Airports Commission

Economy:
Transport Economic Efficiency Impacts

November 2014

An independent commission appointed by Government

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Glossary

Abnormal profits	Any profit in excess of that required to cover long-term running costs
APD	Air Passenger Duty
ATM	Air Transport Movement
Baseline	Specifically the option of adding no new runway capacity as assessed in the *Interim Report*
CAA	Civil Aviation Authority
Capacity constrained	Modelling case where passenger and ATM demand must fit available future capacity where no significant additional runway or terminal capacity is added
Capacity unconstrained	Modelling case where passenger and ATM demand is not limited by runway or terminal capacity
Carbon-capped	Modelling scenario where CO_2 emissions are limited to 2005 levels through an Emissions Trading Scheme (ETS) and higher carbon prices
Carbon-traded	Modelling scenario where CO_2 emissions are part of an ETS
Consumer surplus	The difference between the price consumers are willing to pay and the price they pay in the market. Can be used as a measure of welfare
Cost-benefit analysis (CBA)	An analytical technique to assess and monetise (assign a money value to) the strengths and weaknesses of a policy, programme or project
DECC	Department for Energy and Climate Change
DfT	Department for Transport
Discounting	A method used to estimate how much future costs and benefits would be worth today. The need to 'discount' arises for several reasons, including individuals having a time preference
Green Book	HM Treasury guidance for public sector bodies on how to appraise policies, programmes or projects
I-I	International to International interliners i.e. passengers who are transferring via a UK airport with their origin and destination outside the UK
International-interliners	Passengers starting or finishing their journey in the UK but using a foreign hub
LCC	Low-cost carrier
LDC	Least Developed Country
LGW 2R	Capacity option: Gatwick Airport Second Runway, proposed by Gatwick Airport Limited
LHR NWR	Capacity option: Heathrow Airport North West Runway, proposed by Heathrow Airport Limited
LHR ENR	Capacity option: Heathrow Airport Extended Northern Runway proposed by Heathrow Hub Limited
Monte Carlo analysis	A method of forecasting where inputs are randomly varied within a distribution to calculate the probability of a particular outcome
mppa	Million passengers per annum
NAPAM	The DfT's National Air Passenger Allocation Model
NAPDM	The DfT's National Air Passenger Demand Model
NIC	Newly Industrialised Country
Present value	The current value of future costs and benefits 'discounted' to today's value. Also referred to as discounted value. See 'discounting' for more information
Producer surplus	The difference between the price producers are willing to supply at and the price they receive in the market. Can be used as a measure of welfare
Shadow cost	The extra cost of flying required to reduce passenger demand from above an airport's runway or terminal capacity to a level that is within capacity
Terminal passenger	A person joining or leaving an aircraft at a reporting airport, as part of an ATM. More detail is included in DfT's January 2013 publication[1]
WE	Western Europe
WebTAG	Department for Transport Appraisal Guidance

1 DfT UK Aviation forecasts, January 2013, particularly paragraphs 2.6 to 2.8,https://www.gov.uk/government/publications/uk-aviation-forecasts-2013

1. Introduction

1.1 Many of the costs and benefits attached to airport capacity options fall directly on airports, airlines, passengers and the public finances. Quantifying such impacts is an important part of the complete economic appraisal and this report sets out the Commission's analysis relating to such transport economic efficiency impacts. These impacts also feed into the S-CGE modelling of wider economic benefits.

1.2 **Chapter 2** describes the principles underpinning the approach, which is based largely on HM Treasury's Green Book and the DfT's WebTAG appraisal guidance.

1.3 **Chapter 3** provides details concerning the methodology and assumptions underpinning the analysis.

1.4 **Chapter 4** outlines the results for each of the scenarios, organised by capacity option.

1.5 **Chapter 5** provides sensitivity analysis.

Summary of findings

1.6 This report sets out the transport economic efficiency impacts associated with options to expand airport capacity. The key findings from the analysis are:

- There are significant direct passenger benefits attached to adding airport capacity. Expansion allows passengers to access flights at lower costs, with greater convenience and to more direct destinations.
- Passenger benefits are heavily driven by demand forecasts – the higher the level of forecast demand, the greater the benefit.
- The benefits to passengers are partly offset by the loss in producer surplus. Expanding airport capacity reduces scarcity rents, translating into lower fares for passengers. This, compared to what would have happened without additional capacity, lowers profits for airlines.
- Across all scenarios, expanding capacity benefits passengers travelling to Western Europe relatively more than those travelling to other regions. This reflects the extent to which such traffic dominates the aviation market and that scarcity rents per passenger tend to be higher for short-haul trips.

2. Principles of the approach

2.1 The transport *Appraisal Framework* has been developed and designed based on the principles laid out in HM Treasury's Green Book which recommends the cost-benefit analysis (CBA) approach to appraisal. The broad areas considered are impacts on the economy, environment, society, and government (public accounts).

2.2 To assist analysts involved in transport appraisal, DfT's WebTAG provides detailed guidance on how to appraise the impacts (costs and benefits) of transport schemes.[2] It sets out the principles that should be applied to all costs and benefits that are monetised, and the key elements are summarised below.

- The impacts of a capacity option should be based on the difference between forecasts of the baseline (known in WebTAG as the 'without scheme' option) and capacity options ('with scheme' option).
- Impacts should be assessed over defined appraisal periods, capturing the planned period of scheme development and implementation; it will typically end 60 years after scheme opening for infrastructure projects.
- Values placed on impacts should be in the market prices unit of account, and should be in real terms.
- When calculating present values, streams of costs and benefits should be discounted.

2.3 This report sets out transport economic efficiency impacts, as defined in the Airports Commission's *Appraisal Framework*.[3] These impacts measure the direct benefits to producers (airport operators and airlines), consumers (passengers) and government. The key impacts on these various groups are monetised as far as possible. It should be noted that this report includes only a subset of benefits (and dis-benefits) and does not include any of the costs. These are covered in the Economic case.

2 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/275125/webtag-tag-unit-a1-1-cost-benefit-analysis.pdf#nameddest=chptr02

3 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/300223/airports-commission-appraisal-framework.pdf. See in particular, page 32.

2.4 The calculation of transport user benefits is based on the conventional consumer surplus theory where consumer surplus is defined as the benefit which a consumer enjoys, in excess of the costs which they perceive. WebTAG Unit A1.3 provides more explanation of this approach.[4] WebTAG Unit A5.2 includes guidance specific to a transport economic efficiency appraisal of an aviation intervention focussing on how to appraise the impacts of lower shadow costs when more airport capacity is made available.[5]

2.5 Such user benefits, which represent improvements in 'generalised costs' associated with better transport, might capture important impacts of a transport intervention on the economy. Although the cost saving is often measured by its impact on users, the market economy transfers much of the benefit to others in the economic system. Firms that enjoy a reduction in their costs as a result in a transport improvement, may pass these benefits on to consumers, for example. But such methodology is built on the assumption that markets are perfectly competitive. In the presence of market distortions, other impacts can be observed which are not sufficiently captured through direct user benefits. These 'wider economic benefits' are discussed in the economic case and PwC report "Economy: Wider Impacts assessment".

2.6 Other economic impacts are also not included in this report but covered elsewhere in the appraisal. These include infrastructure costs, direct surface access impacts (for example, on those not travelling by air), freight and noise impacts.

2.7 WebTAG Unit A5.2 sets out that all passengers, whether UK resident or otherwise, should normally be treated the same in the appraisal of aviation interventions. Further, where possible and practical to do so, the costs and benefits of aviation interventions to UK and non-UK residents should be identified separately. The results in **Chapter 4** therefore separately report benefits to UK and foreign resident passengers.

2.8 An exception is made in WebTAG for international to international transfer passengers who neither start nor end their journey at a UK airport, but only interline at one. WebTAG recommends that benefits to these passengers should be excluded. This raises a difficulty in this context, as a proportion of the costs of the capacity option are likely to be borne by such passengers through higher aeronautical charges. So, to ensure consistency, benefits to such passengers

4 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/313801/webtag-a13-user-provider-impacts-may2014.pdf

5 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/275398/webtag-tag-unit-a5-2-aviation-appraisal.pdf.

should be considered, or their contribution to costs should be excluded. In this report, benefits to these passengers are reported separately. But benefits and costs to passengers that do not travel via a UK airport at any stage in their journey are not calculated.

2.9 In all cases, where producer surplus and government revenue impacts are reported, they include those accruing from international to international transfer passengers.

3. Methodology and assumptions

Introduction

3.1 This chapter sets out the implementation of the approach described in **Chapter 2**, along with the key assumptions made.

3.2 The transport economic efficiency appraisal has been undertaken with a new model, Transport Economic Efficiency Appraisal Spreadsheet for Aviation (Teeasa).

Teeasa Model

3.3 Underpinning the Teeasa model are forecasts of passenger volumes, Air Transport Movements (ATMs) and 'shadow costs' (scarcity rent) taken from the DfT aviation model. The aviation model first forecasts unconstrained passenger demand using a series of econometric equations in the National Air Passenger Demand Model (NAPDM). It then allocates these passengers to individual airports, using the National Air Passenger Allocation Model (NAPAM), taking into account capacity constraints. More details on the DfT model is available in the Strategic Fit: Forecasts report.

3.4 As explicit capacity constraints are included, the model outputs 'shadow costs', which act as a form of congestion charge at each constrained airport.[6] In the expansion options, capacity is added, resulting in changes to forecast passenger volumes, ATMs and shadow costs relative to the baseline. As is set out below, this permits a calculation concerning the benefits of additional airport capacity.

