

**Connectivity and global trade**
The concept of air connectivity is usually ill-treated in reports commissioned by the aviation industry. One claim in particular is often made, which is unsubstantiated at best and misleading at worst "that connectivity leads to more trade".

**Connectivity leads to 20 times more trade?**
Frontier Economics (2011, page 11) for instance states that: "There are very clear correlations between the levels of trade and connectivity". They validate this claim by stating that "UK businesses trade 20 times as much with countries (i.e. Brazil, China, India, Russia, South Korea and Turkey) where there are daily flights than with those (i.e. Indonesia and Mexico) with less frequent or no direct service."

The bulk of U.K. trade with the aforementioned countries is of course maritime. It should come as no surprise then, that UK patterns in trade-intensity are no different from those of EU countries with direct air links to all Emerging Markets. CE Delft has calculated (based on UN COMTrade data) that Germany's exports to Indonesia and Mexico as a share of its exports to all eight EMs is the same as that of the UK. Dutch exports to Mexico and Indonesia as a share of exports to all eight EMs is even lower than that of the UK in spite of the direct flights from Schiphol to Jakarta and Mexico City.

Similar reservations apply to Frontier Economics' assertions on trade and growth. CE Delft has compared real export growth to six connected EMs (from a UK perspective) and to ten unconnected EMs (i.e. Mexico, Indonesia, Venezuela, Colombia, Chile, Philippines, Pakistan, Peru, Ukraine and Vietnam) which have direct air links to EU competitors. CE Delft finds that the yearly real growth in UK exports to connected countries was on average 5% higher than real export growth to unconnected countries in the period 2000-2010. This is slightly higher than the difference in real export growth for Spain (4%), but lower than its was for France (6%). the Netherlands (7%) and Germany (9%). The observed patterns in trade-intensity for the UK were in all likelihood not caused by connectivity.

**Economic loss of 14 billion a year?**
Frontier Economics also states that not expanding Heathrow could cost the UK economy £ 14 billion a year in lost trade. That figure could rise to £ 26 billion a year by 2030. Increased international direct connectivity through a hub airport would be vital to supporting increased trade and economic growth; and that a lack of connectivity could choke off trade that would otherwise develop. Frontier Economics implies a causation here which to date no scientific study has been able to show (as indeed they themselves acknowledge reluctantly on page 38 of the report, right before they repeat their earlier claim). There is indeed a correlation between connectivity and trade, but the causation might run backwards (trade drives connectivity) or some third factor (population growth) might drive both trade and connectivity.

### 3.4.2 Increased competition

Better connectivity is said to lead to more global trade by opening domestic markets to foreign competitors. The entrance of foreign firms to the market increases competition. This would force domestic firms to adopt best international practices in production and management methods and encourage innovation.

According to OEF (2006) "air services help to improve competitiveness of almost all aspects of companies' operations, including sales, logistics, inventory management, production and customer support".
The capacity constraints on Heathrow could therefore be a drag on London's competitiveness. Prime (2012) argues that this relates far more to its poor facilities and problems around security and immigration services. Heathrow has long suffered from excessive queues to enter the UK and in particular for transfer passengers.

They argue that BAA has failed to upgrade the facilities over many years and in order to improve its competitiveness passenger experience should be improved.

### 3.4.3 Economies of scale and specialisation

Trade and increased competition encourages firms to specialise in areas where they possess a comparative advantage. Because of this specialisation, production takes place at a larger scale, which leads to economies of scale. A benefit for consumers is that it drives down product prices and improves the quality of goods. According to ATAG (2005) around 25% of the businesses report that air transport services enables them to exploit economies of scale.

### 3.4.4 Productivity

The increased access to foreign markets, the increased competition and the increase in economies of scale, specialisation advantage and availability of new technologies and management techniques enables firms to produce more efficiently. This enables firms to increase the output per one unit of a total input, and thus increase productivity.

A rise in productivity in firms outside the aviation sector comes through two main channels. There are effects on domestic firms of increased access to foreign markets and increased foreign competition in the home market and there is freer movement of investment capital and workers between countries.