3.5 Calculations within Teeasa are, during the modelling period, undertaken at airport to NAPAM route group level within each journey purpose.[7] This is a major enhancement on the predecessor model used for the *Interim Report* which undertook calculations at the more aggregated airport level. The disaggregated approach permits more precise shadow cost and frequency cost calculations, as these impacts can vary significantly between route groups within an airport.

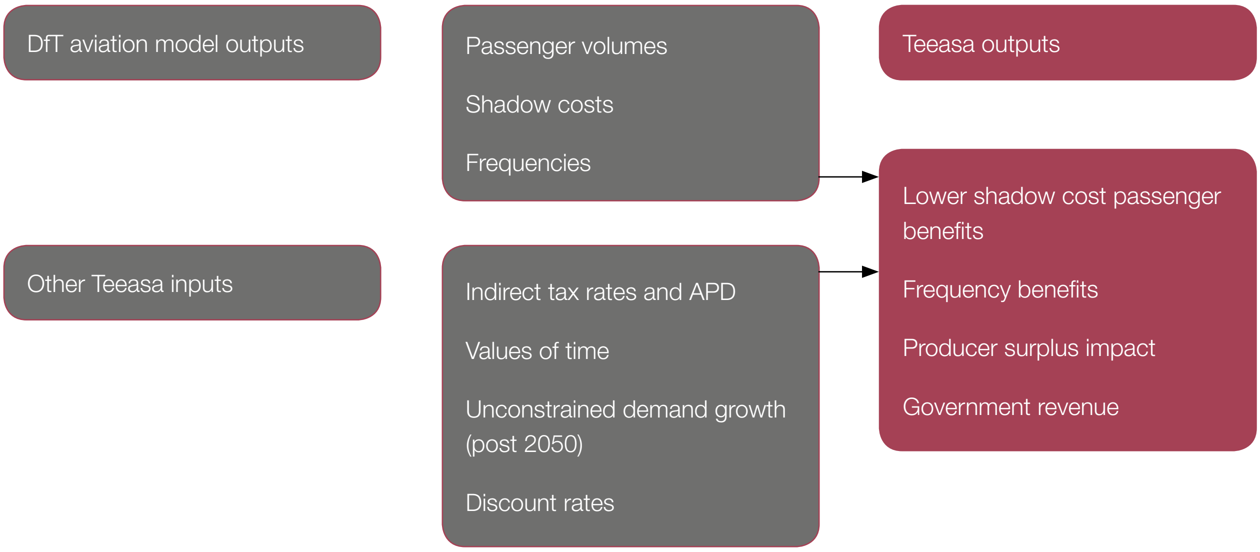
3.6 Teeasa follows WebTAG methodology as set out in Unit A5.2. In addition, it includes a new frequency calculation, described in this chapter.

6 Shadow costs are described in more detail later in this chapter.

7 For appraisal purposes, there are five journey purposes: UK leisure, UK business, foreign leisure, foreign business and international to international transfer passengers.

3.7 **Figure 3.1** provides a simplified overview of the inputs to Teeasa and its outputs.

Figure 3.1: The Teeasa model



The role of shadow costs

3.8 Shadow costs represent the extra cost of flying required to reduce passenger demand from above an airport's runway or terminal capacity, to a level that is within capacity; shadow costs therefore only apply at congested, or capacity constrained, airports. Shadow costs may be referred to as a charge associated with congestion or a congestion premium. The calculation of shadow costs is therefore sensitive to assumptions about demand growth, passenger sensitivity to higher fares, propensity for passengers to reallocate to less constrained airports, and the amount of available capacity.

3.9 Shadow costs also represent the general inconvenience of using an overloaded airport. For example, there could be a locally increased fare differential, or shadow costs could represent higher access costs (such as, increased parking charges, longer transfer times, or a generally more unpleasant travelling environment). Shadow costs therefore represent the value a marginal passenger would place on flying to/from that airport, if extra capacity were available, and are a key monetised input to the appraisal of potential additional capacity.

3.10 Shadow costs are borne by passengers. For appraisal purposes, it is assumed these are passed to passengers in the form of higher fares. Shadow costs are assumed to accrue as scarcity rents to producers (in this context, airlines) through their 'ownership' of slots at constrained airports.

Passenger benefits of lower shadow cost

3.11 Airport expansion allows passengers to access the air network more conveniently and / or at lower cost. The expansion lowers the shadow cost for airports that are constrained without the addition of extra capacity; to the extent the airline market is competitive (and airports are appropriately regulated if necessary), this will lead to a reduction in fares. As well as providing a direct benefit to those who already use the airport, it also generates further benefits for passengers who now choose to access the newly expanded airport. In addition, passengers enjoy benefits associated with greater frequency – so being more likely to be able to travel at their preferred time – and access a greater range of destinations without having to transfer.

3.12 These calculations are all undertaken at route and passenger purpose aggregation level. When a new route is introduced (or lost) at an airport in a capacity expansion option, there is no observed shadow cost in the baseline; however, such a cost is needed to permit a passenger benefit calculation. In such situations, the shadow cost that would have been incurred in the baseline had the route existed is applied to enable the passenger benefit to be estimated.

3.13 The quantification of such benefits follows the methodology outlined in WebTAG Unit A5.2.

Passenger frequency benefits

3.14 Expansion at a constrained airport allows for greater frequencies and new routes. This provides convenience benefits (or dis-benefits) to passengers. Details on how these impacts are quantified is included in **Box 3.1**.

3.15 To be consistent with WebTAG unit, frequency benefits are calculated using **appraisal values of time.**[8] Table 3.1 provides appraisal values of time for leisure and business journey purposes.

8 Values of time grow over time in line with GDP per capita.

Table 3.1: Appraisal Values of Time (£ per hour, 2008 prices)

UK Airport	UK Business	Foreign Business
Aberdeen	£37.32	£42.73
Belfast International	£32.72	£41.65
Belfast City	£21.88	£25.57
Birmingham	£37.32	£37.72
Bournemouth	£44.41	£33.30
Bristol	£39.69	£36.00
Cardiff	£43.82	£34.86
East Midlands	£36.35	£33.85
Edinburgh	£38.91	£40.55
Exeter	£42.24	£47.23
Gatwick	£45.12	£40.06
Glasgow	£40.27	£40.23
Heathrow	£54.98	£51.71
Humberside	£27.51	£30.83
Inverness	£32.42	£23.77
Leeds/Bradford	£41.95	£45.10
Liverpool	£42.64	£52.23
London City	£60.51	£66.92
Luton	£49.39	£40.09
Manchester	£46.05	£38.92
Newcastle	£39.13	£47.65
Newquay	£40.97	£41.61
Norwich	£36.35	£33.85
Southend	£40.97	£41.61
Southampton	£45.12	£40.06
Stansted	£44.20	£36.21
Teesside	£36.87	£50.44
Blackpool	£44.47	£54.47
Coventry	£36.35	£33.85
Doncaster Sheffield	£37.60	£36.52
Prestwick	£25.04	£52.82
	Leisure	
	£6.03	

Producer surplus impacts

3.16 Airport expansion impacts on producer benefits – that is profits accruing to airports or, where the airport is regulated, airlines. The lower fares enjoyed by passengers are largely a direct transfer from airlines to passengers. If reductions in shadow costs did not translate into reductions in fares – but instead into a more pleasant travelling environment – then the producer surplus dis-benefit would be lower than reported in **Chapters 4** and **5.**

3.17 Partially offsetting this, airlines may receive 'new' shadow cost revenue (that is, scarcity rents) attached to greater demand if the airport becomes capacity constrained again even after capacity has been added.

3.18 Aside from such shadow cost revenue, it is assumed that producers, or their supply chain, receive no profits over and above the opportunity cost of the capital employed – that is, they would not receive abnormal profits.

3.19 The quantification of such impacts follows the methodology outlined in WebTAG Unit A5.2.

Public accounts impacts

3.20 The additional passenger demand associated with expanded airport capacity has two sets of impacts on the public accounts (government revenue), both of which are estimated by Teeasa:

- **Additional air passenger duty (APD) revenue.** Within Teeasa, two rates are applied, depending on the NAPAM route group, reflecting the forthcoming APD structure.[9]
- **Indirect tax revenue foregone.** Additional passenger demand transfers expenditure from other goods and services in the economy, many of which are subject to VAT; therefore, additional demand can reduce indirect tax revenue. Offsetting this, lower shadow costs (and therefore air fares) reduces the indirect tax revenue loss per passenger.

3.21 The quantification of such impacts follows the methodology outlined in WebTAG Unit A5.2.

3.22 The potential additional carbon revenue accruing from increased aviation demand is not normally calculated. This is because, in the scenarios described in **Chapter 4**, aviation is assumed to be part of a carbon trading scheme, meaning the total quantity of carbon emitted is unaffected. Assuming aviation acts as a carbon price taker, government revenues are unaffected directly, although knock-on impacts on shadow costs and therefore APD and other indirect tax revenue are calculated. **Chapter 5** considers an alternative carbon price sensitivity where prices are higher

9 The new bands are set out in https://www.gov.uk/government/publications/air-passenger-duty-banding-reform.

than in the carbon-traded case which does have implications for government revenue; the methodology for this sensitivity is described in **Chapter 5**.