A number of studies have attempted to quantify the long term impact of connectivity on productivity. This is not straightforward and resulted in a wide range of estimates.

**Table 9 Impact of connectivity on productivity**

| | Impact of 10% increase in connectivity (relative to GDP), on productivity |
|---|---|
| IATA (2007) | 0.07% |
| EEC (2005) | 1.3% |
| OEF (2006) | 0.56% |

The estimates of the impact of a 10% increase in connectivity on productivity range from 0.56 to 1.3%. IATA (2007) finds an impact of 0.07% on productivity if connectivity increases by 10%. This is a very small effect and causality is not proven[12].

BCC (2009) has studied the economic impacts of hub airport expansion and find that improved airport expansion could benefit the UK economy by £ 8.6-12.8 billion (present value) in direct productivity. It must be mentioned that these benefits are spread out over 60 years and includes double counting of indirect benefits.

[12] A Granger causality test was undertaken on the relationship between connectivity and labour productivity. This is a technique for determining whether one time-series causes changes in another or vice versa. The test was unable to clearly determine that connectivity granger-causes productivity growth, nor that productivity granger-causes connectivity. In other words, no causality was detected in either direction between these two variables.

**The British Chambers of Commerce** commissioned a report in 2009 in which the direct and indirect benefits of the expansion of Heathrow were estimated. Direct benefits would amount to £ 8.6 to £ 12.8 billion (present value) and another £ 20 billion (PV) in wider economic benefits (BCC, 2009).

The direct benefits were obtained by multiplying the assumed reduction in travel times for business trips with the value of an hour to business passengers. Yet this figure is already contained in the estimate for wider economic benefits, where productivity gains have been calculated as the rise in GDP as a result of an increase in connectivity. The two impacts are presented separately, but they are the same impact calculated in different ways: the gains in productivity are largely the result of the reduction in travel times.
The other indirect benefits refer to gross impacts on employment, neglecting the economic reality of displacement of labour elsewhere and discarding any negative impacts (noise, pollution) of more air traffic.

BCC further claims that increased connectivity boosts economic growth. Trade would seem the most direct impact of better connectivity alongside tourism. CE Delft has calculated that the UK did not fall behind its EU competitors in exporting to unconnected (from a British perspective) Emerging Markets.

Another noteworthy result in the scenario analysis, is that if Heathrow were expanded, gains from opening up new destinations would amount to £ 9,850 billion in PV, whereas the less profitable strategy aimed at increasing the frequency of existing flights would lead to gains of £ 6,200 billion in PV. Section 3.3 of this report has revealed that Heathrow's strategy went in the exact opposite direction: an increase in frequency at the expensive of (the seemingly more profitable) increase in centrality.

On the whole, the main flaw of the report remains the double-counting of benefits from a reduction in travel times.

IATA (2007) has studied the relationship between productivity and connectivity and found a positive relationship, as shown in Figure 3.

**Figure 3 Connectivity and productivity**


Source: IATA (2007).

Figure 3 shows that developing and transitional economies (bottom left) typically have low connectivity relative to their GDP and also relatively low labour productivity. The top right of the figure shows the developed economies (Asia, North America and Europe) with high levels of connectivity and high labour productivity.

The flattening of the curve suggests that there is a positive relation between productivity and connectivity for developing economies, but that this relation is much smaller for developed economies like the UK. Therefore, it seems that developing countries have a great deal to gain from expansion, while developed countries receive diminishing returns from each increase in connectivity. Also the large amount of variation in this figure shows that there might be other – potentially more important – drivers of labour productivity as we can see from nations with lower connectivity but much higher labour productivity.

The underlying model of InterVISTAS is presented in the Annex of the IATA (2007) report. The model fails the test for 'Granger-causality', i.e. productivity did not cause connectivity, nor did connectivity cause productivity. This could imply a number of things:

- The model does not contain a time trend: trend growth in connectivity coincided with trend growth in productivity, with no causal relation.
- Some non-modelled factor could have caused both connectivity and productivity.
- Connectivity is first divided by GDP in the model: the model could have captured the short term relation between productivity growth and GDP growth[13].

Although the theoretic link between connectivity and labour productivity seems straightforward, is has been difficult to prove a causal link in practice.

### 3.4.5 Economic growth

Lastly, we discuss the effect of connectivity on economic growth. The benefits of connectivity and its assumed impact on economic growth are often mentioned as an argument in favour of airport expansion. In this section, we discuss the different studies found on the impact of connectivity on economic growth. Since this number is limited, we also looked at studies that investigate the impact of aviation in general on economic growth, either in terms of GDP or employment.

#### Connectivity and economic growth (GDP)

Although there has been much research on the broader impact of aviation on economic growth, so far, there has been no academic research carried out on the specific relationship between connectivity and economic growth. The aviation industry has published several reports on the impact of connectivity on economic growth, of which the results are shown in Table 10.

[13] Productivity growth is a major determinant of economic growth, alongside growth in labour supply and technological growth. During the investigated period (1996-2005) however, many EU countries experienced an unexpected drop in productivity while maintaining a robust economic growth.

Table 10 Effect of connectivity on economic growth (GDP)

| Study | Impact of a 10% increase of connectivity on economic growth (GDP) |
|---|---|
| IATA (2006) | 1.2% |
| IATA (2007) | 0.07% |
| EEC ( 2005) | 1.9% |
| OEF (2006) | 0.6% |

The impact of a 10% increase of connectivity on GDP varies between the studies from 0.07 to 1.9%. There remain large uncertainties about the elasticities of connectivity on economic growth. The differences between the IATA data result from a different method used to estimate the elasticities. The 2006 study used modelled data from world economy models. The results of the 2007 study are based on cross sectional statistical analysis of air connectivity and labour productivity. The 2006 estimation may have been overestimated due to constraints on available data. Also the impact of 0.07% on economic growth does not provide us an answer to our question whether connectivity causes economic growth, since there was no causal relationship found.

Since there is not much scientific research carried out on the relationship between connectivity and economic growth, we also examined the broader impact of aviation demand on economic growth (measured by GDP or employment).

## Air travel and economic growth (GDP)

The results of different studies on the impact of air travel on economic growth are shown in Table 11, where economic growth is measured as an increase in GDP.

Table 11 Impact of air travel on economic growth: GDP

| Study | Impact of air travel demand on GDP | Type of research (method) |
|---|---|---|
| NYFER (2000) | 10% increase in aviation growth results in 1.7% economic growth (elasticity of 0.17). Causal relation | Panel data van 175 Europese luchthavens (3LS) |
| Mukkala and Tervo (2012) | Strong correlation between air traffic and economic growth. Causality from air traffic to regional growth in peripheral regions but causality is less evident in core regions | Empirical analysis herein is based on European-level annual data from 86 regions and 13 countries on air traffic and regional economic performance between 1991-2010. Granger-non-causality test applied |
| MIT ICAT (2009) | Strong positive correlation between air transport passengers and GDP of 0.99 for the UK (mutual causality) | Country-data analysis for 139 countries between 1975-2005 |
| Tittle et al. (2010) | Positive relationship between the number of runways and real gross metropolitan product | Panel data analysis for 33 U.S. airports between 2001-2007 |
| Oxford Economics (2012) | Constraints at Heathrow airport reduces economic activity in UK by 2021 by<br>£ 8.5 billion each year | Analysis based on Input-output model and ad hoc econometric models |

Table 11 shows that there remain large uncertainties about the impact of air travel demand on economic growth. Most of the studies find a positive correlation, but cannot find causality. In other words, it is not clear whether connectivity causes economic growth or the other way around.

Mukkala and Tervo (2012), for example, studied the role of air transportation in regional growth. They find a strong correlation between air traffic and economic growth, but find no clear causality. In peripheral and remote regions provision of air transportation may result in a boost for the regional development of the economy (supply effect), but this effect is less likely in core regions. In remote regions, the implementation of transportation infrastructure and accessibility leads to economic development and airports may act as catalysts for local investment. In core regions, however (like London), these agglomeration effects are already exploited and here it is economic development that spurs a region to provide increased and better air transportation. Hence, in core regions it is the economic development that determines transportation needs and services. Furthermore, they state that the development of core regions is led by many agglomerative forces, and their success is not inevitably dependent on the impact of airports, although they naturally require efficient airlines.