Carbon emissions

3.23 Quantified carbon emissions in the various scenarios and sensitivities are shown in the Strategic Fit: Forecasts report. The assumption that aviation is part of an aviation trading scheme means that there is no need to monetise carbon emissions in such scenarios – this is in set out in WebTAG Unit A3.[10] **Chapter 5** considers an alternative carbon price sensitivity where this assumption is dropped and so valuation is needed; the methodology in this case is described in that chapter.

Box 3.1: Quantification of frequency benefits

As set out in the Strategic Fit: Forecasts report, frequency is a key driver of passenger airport choice, which demonstrates that frequency is valued by passengers. This box sets out how such passenger benefits are quantified for the purpose of the transport economic efficiency appraisals undertaken. The methodology described here is new; WebTAG unit A5.2 does not include guidance on this.

Within Teeasa, frequency costs are expressed in pounds. They are disaggregated by journey purpose and by route group and calculated using (1); this follows the same functional form as is included in NAPAM:

$$freq = \frac{1}{2} \times \frac{16}{F} \times [1-(1-a)^F] \times VoT \qquad (1)$$

Where:
F: daily (two-way combined) frequency, assuming a 16 hour day
a: parameter value between zero and 1; for business passengers it is set to 0.2; for leisure passenger it is 0.4, and for international to international interliners it is 0.35. These values are taken from NAPAM.
VoT: value of time

WebTAG Unit A5.2 includes functions providing guidance on how shadow cost-benefits should be valued; see in particular page 4. By assuming that £1 of frequency costs are valued identically to £1 of shadow costs, these formulae can be adjusted to incorporate passenger frequency benefits as shown in (2). For simplicity, tax and airline costs are excluded as these are assumed to not vary by scenario and so cancel out.

10 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/313826/webtag-a3-environmental-impact-appraisal-may2014.pdf

$$\sum_{a,\,m,\,y} \tfrac{1}{2} \times \{(pax_1 + pax_2) \times [(sc_1 + freq_1) - (sc_2 + freq_2)]\} \quad (2)$$

Where:

a: airport

m: market segment

y: year

pax_i: passenger numbers in capacity option i

sc_i: per passenger shadow cost in capacity option i

$freq_i$: per passenger frequency cost in capacity option i

Changes in frequency costs are not calculated for passengers taking charter flights. This is because the allocation model does not apply the frequency function of (1) to these ad hoc services, as they do not operate to a published timetable; effectively the appraisal assumes passengers on charter flights do not value increased frequency. Similarly, those flying solely within the UK are not assigned frequency benefits, because any estimate would lack accuracy – many of these flights are not explicitly modelled as they are to airports not included within NAPAM.

The frequency cost is capped such that the cost per passenger does not exceed that associated with a once-a-day-service to the route group in each direction. This permits an estimate of the benefits of new routes being introduced or lost at an airport, preventing the frequency cost reaching infinite or becoming implausibly high.

Extrapolation methodology

3.24 The appraisals relate to a 60 year period, ending in 2084 or 2085 depending on the capacity development option. As NAPAM cannot be run beyond 2050 – and in the case of very high demand scenarios it may not run this far – the appraisal requires extrapolation beyond the final modelled year. The appropriate way of doing this is subject to judgement, and the following text explains the assumptions underpinning the results described in **Chapter 4.** The same approach is applied to the results described in **Chapter 5** unless stated otherwise.

3.25 Due to computational constraints and to avoid spurious disaggregation given the lack of an allocation model during the extrapolation period, all extrapolations are undertaken at airport and journey purpose level – that is, at a higher aggregation level than during the modelling period.

Shadow costs extrapolation

3.26 The approach to extrapolating shadow costs has changed to that used previously. In the *Interim Report*, it was assumed that shadow costs at each airport would continue to grow at the same absolute rate, when expressed in pounds growth per year, as they had in the immediate years prior to the final modelled year. There are two limitations with this approach:

- shadow costs in the final modelled year can be volatile, especially when many airports in the system are constrained – extrapolating this growth rate, even linearly, for more than thirty years carries some risk; and
- the forecast growth rate has no connection to its drivers.

3.27 The new approach adopted here, deals with these two limitations.

3.28 There are two primary drivers of growth in shadow costs over time:

- **Values of time growth** determine the extent to which passengers are willing to pay more to avoid more time consuming routes – for example, travelling to an airport which has lower shadow costs but takes longer to reach than their preferred airport.
- **Unconstrained demand growth** drives shadow costs which determines the growth in the volume of traffic that needs to be cut back through higher shadow costs to stay within capacity limits.

3.29 During the extrapolation period,[11] Teeasa grows shadow costs for all airports in line with the product of these two factors:

$$sc_t = sc_{t-1} \times \frac{VoT_t}{VoT_{t-1}} \times [1 + d]$$

Where

sc_t: shadow costs in time t

VoT_t: value of time in time t

d: scenario and option specific national unconstrained demand forecast average percentage growth from 2050: taken from NAPDM.

3.30 To the extent demand growth is expected to continue post 2050, this is a cautious approach as during the modelled period, shadow costs grow more strongly than this approach implies. Furthermore, this approach results in those airports which do not have a shadow cost in the final modelled year failing to obtain one during the extrapolation period, even if their demand reaches their capacity. This again is a cautious assumption.

11 During the modelled period, shadow cost values are taken directly from NAPAM.

3.31 **Chapter 5** includes a sensitivity test where demand growth is assumed to be flat post 2050, resulting in shadow costs growing in line with values of time only.

Passenger demand extrapolation

3.32 During the extrapolation period, annual passenger growth is assumed to be the same as that modelled, at airport level, in the ten years prior to the final modelled year. This annual rate is capped such that it cannot be negative nor increase by more than 10%, to avoid volatile results in the final modelled years unduly skewing the extrapolation.

3.33 Passenger demand is then constrained to each airport's binding capacity. The binding capacity is the maximum number of passengers that can be accommodated given terminal and runway capacity constraints.[12] If in the final modelled year passenger demand is higher than the calculated binding capacity – this can occur because of the tolerances within NAPAM to allow convergence – then the final modelled year passenger demand is used as the binding capacity.

Public accounts impact forecast extrapolation

3.34 APD and fare levels affect the public finance impact of additional airport capacity. APD is assumed to be held constant in real terms from the final modelled year. Fares, excluding shadow costs, are assumed to grow by 1% per annum; this is based on an examination of post 2050 fares forecasts in NAPDM.

Passenger benefits forecast extrapolation

3.35 The combination of passenger demand and shadow costs forecasts allow for an estimate of the benefit to passengers of lower shadow costs during the extrapolation period. This is done using the same WebTAG approach as during the modelled period. The growth resulting from this approach is applied to the shadow cost passenger benefit calculated in the final modelled year.

3.36 Frequency benefits are assumed to grow in line with values of time growth beyond the final modelled year. This is the growth that would be expected if there were no changes in frequency in the baseline or capacity option, as the frequency function in Box 3.1 shows. This is a cautious assumption as there is more scope for increased frequencies in the option with greater capacity.

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12 Note that loadings per plane are assumed to be unchanged during the extrapolation period.

Producer surplus impact extrapolation

3.37 The WebTAG approach adopted during the modelling period is applied throughout the extrapolation period.

Other assumptions

3.38 When calculating present values, discounting is applied. In line with HM Treasury's Green Book[13] and WebTAG guidance, a rate of 3.5% per annum is applied until and including 2044, after which the rate changes to 3% for the remainder of the appraisal period.

3.39 To convert all components of the appraisal into the same unit of account, an indirect tax correction factor of 1.19 is applied to those elements that are not already in market prices.[14] WebTAG Unit A5.2 sets out those elements for which the factor needs to be applied.

Carbon-capped appraisals

3.40 As set out in the Strategic Fit: Forecasts report, and in line with the approach taken in the *Interim Report*, two sets of forecasts have been prepared based on different approaches to handling carbon emissions from aviation:

- 'Carbon-traded' – These cases assume that carbon emissions from flights departing UK airports are traded at the European level until 2030 and then as part of a liberal global carbon market. As such these forecasts assume that the total emissions allowed beyond 2030 in the global market are set with reference to stabilisation targets and that society seeks to make reductions where they are most desirable or efficient across the global economy. This market would be established under a future international agreement that aims for a global temperature increase of equal, or close to 2 degrees C and aims to ensure that a 4 degree C global temperature increase is reached only with very low probability (less than 1 per cent). Therefore, it is assumed that any aviation emissions target can be met in part through buying credits from other sectors. The carbon-traded case assumes that carbon is traded at a price equal to DECC's central long run forecast of carbon prices for appraisal.

13 See Annex 6 of https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/220541/green_book_complete.pdf

14 The reasoning behind this is explained in WebTAG Unit A1.1, available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/275125/webtag-tag-unit-a1-1-cost-benefit-analysis.pdf. The value is taken from WebTAG data book (May 2014), available at https://www.gov.uk/government/publications/webtag-tag-data-book-may-2014

- 'Carbon-capped' – These cases represent the level of aviation demand consistent with the Committee on Climate Change's (CCC) current assessment of how UK climate change targets can most effectively be met. These forecasts increase the costs of carbon to ensure demand for aviation in the UK is reduced to stay within this planning assumption and as such assume no trading of aviation emissions either within the UK economy or internationally e.g. such as under an EU emissions trading scheme or any international global agreement to tackle these emissions.