Tittle et. al. (2010) explored the economic impact that additional runway capacity has upon a metropolitan growth and economic development. Based upon panel data for 33 medium and large airports, they find a positive relationship between the number of runways and real gross metropolitan product[14]. Capacity constraints (measured by flight delays) were found to be an important determinant of economic development, decreasing gross metropolitan product by 2.9% ($ 1.5 billion) and labour productivity by 1.31% ($ 1,029) on average.

Many studies show a strong correlation between aviation and economic growth, but no clear causation. Furthermore, effects might be overestimated due to a failure to account for changes in other strategic variables, such as prices and network development and Open Skies air service agreements.

Oxford Economics (2012) has prepared a position paper for Heathrow which builds upon their earlier research for the aviation industry. Oxford Economics claim that “if Heathrow is constrained, it is likely to reduce economic activity in the UK (as measured by GDP) by 2021 by £ 8.5 billion each year and lower employment by 141,400.”

CE Delft has critically assessed the framework used by Oxford Economics on two occasions (CE, 2008 and 2012). Our main points of criticism are:
Oxford Economics presents gross impacts of aviation on employment, taxes and GVA. An estimate of the net impacts on the UK economy would take account of the displacement of jobs, changes in the wage and air freight rate.
Connectivity moves in both directions: an increase in tourism would lead to more spending of foreign visitors in the UK, but would also lead to higher spending of UK residents abroad. Oxford Economics only addresses the first issue.
A loss of connectivity at Heathrow does not mean that trade and passengers are lost to the UK. They could reach the country through other UK airports, by connecting flights from continental hubs or by other modes of transport. Alternatives travel modes are insufficiently addressed.
Scenarios used contain several unrealistic assumptions. Upper limits are applied for

[14] Gross Metropolitan Product (GMP) is similar to Gross Domestic Product (GDP), but then for a metropolitan area. GMP is defined as the market value of all final goods and services produced within a metropolitan area in a given period.

projections on passenger and cargo growth and capacity. For instance, capacity during the busy summer period is used as an estimate for capacity throughout the year.
Air connectivity is confused with air centrality*, most losses reported by Oxford Economics are in all likelihood related to the latter rather than to the first concept.
Some impacts (e.g. the economic value of business trips, GVA of non-airliner entities at Heathrow airport) are counted twice.
Taxes are treated as benefits to the UK economy, but this only applies to taxes paid by foreign entities in the UK. Taxes are transfers within the UK, with possibly distortionary impacts.
The value added of foreign airliners is incorrectly added to UK GDP.
The negative impacts of aviation (noise, pollution, congestion, lower property values) are not addressed.

CE Delft has assessed that Oxford Economics' estimates of the gross impacts on GVA are inflated by a margin of 65 to 72.5% and presumably by even more. A social cost benefit analysis conducted by CE Delft (2011) suggests that net impacts of Heathrow expansion are likely negative, due to lower gross benefits and high social costs of noise impacts.

*Connectivity is often confused with centrality, which is measured by the number of routes (and ignoring frequency of flights and importance of destinations)

## Air travel and employment

Air travel is said to have a large contribution to the creation of jobs, not only in the aviation industry, but also in the service industry due to a large amount of incoming passengers. The results of different studies on the impact of air travel on employment are shown in Table 12.

**Table 12 Impact of air travel on employment**

| Study | Impact of air travel demand on employment | Type of research (method) |
|---|---|---|
| Oxford Economics (2012) | Constraints at Heathrow airport lowers employment in UK by 2021 by 141,400 jobs | Input-output model (multiplier used for indirect employment is 1.7) |
| NYFER (2000) | 10% increase in aviation growth results in 1.8% employment in the service sector (elasticity of 0.18). Indication of positive causational relation between aviation and employment | Panel data of 175 European airports between 1992-1997. Correlation coefficient and Spearman rank correlation applied |
| Green (2007) | Hub cities see their employment grow between 8.4 and 13.2% faster than non-hub cities | Regression analysis with panel data of 83 metropolitan cities in US between 1990-2000 |
| Hakfoort et al. (2001) | One job at the airport leads to one job in indirect and induced employment (Amsterdam Schiphol) | Input-output model (MADAM) for Amsterdam Schiphol between 1987 and 1994 |
| Button and Taylor (2000) | Increasing destinations from 2 to 3 increases jobs with 2486. But diminishing returns: from 20-21 destinations results in additional 450 jobs. (Assumption that new destination increases number of on-board passengers) | Regression analysis on 41 US airports in 1996 with new EU-destinations |

| Study | Impact of air travel demand on employment | Type of research (method) |
|---|---|---|
| Percoco (2010) | Elasticity of service-sector employment to air passengers is 0.045 (Italy) | Two step procedure with tobit model with data including 35 Italian airports in 2002 |
| Brueckner (2003) | A 10% increase in passenger enplanements in a metropolitan area leads approximately to a 1% in employment in service-related industries (but not in manufacture or other goods-related employment) | 2SLS regression analysis with 91 US metropolitan areas in 1996. Causality accounted for with instrumental variables |
| Neal (2011) | Central position in the network (centrality ) leads to economic growth in terms of jobs | Analysis on 128 U.S. metropolitan areas from 1993-2008 using a series of lagged regression models |

Most studies find that an increase in air travel and employment are positively related, however causality can not always be proven. Green (2007) finds that passenger activity can be a powerful predictor of growth under a variety of specifications. He finds a strong correlation between air traffic and employment, but the direction of the causality is not clear. Button and Taylor (2000) find that increasing the number of destinations from 2 to 3 (accompanied by an increase of passengers) results in higher employment by 2,486 jobs. This effect becomes smaller as the number of destinations increases (diminishing returns). An increase from 20 to 21 destinations (with an increase in on-board passengers from 145,000 to 150,000) results in additional 450 jobs. Brueckner (2003) and Percoco (2010) state that the positive employment effect is quite small (0.4 to 1%) and only found in the service sector (not in the manufacturing or other goods-related sectors).

Neal (2011) examined the relationship between centrality and employment for 128 US cities. He finds that a city's economic growth is closely related to its position in networks of inter-urban exchanges i.e. its centrality.
Yet centrality is a narrower concept than connectivity. Centrality refers to the number of destinations that can be reached directly, not to the frequency of flights on these routes. He questions whether a city occupies a central position in the network because of its significant economic activity (demand based theory) or whether cities experience economic growth because they occupy a central position in the network (supply based theory)[15]. The latter appears to be the case, albeit in a different way from that in which the author interprets his results: cities with a central position in the network experienced more economic growth (employment in jobs), whereas centrality seems to be a process that is unrelated to the level of employment. Therefore, this study does not fully answer the question of whether increased connectivity leads to more economic growth, it only implies that one of its components, centrality, may perhaps cause more economic growth and employment.

Neal incorrectly assumes that problems with causality are circumvented by using a lagged value for centrality in explaining employment. His estimation results however, reveal that centrality today was similar to centrality one year ago supplemented by some random factor (i.e. the addition or cancellation of

[15] Centrality is expressed by the volume of air traffic in terms of number of passengers for whom a city is either their origin or destination. More centrality in the network implies a higher volume of air traffic.

air links or airport expansion or closure). As such, it would probably make no difference to his relation between employment and centrality if the current value of centrality is substituted for its lagged value. The question on the causality between centrality and growth remains unsettled.

### 3.4.6 Causation or correlation?

This study investigates the relation between connectivity and economic growth. In many of the studies discussed above a positive relation (correlation) is found between connectivity and economic growth. However, it is important to mention that a differentiation should be made between correlation and causation. Correlation merely means that two variables appear to be related to one another by some statistical function over the period examined. Causation shows a clear relation and direction: a change in one variable *causes* a change in the other variable but not the other way around. Often correlation is misinterpreted for causation e.g. there is a clear correlation between shoe sizes and the reading skills among children, but it is obvious that there is no causal relationship between the two.