3.41 In the carbon-traded case, the carbon price is identical in the baseline and each capacity option forecasts. But in the carbon-capped case, because adding airport capacity stimulates further demand, carbon prices are higher in the capacity options than in the baseline: higher carbon prices are needed to offset additional demand to ensure the overall carbon cap is met.

3.42 As the text below explains, an appraisal of the capacity options in the carbon-capped case has not been undertaken. Any appraisal of a capacity option in the carbon-capped case would inevitably be an appraisal of carbon policy as well, because of the different level of carbon policies required to hit a given emissions cap in the various capacity options. And, given the carbon prices set out in Appendix 5 of the Strategic Fit: Forecasts report – with carbon prices being much higher than the level seen in the baseline – it is likely that the carbon policy component of the appraisal would dominate the capacity appraisal component.

3.43 This is particularly problematic as appropriate carbon policies have not been investigated in detail. For example, carbon emissions have been forecast assuming that the same technology is in use in the baseline as in the capacity options. But it might be expected that the higher carbon prices associated with greater capacity incentivise technological developments and uptake which enhance the carbon efficiency of aircrafts. So although it is likely that a mix of policies would result from a carbon-capped policy, only higher carbon prices have been considered – this implies greater dis-benefits attached to cutting carbon than can be viewed as realistic.

3.44 Compounding this, there are complications relating to the incidence of any carbon revenue resulting from higher carbon prices. The natural assumption is that such revenue would accrue to government. However, this assumption would lead to tax revenues which would be so high that they would then become the overriding factor in the calculation, even though the main impacts of interest relate to passengers, producers and carbon. Furthermore, in the case where benefits (and dis-benefits) to international to international transfer passengers are not scored, it results in spuriously high benefits to the UK. The carbon revenue accruing from international to international transfer passengers is scored as a benefit to government, but not as a dis-benefit to such passengers.

3.45 Finally, higher carbon prices are modelled in the overseas hubs as well as in UK airports. This leads to an additional technical difficulty with respect to the calculation of benefits accruing to those international to international transfer passengers who switch from transferring at an overseas hub in the baseline (and so whose benefits are not included in the calculations) to transferring at a UK airport in the capacity options (and so whose benefits should be included). This difficulty, in conjunction with the different carbon prices observed in the baseline and in the capacity options at overseas hubs, has meant that it has not been possible to calculate benefits to international to international passengers in the carbon-capped case.

3.46 If a carbon-capped calculation were possible, it would likely show that the transport economic efficiency benefits of adding capacity in the carbon-capped case are lower than in the carbon-traded case.

3.47 None of these difficulties arise in the carbon-traded case, as the carbon price is the same in the capacity options as in the baseline.

3.48 To gain an understanding of the potential impact of higher carbon prices in both the baseline and the capacity options, a sensitivity test is undertaken, results of which are shown in **Chapter 5.**

4. Results

Introduction

4.1 This chapter sets out the estimated direct transport economic efficiency impacts of the three shortlisted capacity options for each of the five future demand scenarios.

4.2 As set out in **Chapter 3**, all impacts are shown relative to the baseline for the equivalent scenario. The underpinning demand forecasts (taken from the NAPDM module of the aviation model) are identical in each capacity option, including the baseline, within each scenario.

4.3 All values are shown in 2014 market prices, and in the case of discounted and present values, are discounted to 2014.

Future demand scenarios

4.4 The appraisal results described in this chapter refer to the carbon-traded case – that is, any aviation sector carbon target can be met through trading.

4.5 Five possible scenarios of future demand are considered which are briefly described below and discussed more fully in **Chapter 3** of the Strategic Fit: Forecasts report. Unless stated otherwise, the assumptions are identical in the capacity options and baseline.

Assessment of need	This scenario updates the central forecasts published in the *Interim Report*. Future demand is primarily determined by central projections published by sources such as the Office for Budget Responsibility, OECD and IMF.
Global growth	This scenario sees higher *global growth* in demand for air travel than in the *assessment of need* scenario. It adopts higher GDP growth forecasts for all world regions, coupled with lower operating costs.
Relative decline of Europe	This scenario sees higher relative growth of passenger demand in emerging economies in the future compared to the growth in the developed world. It adopts higher GDP growth rates for newly industrialised and developing countries than in the *assessment of need* scenario, and a strengthened position of Far and Middle Eastern aviation hubs and airlines.
Low-cost is king	This scenario sees the low-cost carriers strengthening their position in the short-haul market and capturing a substantial share of the long-haul market. As with the *global growth* scenario, it also sees GDP growth rates for all world regions and lower operating costs, resulting in higher passenger demand growth rates than in the *assessment of need* scenario.

Global fragmentation	This scenario sees economies close themselves off by adopting more conditional and interventionist national policies. As a result, there is a decline in GDP growth rates for all world regions (relative to the *assessment of need*), coupled with higher operating costs. This results in lower passenger demand growth rates.

4.6 There are uncertainties associated with all appraisal results, not least because the demand forecasts and associated shadow costs underpinning them are themselves uncertain. As this chapter shows, the results are highly sensitive to such demand forecasts. And, as noted in **Chapter 3**, there is judgement required on how best to extrapolate beyond the final modelled year. Additionally, there is uncertainty attached to how best to value frequency and lower shadow cost-benefits when routes are introduced or lost at an airport.

4.7 This uncertainty is particularly significant in the high demand growth scenarios – *global growth* and *low-cost is king* – because shadow costs in such scenarios are more volatile, especially towards the end of the modelling period (that is, the late 2040s). Compounding this, the nature of the capacity constraint at Heathrow and Gatwick often switches between the baseline and the capacity options. In these two scenarios, the appraisals often compare a capacity option with a runway capacity constraint against a baseline with a terminal capacity constraint. This makes a consistent comparison of the capacity options more difficult, although it does not obviously skew the results in any particular direction.

Disaggregation of results

4.8 For each option, the present value of benefits are broken down by whether the passenger is a resident in the UK or overseas or whether they are an international to international transfer passenger (I to I).

4.9 Passenger benefits are further broken down by whether the primary purpose of the journey is business or leisure. Most journeys are classified as leisure, and because of this, most benefits of airport expansion accrue to leisure passengers.

4.10 Reported passenger benefits are also broken down by type of destination at the aggregated NAPDM level: that is domestic end to end journeys, Western Europe, the rest of OECD, Newly Industrialised Countries (NICs) and Least Developed Countries (LDCs).[15]

15 The classification of regions is described in Section 3 of Appendix 3 of the Commission's *Interim Report*.

4.11 Across all capacity options and all scenarios, a significant proportion of the passenger benefits relate to those travelling short-haul to the region defined in the aviation model as Western Europe. There are a number of reasons for this:

- Such traffic dominates the aviation market – they account for about two-thirds of total traffic (excluding all international to international transfer passengers) in 2013.
- Compared with long-haul, short-haul flights tend to be operated by smaller planes, carrying fewer passengers. Both Gatwick and Heathrow airports are normally forecast to be constrained by runway capacity rather than terminal capacity and so incur a runway shadow cost – that is, shadow costs are per plane rather than per passenger – in most scenarios. Therefore, shadow cost per passenger tends to be higher for short-haul flights as there are fewer passengers over which to spread the shadow cost. Thus a reduction in shadow cost tends to benefit short-haul traffic by more.
- For short-haul traffic, a given level of shadow cost makes up a bigger proportion of total costs of travel than for long-haul; for example, the air fare (excluding any shadow costs) is typically much lower. This means shadow costs often have a bigger impact on short-haul passenger behaviour making them more likely to switch airport or to not travel by plane at all.

Drivers of results

4.12 As is seen throughout the results shown in this chapter, unconstrained demand growth – that is, demand growth that would occur in the absence of any capacity constraints – is a key driver of the estimate of passenger benefits associated with adding airport capacity. Much of the benefit arises from passengers undertaking trips they would not have made without the additional capacity – the higher the level of demand, the higher the value the marginal passenger places on being able to undertake that trip as a result of the additional capacity.

4.13 This chapter reports producer and government revenue impacts. Much of the reduction in shadow cost, according to WebTAG guidance, represents a transfer from producer (either airlines or airports depending on the regulatory regime) to the passenger – therefore, there are significant dis-benefits to producers attached with each expansion option. But, as **Chapter 3** explains, this is partially offset by airlines potentially receiving ‘new’ shadow cost revenue attached to greater demand if the airport remains capacity constrained.

4.14 With this in mind, it is important that the passenger benefits are not viewed in isolation. In particular, a capacity option which generates significant demand growth may increase shadow costs relative to an alternative capacity option, potentially lowering total passenger benefits – as all passenger have to pay more – but generating new producer surplus benefits.

4.15 In addition, as **Chapter 3** sets out, there are government revenue implications of lower shadow costs and increases in passenger numbers which are also reported.

4.16 These impacts are brought together, and discounted, to show an estimated total present value of each option under each scenario.

Gatwick Airport Second Runway option

4.17 The Gatwick Airport Second Runway option (LGW 2R) increases ATM capacity from 280,000 to 560,000 per annum. It has been appraised over sixty years, with an opening date of 2025.

4.18 **Table 4.1** sets out the estimated present value of benefits by type of passenger in all five scenarios. Much of these passenger benefits are transferred from producers, as discussed in **Chapter 3**, and so they should not be viewed in isolation.