The question raised in this study is whether connectivity leads to economic growth or not. Regarding the relationship between air traffic and economic growth, there is a lot of literature provided by the aviation industry, but there is only a limited number of scientific studies. Most of the studies find a positive correlation between air traffic and economic growth, but the causality is not clear. Brueckner (2003), Nyfer (2000), and Green (2007) studied the causal relation of air traffic and economic growth (measured by employment) and claim that there is a causal relationship. Brueckner (2003) and Green (2007) utilised the methodology of instrumental variables (IV) in panel data to control for the potential endogeneity of airline traffic. The problem with the IV method as applied here is to find appropriate instruments that explain only airport activity, not regional growth. NYFER (2000) suggests that an increase in aviation growth results in 1.7% economic growth. These studies found support for bidirectional influence, but conclude that air traffic has a larger impact on economic growth than vice versa (Brueckner, 2003; Button and Lall, 1999; Irwin and Kasarda, 1991; Ivy et al., 1995). These studies suffer, however, from several limitations with respect to the measurement of air traffic and the connectivity of cities in the network, by ignoring leisure travellers (Neal, 2011). Neal states that there is a causal relation between centrality and employment, which covers only one part of connectivity (number of destinations) and ignores frequency of flights. Concluding we can state that the methodological shortcomings of these papers undermine their ability to differentiate between correlation and causation.[16]

[16] The problem of causation can be addressed in two ways: a co-integration analysis to differentiate between the long-term and short-term relationship between growth and connectivity or better yet, an approach in which connectivity is first instrumented. The 'instruments' in the latter approach should be able to predict connectivity without being related to economic of employment growth. The predicted value for connectivity, which will now be no longer dependent upon growth, can be used to reveal the proper impact on employment or economic growth.

## 3.5 Conclusion

In this chapter, we analysed the relationship between capacity, connectivity and economic growth. We have seen that capacity refers to the ability of an airport to handle a given volume or magnitude of traffic (demand) and constraints result when there is unmet demand. Capacity constraints can be caused by operational, economic or environmental restrictions.

The impact of capacity constraints on connectivity can be twofold: either the number of destinations served or the frequency of flights is reduced. Regarding Heathrow's capacity, we found that compared to other main European airports.:

- Heathrow has lowest number of destinations (139) and smallest increase of new destinations (2.1%) compared to other main airports.
- Heathrow has the highest frequency of flights.
- Heathrow has the highest number of passengers, although the gap with other main airports has closed somewhat.
- Heathrow has the second largest number of total flights after Frankfurt.

It appears that Heathrow's strategy for the last decade has been to focus on a limited amount of destinations, but with a very high frequency. Heathrow has developed itself differently than the other main European airports, which may have been the result of capacity constraints.

Capacity constraints may in the long run affect connectivity in two ways: fewer destinations or lower frequency of flights. What this implies for economic growth remains unclear. Although connectivity is said to increase global trade, and to contribute to competitiveness, productivity and eventually economic growth, proof is extremely difficult to establish. There remain large uncertainties and although many studies show a strong and positive correlation, causation cannot be proven.

# 4 Conclusions

This report set out to answer two questions:

1. What framework should be used to assess the economic impacts of airport investment projects?
2. Does airport expansion lead to increased capacity, more connectivity and more economic growth?

### Assessing the economic impacts of airport projects

The most widely recognised method to assess the economic impacts of airport investment projects is a social cost benefit analysis (SCBA). A SCBA identifies all the effects of an investment project over time and expresses them in monetary terms. For effects that are traded, such as building a runway, market prices can be used. For most effects that are not traded, such as time savings, various well-established methods exist to estimate their monetary value. By expressing all effects in monetary terms, the relative importance of the various costs and benefits can be analysed. Some effects, such as the impact on biodiversity and landscape, are often not expressed in monetary terms.

In the UK, the Transport Assessment Guidelines recommend social cost benefit analysis for airport investment projects. A SCBA yields very different results from other methods that are sometimes used to determine the economic impact of airports or aviation. A commonly used method is to add the direct, indirect, induced and catalytic effects. The results cannot be used in a SCBA, however, since the indirect and induced effects are in fact part of the direct effects. For example, if an airport expansion results in more passengers using the airport, this indicates that a consumer surplus exists. Passengers may decide to use a share of the surplus to buy something at the airport. Thus consumer or producer surplus created in shops and restaurants at the airport is included in the consumer surplus of the expansion and should not be added to the former.

A SCBA shows whether or not a particular project creates wealth and, if there are alternatives, which of these creates the greatest wealth. Of course, creating wealth need not be the only policy objective. A political decision-making process may also take into account distributional effects, legal aspects, public opinion, equity, fairness and employment effects, which do not feature in SCBAs.

### The relation between aviation activity and economic performance

Among the wider economic benefits of airport expansion are the impacts on productivity agglomeration, output change, labour market supply and the move to more or less productive jobs. These are often captured under the heading ‘benefits of connectivity’. They provide one of the main arguments used in the public debate on airport expansion and studies have been published which claim the benefits of expanding London’s airports will be very large for the capital as well as for the country as a whole.

This study has reviewed the evidence on the relation between connectivity and economic performance. Although the few academic studies found report some degree of correlation, this study has not identified any evidence of causation either way. Hence, claims about the economic benefits of connectivity are not founded on solid evidence.

The relation between aviation activity and economic performance has attracted more attention. A review of the academic literature suggests there is a two-way causal relation between aviation activity and regional economic performance, with an increase in aviation activity causing an increase in GDP, and vice versa. This relation appears to be stronger for remote regions and stronger for poorer regions and countries than for well-developed ones. When reviewing this evidence, one should be aware that the method used to establish a causal relation cannot establish whether airports cause additional economic activity per se, or whether regions with airports grow at the expense or surrounding regions without airports.

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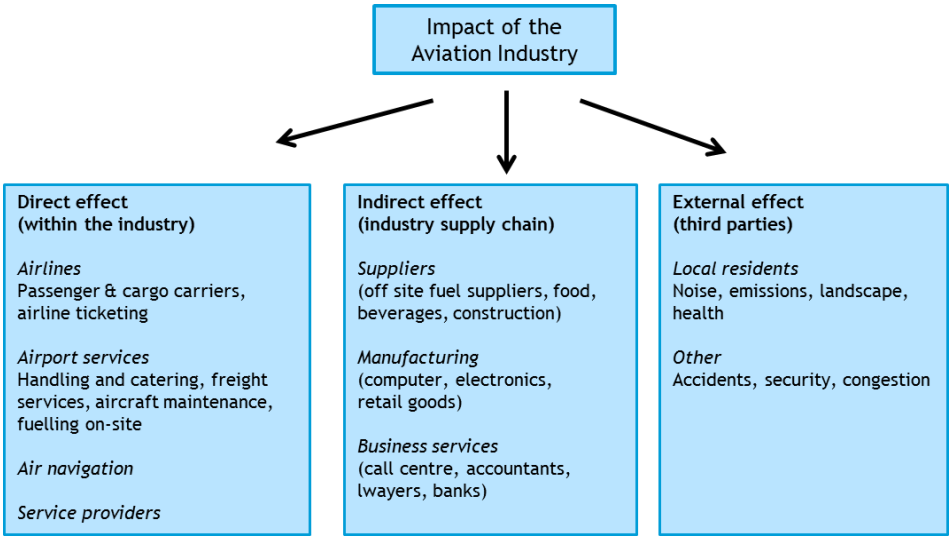
# Annex A Direct, indirect and external effects of the aviation industry




***Direct effects*** are impacts that are a direct consequence of the expansion/new airport development of the airport. It includes the employment and income generated within the aviation industry, including airline and airport operations, aircraft maintenance, air traffic control and regulation and activities directly servicing air passengers.