Table 4.1: Gatwick Airport Second Runway option, passenger benefits, present value (£billion)

		UK resident		Foreign resident		
	Total	Business	Leisure	Business	Leisure	I to I
Assessment of need						
Lower shadow costs	43.9	9.1	21.9	4.2	7.2	1.4
Frequency benefits	3.2	1.3	0.5	0.7	0.4	0.2
Total passenger benefits	**47.1**	**10.5**	**22.4**	**5.0**	**7.6**	**1.7**
Global growth						
Lower shadow costs	123.0	22.5	63.5	12.7	21.2	3.0
Frequency benefits	9.1	3.2	1.5	1.9	1.1	1.3
Total passenger benefits	**132.0**	**25.7**	**65.0**	**14.7**	**22.3**	**4.3**
Relative decline of Europe						
Lower shadow costs	42.6	8.6	20.7	4.7	7.7	1.0
Frequency benefits	4.6	2.2	0.3	1.3	0.6	0.3
Total passenger benefits	**47.2**	**10.7**	**20.9**	**5.9**	**8.3**	**1.4**
Low-cost is king						
Lower shadow costs	92.8	17.1	45.6	10.0	16.5	3.6
Frequency benefits	10.1	3.0	0.6	1.9	0.9	3.7
Total passenger benefits	**102.9**	**20.1**	**46.2**	**11.9**	**17.4**	**7.2**

	Total	UK resident		Foreign resident		
		Business	Leisure	Business	Leisure	I to I
Global fragmentation						
Lower shadow costs	30.2	6.2	15.7	2.5	4.9	0.9
Frequency benefits	2.2	0.8	0.4	0.5	0.3	0.1
Total passenger benefits	**32.4**	**7.0**	**16.1**	**3.0**	**5.2**	**1.0**

4.19 All passengers enjoy benefits from lower shadow costs resulting from additional capacity.

4.20 As set out above, the extent of demand growth is a key driver of passenger benefits. This can be seen in **Table 4.1**, where the level of passenger benefits is closely correlated with the extent of forecast demand growth across the scenarios.

4.21 Care should be taken when comparing passenger benefits alone across scenarios. For example, the *low-cost is king* scenario results in higher demand growth than the *global growth* scenario. Despite this, passenger benefits are lower because such demand growth results in higher shadow costs than in the *global growth* scenario, thus increasing fares for all passengers and reducing the lower shadow costs passenger benefit. But this lower passenger benefit is offset by lower producer surplus dis-benefits as shown in **Table 4.2**.

4.22 Leisure passengers receive much of the additional shadow cost-benefit associated with expansion at Gatwick. This reflects the dominance of the leisure market.

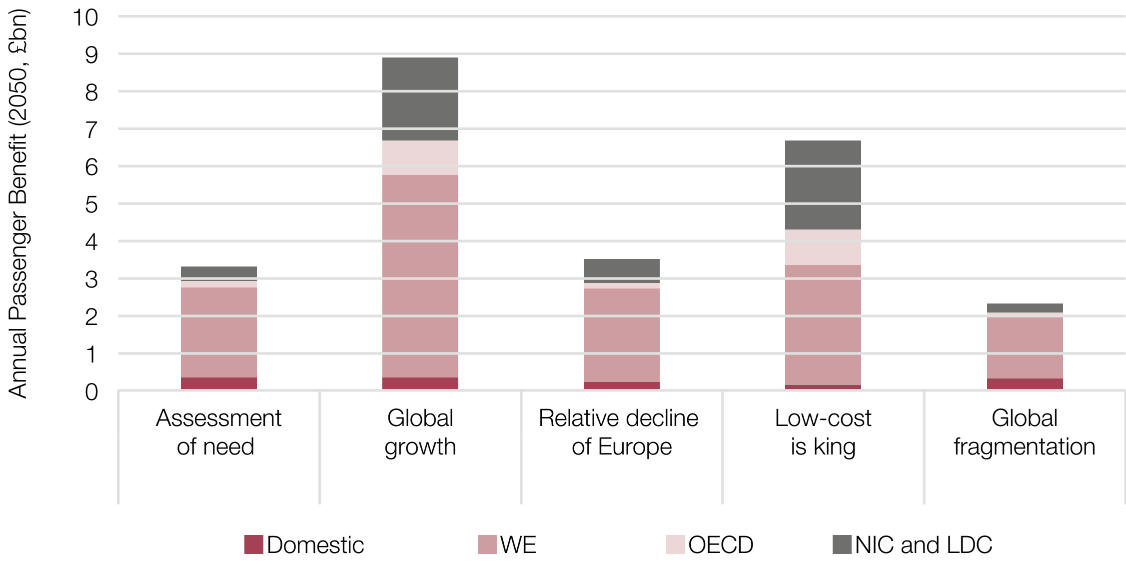
4.23 Leisure passengers experience relatively low frequency benefits, compared with business passengers, despite their greater number. This partly reflects the greater value business passengers place on higher frequency gains, given their higher values of time as set out in **Chapter 3**. Compounding this, frequencies at regional airports are lower compared to the baseline (in future years), as they lose frequencies and routes to Gatwick. Given such airports are disproportionately used by leisure passengers, this contributes to offsetting the frequency gains at Gatwick.

4.24 International to international transfer passengers receive low benefits across most of the scenarios, reflecting their small share of traffic in the baseline, particularly at Gatwick. The benefits that are observed arise largely from easing capacity constraints, and therefore shadow costs, at Heathrow freeing up space for more such passengers. The *low-cost is king* scenario, however, sees relatively higher benefits for international to international transfer passengers, reflecting the assumption that such a scenario results in increased transfers at Gatwick.

4.25 Foreign residents travelling to and from the UK enjoy benefits broadly in line with UK residents. However, the proportion of benefits relating to business travel is higher, reflecting the higher share of business traffic associated with foreign residents travelling to the UK.

4.26 **Figure 4.1** shows the breakdown of passenger benefit by type of destination.

Figure 4.1: Gatwick Airport Second Runway option, breakdown of annual passenger benefits (2050), excluding I to Is, by destination, £billion



4.27 In all scenarios, most of the passenger benefits relate to those travelling to the region defined in the aviation model as 'Western Europe' (WE). The reasons for this are set out in **paragraph 4.11**.

4.28 The benefits to short-haul traffic are smaller as a proportion of the total in the *low-cost is king* scenario compared with the other scenarios. This is largely a result of high shadow cost imposed in the demand forecasts. In the Gatwick Airport Second Runway option, the capacity constraints at these airports relate to runway capacity. The new Gatwick runway is fully utilised by 2033 in *low-cost is king* and by 2040 under *global growth*. Under *global fragmentation* some capacity remains in 2050 and in the other two scenarios, Gatwick is operating at over 90% of its capacity by 2050. This leads to higher shadow costs per passenger in the *low-cost is king* scenario especially for short-haul traffic.[16] This lowers benefits for such traffic.

4.29 **Table 4.2** shows the transport economic efficiency impacts estimated in this report. As set out in **Chapter 2**, this includes only a subset of impacts.

16 This is because such passengers tend to be on planes with relatively lower loadings. Conversely, long-haul passengers face higher shadow costs.

Table 4.2: Gatwick Airport Second Runway option, passenger, producer and government impacts, present value (£billion)

	Assessment of need	Global growth	Relative decline of Europe	Low-cost is king	Global fragmentation
Passenger benefits excluding I to I	45.4	127.7	45.8	95.7	31.4
Producer shadow cost impact	(41.8)	(110.4)	(43.3)	(64.0)	(29.7)
Government revenue impact	2.5	8.4	3.1	5.2	1.0
Total excluding I to I	6.1	25.6	5.6	36.9	2.8
Passenger benefits to I to I	1.7	4.3	1.4	7.2	1.0
Total including I to I	7.8	30.0	7.0	44.1	3.7

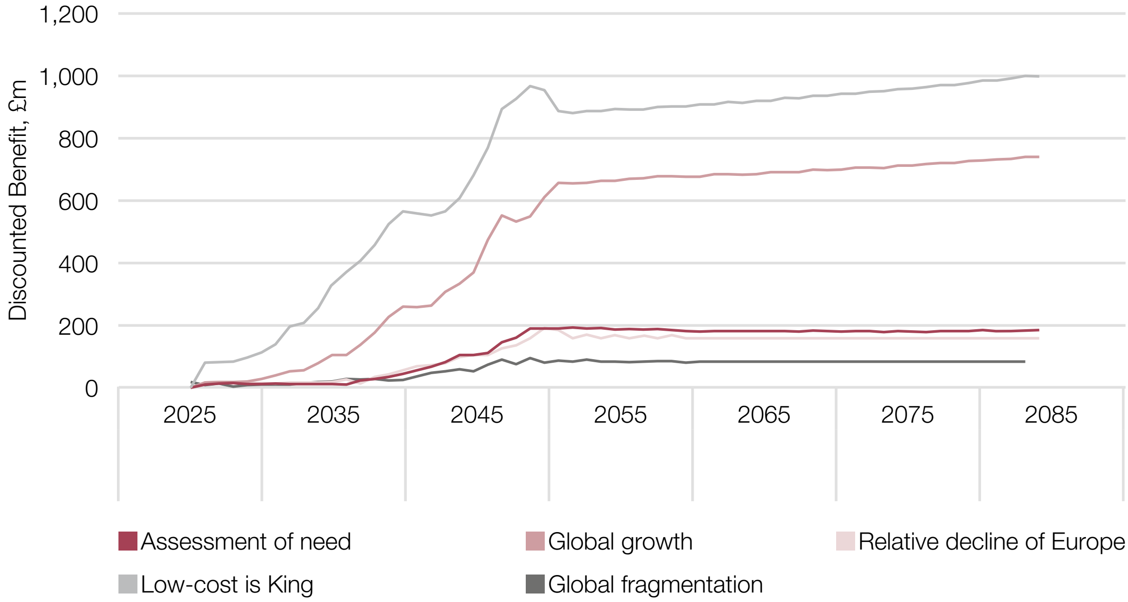
4.30 **Table 4.2** shows that most of the passenger benefits are driven by a transfer from producers to passengers. This is driven by additional capacity lowering shadow costs and transferring benefits from producers to passengers in the form of lower air fares.

4.31 The expansion of the *low-cost is king* scenario results in the highest level of benefit to passengers, producers and government combined. This largely reflects the high levels of national demand growth forecast, and also the levels of low-cost carrier (LCC) traffic at Gatwick.

4.32 Most of the passenger benefits under the *global fragmentation* scenario are a transfer from producers to passengers as this scenario generates less in the way of additional traffic, resulting in a relatively lower benefit once changes in producer surplus are taken into account.

4.33 **Figure 4.2** shows the profile of discounted benefits over time.

Figure 4.2: Gatwick Airport Second Runway option, total annual discounted benefits over time



4.34 The discounted benefits increase throughout the modelled period, as more of the capacity is used, and as shadow costs in the baseline become higher driven by higher demand and values of time.

4.35 From 2050, the extrapolation takes over – it can be seen that the extrapolation is relatively cautious in that the growth in discounted benefits, if there is any at all, is much lower than during the modelled period. Indeed, discounted benefits fall in the lower growth scenarios during the extrapolation period, as the growth in benefits are lower than the discount rate at this stage in the appraisal (3%). The approach to extrapolation is described in **Chapter 3.**

Heathrow Airport Extended Northern Runway option

4.36 The Heathrow Airport Extended Northern Runway option increases ATM capacity from 480,000 to 700,000 per annum. It has been appraised over sixty years, with an opening date of 2026.

4.37 **Table 4.5** sets out the estimated present value of benefits by type of passenger in all five scenarios. Much of these passenger benefits are transferred from producers, as discussed in **Chapter 3**, and so they should not be viewed in isolation.

Table 4.5: Heathrow Airport Extended Northern Runway option, passenger benefits, present value (£billion)

		UK resident		Foreign resident		
	Total	Business	Leisure	Business	Leisure	I to I
Assessment of need						
Lower shadow costs	41.9	9.6	17.8	4.6	6.6	3.2
Frequency benefits	4.6	1.9	(0.4)	1.3	(0.2)	1.9
Total passenger benefits	**46.5**	**11.5**	**17.4**	**5.9**	**6.5**	**5.1**
Global growth						
Lower shadow costs	111.5	21.0	53.0	12.2	19.5	5.8
Frequency benefits	5.8	2.4	(0.5)	1.6	(0.1)	2.2
Total passenger benefits	**117.3**	**23.5**	**52.5**	**13.8**	**19.4**	**8.0**
Relative decline of Europe						
Lower shadow costs	45.5	9.6	20.6	5.4	7.8	2.1
Frequency benefits	6.6	2.7	0.5	1.9	0.4	1.0
Total passenger benefits	**52.1**	**12.4**	**21.1**	**7.2**	**8.2**	**3.1**
Low-cost is king						
Lower shadow costs	116.7	22.1	57.4	12.2	20.3	4.8
Frequency benefits	7.7	3.2	0.2	2.2	0.5	1.5
Total passenger benefits	**124.4**	**25.3**	**57.6**	**14.5**	**20.7**	**6.3**
Global fragmentation						
Lower shadow costs	36.0	7.5	16.1	3.6	5.9	2.8
Frequency benefits	3.7	1.3	(0.2)	0.9	(0.0)	1.7
Total passenger benefits	**39.8**	**8.8**	**16.0**	**4.5**	**5.9**	**4.5**

4.38 All passengers enjoy benefits from lower shadow costs resulting from additional capacity.

4.39 The extent of demand growth is a key driver of passenger benefits. This can be seen in **Table 4.5**, where the level of passenger benefits is closely correlated with the extent of forecast demand growth across the scenarios.

4.40 Leisure passengers receive much of the additional shadow cost-benefits associated with expansion at Heathrow. This reflects the dominance of the leisure market within aviation. They receive relatively high benefits in the *low-cost is king* scenario, partly reflecting the assumption that low-cost airlines start to operate at Heathrow as a result of increased capacity and the greater likelihood of these airlines being used by leisure passengers.

4.41 Leisure passengers experience relatively low, or even negative, frequency benefits, compared with business passengers, despite their greater number. This partly reflects the greater value business passengers place on higher frequency gains, given their higher values of time as set out in **Chapter 3**. Compounding this, frequencies at regional airports are lower compared to the baseline (in future years), as these airports gain frequencies and routes when the London airport system is at capacity in the baseline, which switch to Heathrow upon expansion. Given regional airports are disproportionately used by leisure passengers, this contributes to offsetting the frequency gains at Heathrow, especially as Heathrow has a disproportionate share of business traffic.

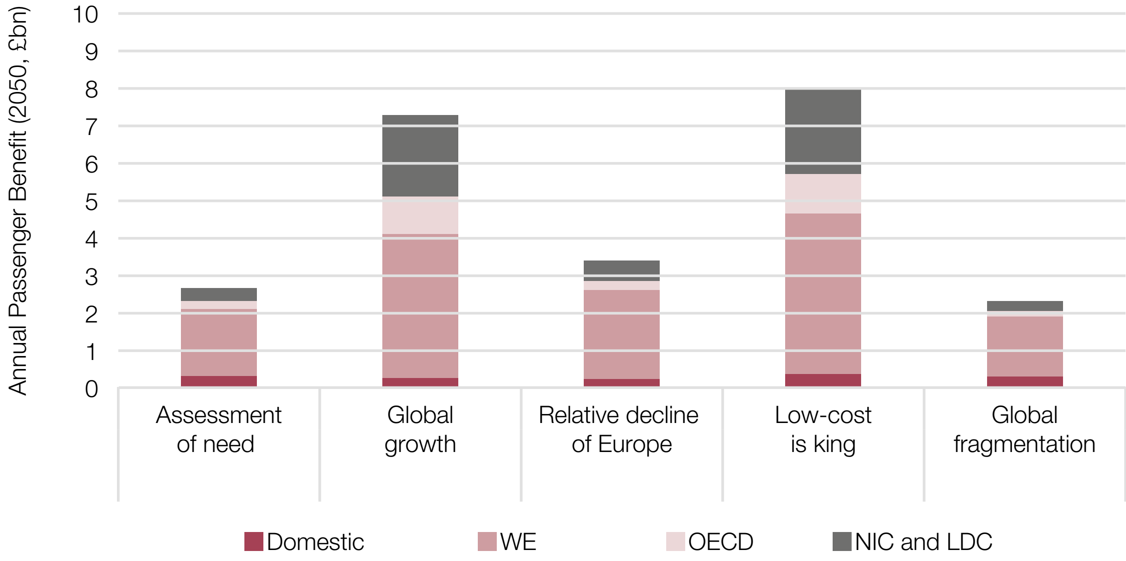
4.42 International to international transfer passengers enjoy significant benefits in the high demand growth scenarios. This reflects the high demand growth, including for transfer traffic, and associated shadow costs which such passengers face in the absence of any additional airport capacity. International to international transfer passengers are sensitive to runway shadow costs largely because they have a number of alternative hubs offering similar routes, and because all transfer passengers pay the shadow cost twice (as they count as two terminal passengers).

4.43 International to international transfer passengers receive relatively low frequency benefits in the *relative decline of Europe* scenario as Heathrow becomes a less attractive airport at which to transfer compared to Dubai and Schiphol.

4.44 Foreign residents travelling to and from the UK enjoy benefits broadly in line with UK residents. However, the proportion of benefits relating to business travel is higher, reflecting the higher share of business traffic associated with foreign residents travelling to the UK.

4.45 **Figure 4.5** shows the breakdown of annual passenger benefits by the type of destination.

Figure 4.5: Heathrow Airport Extended Northern Runway option, breakdown of annual passenger benefits (2050), excluding I to Is, by destination, £billion



4.46 In all scenarios, most of the passenger benefits relate to those travelling to the region defined in the aviation model as 'Western Europe' (WE). The reasons for this are set out in **paragraph 4.11**.

4.47 The *global growth* and *low-cost is king* scenarios show a similar distribution of benefits to each other, reflecting the commonalities of the scenarios in this option.

4.48 The benefits of the *relative decline of Europe* scenario are not heavily concentrated on those travelling to NICs and LDCs. This is despite assumed higher GDP growth in such regions – in common with the *global growth* and *low-cost is king* scenarios – generating some additional traffic. This is because this impact is offset by Heathrow being assumed to become a less attractive hub in the *relative decline of Europe* scenario, which cuts transfer traffic at Heathrow and with it, frequencies to long-haul destinations.

4.49 **Table 4.6** shows the transport economic efficiency impacts estimated in this report. As set out in **Chapter 2,** this includes only a subset of impacts.