***Indirect effects*** denotes economic activity created by the industry supply chain. These include the employment and activities of suppliers to the air transport industry, such as aviation fuel suppliers, construction companies that build additional facilities, manufacture of goods sold at airport retail outlets, and the production of airline meals and of the goods. These effects are also called backward linkages.

***External effects*** relate to unintended changes in the welfare of third parties due to a certain action or change in policy for which no compensation is received. These often concern the environmental impact, such as the effects on human health, nature (soil, water), landscape, noise, air quality, GHG emissions, but also security. Since these impacts are not incorporated in market prices, they are denoted as external effects.

# Annex B Overview CBA framework in the UK, the Netherlands and the EU

| Transport Analysis Guidance (UK, DfT) | OEI (Netherlands) | EU - CBA Guideline |
|---|---|---|
| **Economic impacts** | **Direct effects (1st order)** | **Economic impacts** |
| Transport economic efficiency (PS,CS)<br>Time savings from delay reduction<br>Wider economic impacts<br>Surface access impacts (new levels of traffic)<br>Impact on non-UK residents<br>Public account | Exploitation profits of the new infrastructure (PS)<br>Transport related benefits (CS)<br>Location related effects<br>Economies of scale | Consumer surplus (passengers)<br>Producer and user surplus<br>Time benefits<br>Impact on land values<br>Public account |
| **Social impacts** | **Indirect effects (2nd order)** | |
| Accidents<br>Security<br>Accessibility<br>Integration | Labour market (jobs)<br>Real estate market<br>Impact on other transport modalities<br>Strategic effects | |
| **Environmental impacts** | **External effects** | **External effects** |
| Noise<br>Air quality<br>GHG emissions<br><br>Non monetised effects:<br>Landscape<br>Biodiversity<br>Water<br>Historic heritage | Noise<br>Emissions<br>Air quality<br>Landscape<br>Security<br>Congestion<br>Regional inequality | Environment (landscape, noise, pollution)<br>Safety and accidents<br>Congestion<br>Health |
| **Costs** | **Costs** | **Costs** |
| Investment costs<br>Maintenance costs<br>Exploitation/ operating costs | Investment costs<br>Maintenance costs<br>Exploitation/ operating costs | Investment costs<br>Maintenance costs<br>Exploitation/ operating costs |
| **Net result** | **Net result** | **Net result** |

# Annex C Appraisal Summary Table

| Impacts | | Summary of key impacts | Assessment | | | | |
|---|---|---|---|---|---|---|---|
| | | | Quantitative | | Qualitative | Monetary £ (NVP) | Distributional 7-pt scale/ vulnerable grp |
| Economy | Business users & transport providers | | Value of journey time changes (£) | | | | |
| | | | Net journey time changes (£) | | | | |
| | | | 0-2min | 2-5min | | | |
| | | | | | | | |
| | Reliability impact on Business users | | | | | | |
| | Regeneration | | | | | | |
| | Wider Impacts | | | | | | |
| Environmental | Noise | | | | | | |
| | Air Quality | | | | | | |
| | Greenhouse gasses | | Change in non-traded carbon over 60y ($CO_2e$) | | | | |
| | | | Change in traded carbon over 60y ($CO_2e$) | | | | |
| | Landscape | | | | | | |
| | Townscape | | | | | | |
| | Heritage of Historic resources | | | | | | |
| | Biodiversity | | | | | | |
| | Water Environment | | | | | | |
| Social | Commuting and Other users | | Value of journey time changes (£) | | | | |
| | | | Net journey time changes (£) | | | | |
| | | | 0-2min | 2-5min | | | |
| | | | | | | | |
| | Reliability impact on Commuting and Other users | | | | | | |
| | Physical activity | | | | | | |
| | Journey quality | | | | | | |
| | Accidents | | | | | | |
| | Security | | | | | | |
| | Access to services | | | | | | |
| | Affordability | | | | | | |
| | Severance | | | | | | |
| | Option values | | | | | | |
| Public Accou | Cost to Broad Transport Budget | | | | | | |
| | Index Tax Revenues | | | | | | |

Source: DfT (2012).