Table 4.6: Heathrow Airport Extended Northern Runway option, passenger, producer and government impacts, present value (£billion)

	Assessment of need	Global growth	Relative decline of Europe	Low-cost is king	Global fragmentation
Passenger benefits excluding I to I	41.3	109.2	49.0	118.1	35.2
Producer shadow cost impact	(31.6)	(88.5)	(38.3)	(94.9)	(32.0)

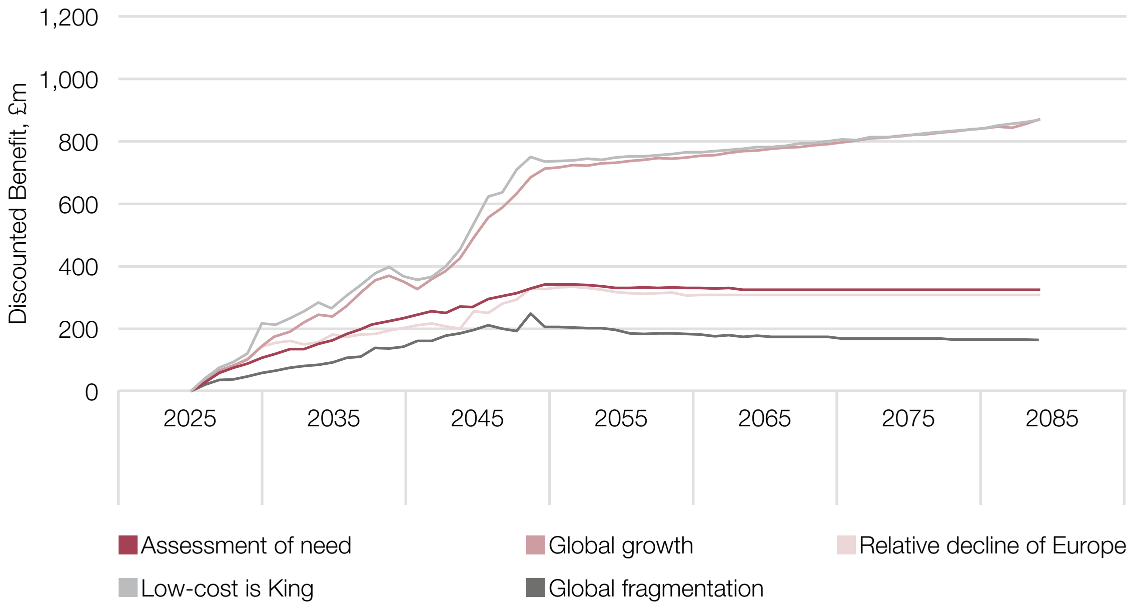
	Assessment of need	Global growth	Relative decline of Europe	Low-cost is king	Global fragmentation
Government revenue impact	1.5	6.8	1.9	7.2	1.6
Total excluding I to I	11.3	27.6	12.6	30.4	4.9
Passenger benefits to I to I	5.1	8.0	3.1	6.3	4.5
Total including I to I	16.4	35.6	15.7	36.7	9.4

4.50 **Table 4.6** shows that most of the passenger benefits are driven by a transfer from producers to passengers. This is driven by additional capacity lowering shadow costs and transferring benefits from producers to passengers in the form of lower air fares.

4.51 The results follow the pattern of demand growth, with the *global growth* and *low-cost is king* scenarios resulting in the highest total benefit, and *global fragmentation* resulting in the lowest.

4.52 **Figure 4.6** shows the profile of discounted total benefits (including international to international transfer passengers) by scenario.

Figure 4.6: Heathrow Airport Extended Northern Runway option, total annual discounted benefits over time



4.53 The discounted benefits increase throughout the modelled period, as more of the capacity is used, and as shadow costs in the baseline become higher driven by higher demand and values of time.

4.54 From 2050, the extrapolation takes over – it can be seen that the extrapolation is relatively cautious in that the growth in discounted benefits, if there is any at all, is much lower than during the modelled period. Indeed, discounted benefits fall in the lower growth scenarios during the extrapolation period, as the growth in benefits are lower than the discount rate at this stage in the appraisal (3%). The approach to extrapolation is described in **Chapter 3.**

4.55 The similarities between the *global growth* and *low-cost is king* scenarios – reflecting the similar input assumptions in this option – is apparent throughout the appraisal period.

Heathrow Airport North West Runway option

4.56 The Heathrow Airport North West Runway option (LHR NWR), increases ATM capacity from 480,000 to 740,000 per annum. This has been appraised over sixty years, with an opening date of 2026.

4.57 **Table 4.3** sets out the estimated present value of benefits by type of passengers in all five scenarios. Much of these passenger benefits are transferred from producers, as discussed in **Chapter 3,** and so they should not be viewed in isolation.

Table 4.3: Heathrow Airport North West Runway option, passenger benefits, present value (£billion)

		UK resident		Foreign resident		
	Total	**Business**	**Leisure**	**Business**	**Leisure**	**I to I**
Assessment of need						
Lower shadow costs	49.2	11.2	20.8	5.4	7.8	4.0
Frequency benefits	5.7	2.2	(0.3)	1.4	(0.1)	2.4
Total passenger benefits	**54.8**	**13.4**	**20.5**	**6.8**	**7.6**	**6.5**
Global growth						
Lower shadow costs	127.4	24.7	60.6	13.4	21.7	6.9
Frequency benefits	7.3	2.9	(0.3)	1.9	(0.1)	2.8
Total passenger benefits	**134.6**	**27.6**	**60.4**	**15.3**	**21.6**	**9.7**
Relative decline of Europe						
Lower shadow costs	52.3	11.3	23.5	6.0	8.9	2.6
Frequency benefits	6.8	2.9	0.4	2.0	0.4	1.3
Total passenger benefits	**59.1**	**14.2**	**23.8**	**8.0**	**9.2**	**3.8**
Low-cost is king						
Lower shadow costs	128.8	25.0	62.2	13.5	22.1	6.1
Frequency benefits	8.7	3.5	0.2	2.4	0.4	2.2
Total passenger benefits	**137.5**	**28.5**	**62.4**	**15.9**	**22.5**	**8.3**

	Total	UK resident		Foreign resident		
		Business	Leisure	Business	Leisure	I to I
Global fragmentation						
Lower shadow costs	42.2	8.7	18.7	4.2	6.9	3.6
Frequency benefits	4.5	1.5	(0.0)	1.0	(0.0)	2.0
Total passenger benefits	**46.7**	**10.2**	**18.7**	**5.2**	**6.9**	**5.6**

4.58 All passengers enjoy benefits from lower shadow costs resulting from additional capacity.

4.59 The extent of demand growth is a key driver of passenger benefits. This can be seen in **Table 4.3**, where the level of passenger benefit is closely correlated with the extent of forecast demand growth across the scenarios.

4.60 Leisure passengers receive much of the additional shadow cost-benefit associated with expansion at Heathrow. This reflects the dominance of the leisure market within aviation. They receive relatively high benefits in the *low-cost is king* scenario, partly reflecting the assumption that low-cost airlines start to operate at Heathrow as a result of increased capacity and the greater likelihood of these airlines being used by leisure passengers.

4.61 Leisure passengers experience relatively low, or even negative, frequency benefits, compared with business passengers, despite their greater number. This partly reflects the greater value business passengers place on higher frequency gains, given their higher values of time as set out in **Chapter 3**. Compounding this, frequencies at regional airports are lower compared to the baseline (in future years), as these airports gain frequencies and routes when the London airport system is at capacity in the baseline, which switch to Heathrow upon expansion. Given regional airports are disproportionately used by leisure passengers this contributes to offsetting the frequency gains at Heathrow, especially as Heathrow has a disproportionate share of business traffic.

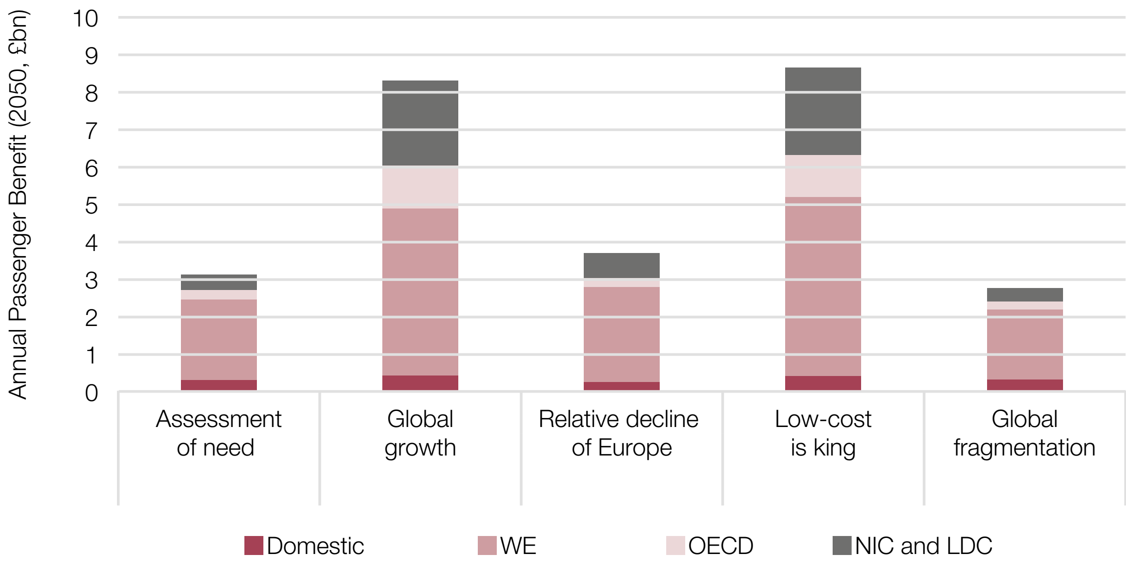
4.62 International to international transfer passengers enjoy significant benefits in the high demand growth scenarios. This reflects the high demand growth, including for transfer traffic, and associated shadow costs which such passengers face in the absence of any additional airport capacity. International to international transfer passengers are sensitive to runway shadow costs largely because they have a number of alternative hubs offering similar routes, and because all transfer passengers pay the shadow cost twice (as they count as two terminal passengers).

4.63 International to international transfer passengers receive relatively lower frequency benefits in the *relative decline of Europe* scenario as Heathrow becomes a less attractive airport at which to transfer compared to Dubai and Schiphol.

4.64 Foreign residents travelling to and from the UK enjoy benefits broadly in line with UK residents. However, the proportion of benefits relating to business travel is higher, reflecting the higher share of business traffic associated with foreign residents travelling to the UK.

4.65 **Figure 4.3** shows the breakdown by type of destination.

Figure 4.3: Heathrow Airport North West Runway option, breakdown of annual passenger benefits (2050), excluding I to Is, by destination, £billion



4.66 In all scenarios, most of the passenger benefits relate to those travelling to the region defined in the aviation model as 'Western Europe' (WE). The reasons for this are set out in **paragraph 4.11**.

4.67 The *global growth* and *low-cost is king* scenarios show a similar distribution of benefits to each other, reflecting the commonalities of the scenarios in this option.

4.68 The benefits of the *relative decline of Europe* scenario are not heavily concentrated on those travelling to NICs and LDCs. This is despite assumed higher GDP growth in such regions – in common with the *global growth* and *low-cost is king* scenarios – generating some additional traffic. This is because this impact is offset by Heathrow being assumed to become a less attractive hub in the *relative decline of Europe* scenario, which cuts transfer traffic at Heathrow and with it frequencies to long-haul destinations.

4.69 **Table 4.4** shows the transport economic efficiency impacts estimated in this report. As set out in **Chapter 2,** this includes only a subset of impacts.

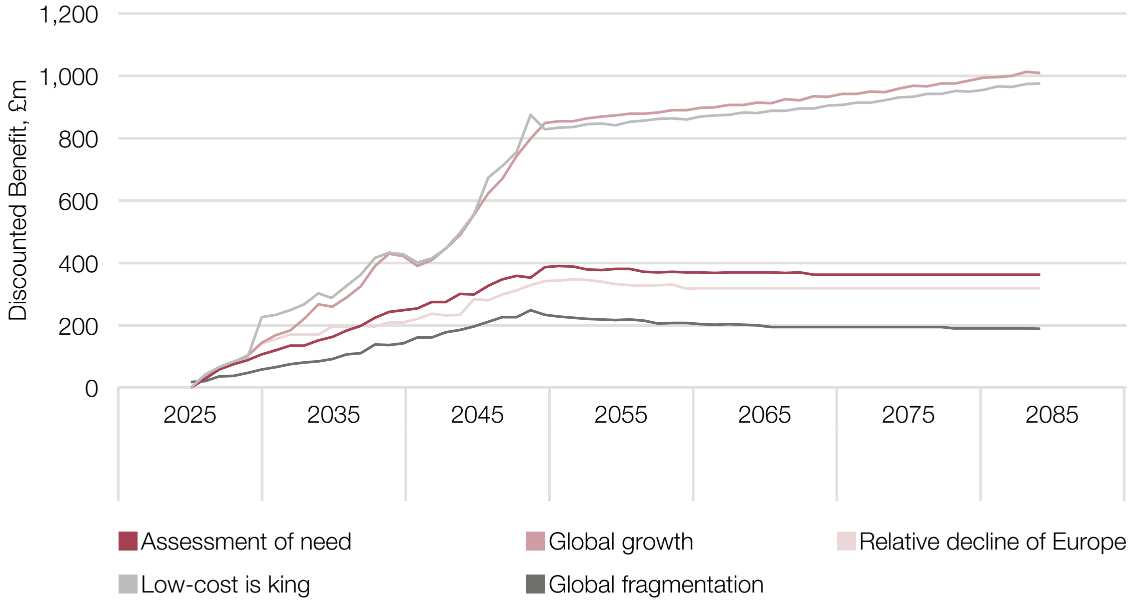
Table 4.4: Heathrow Airport North West Runway option, passenger, producer and government impacts, present value (£billion)

	Assessment of need	Global growth	Relative decline of Europe	Low-cost is king	Global fragmentation
Passenger benefits excluding I to I	48.4	124.9	55.2	129.3	41.1
Producer shadow cost impact	(38.4)	(100.5)	(44.9)	(103.9)	(38.5)
Government revenue impact	1.8	7.8	2.2	7.9	2.1
Total excluding I to I	*11.8*	*32.2*	*12.5*	*33.3*	*4.7*
Passenger benefits to I to I	6.5	9.7	3.8	8.3	5.6
Total including I to I	18.3	42.0	16.4	41.6	10.3

4.70 **Table 4.4** shows that most of the passenger benefits are driven by a transfer from producers to passengers. This is driven by additional capacity lowering shadow costs and transferring benefits from producers to passengers in the form of lower air fares.

4.71 The results follow the pattern of demand growth, with the *global growth* and *low-cost is king* scenarios resulting in the highest total benefit, and *global fragmentation* resulting in the lowest.

Figure 4.4: Heathrow Airport North West Runway option, total annual discounted benefits over time



4.72 The discounted benefits increase throughout the modelled period, as more of the capacity is used, and as shadow costs in the baseline become higher driven by higher demand and values of time.

4.73 From 2050, the extrapolation takes over – it can be seen that the extrapolation is relatively cautious in that the growth in discounted benefits, if there is any at all, is much lower than during the modelled period. Indeed, discounted benefits fall in the lower growth scenarios during the extrapolation period, as the growth in benefits are lower than the discount rate at this stage in the appraisal (3%). The approach to extrapolation is described in **Chapter 3.**

4.74 The similarities between the *global growth* and *low-cost is king* scenarios – reflecting the similar input assumptions in this option – is apparent throughout the appraisal period.

5. Sensitivity analysis

Introduction

5.1 This chapter sets out the results of sensitivity tests for each of the capacity options. For each sensitivity, one assumption in the *assessment of need* case is changed in order to isolate the impact of that factor.

5.2 The results in this chapter describe the impact of adding airport capacity to the transport economic efficiency appraisal under a range of sensitivities – they do not test the impact of the sensitivity directly. For example, the results show how the benefits of adding airport capacity change if passengers are assumed to face a zero carbon price; they do not show the benefits or costs of assuming a zero carbon price.

5.3 The sensitivities explored for each capacity option are:

- **High Carbon Price.** This tests the impact of assuming all passengers face higher carbon prices in line with the DECC high carbon price scenario for appraisal.[17]
- **No Carbon Price.** This tests the impact of assuming all passengers face no carbon prices.
- **High Demand.** This tests the impact of demand growth being greater than in the *assessment of need* scenario
- **Low Demand.** This tests the impact of demand growth being lower than in the *assessment of need* scenario
- **No Passenger Demand Growth Beyond 2050.**

5.4 For the Heathrow Airport North West Runway and Heathrow Airport Extended Northern Runway options, one further sensitivity is explored for each option:

- **Phasing In Capacity in the Heathrow Airport North West Runway option** This sensitivity test explores the impact of allowing new capacity at Heathrow to open gradually as opposed to all the capacity being available in the opening year. The phased release of new capacity may be necessary in order for the airport

17 DECC Appraisal Guidance Toolkit (2013), available at https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

to operate within any environmental limits set as a condition for growth. It may also drive commercial gains for the airport operator, maintaining high demand for slots. Heathrow Airport Limited modelled a staged release of new capacity in its submission to the Airports Commission.

- **Lowering Capacity in the Heathrow Airport Extended Northern Runway option** This sensitivity test examines the impact of having a lower additional runway capacity under the Heathrow Airport Extended Northern Runway option. It is assumed that the northern runway extension results in 200,000 rather than 220,000 additional ATMs at Heathrow. This test has been run under the *assessment of need* demand scenario. This test was made because of some uncertainty on the exact capacity of the proposed runway extension and taxiway network, given the innovative and untested nature of its proposed form of operation.

Methodology

5.5 The analysis considers all impacts set out in **Chapter 4**.

5.6 The High Demand and Low Demand sensitivities are based on Monte Carlo analysis, which is a probability assessment technique estimating the likelihood of different outcomes. These forecasts are based on a 60% confidence interval range. For more information see the Strategic Fit: Forecasts report.

5.7 The High Demand sensitivity results should be treated with caution, as the demand model reached only as far as 2042, compared with 2050 for all other sensitivities and scenarios. Therefore, the extrapolation of benefits starts eight years earlier in this sensitivity; given the extrapolation approach is cautious, as set out in **Chapter 3**, it is likely that this results in lower benefits than would be estimated if the model were able to run successfully to 2050.

5.8 As **Chapter 3** explains, the analysis contained in this report normally assumes that the carbon price faced by passengers internalises the externality through a global emissions trading scheme, meaning no monetisation of carbon emissions or carbon market revenues are necessary. However, when passengers face no carbon price, it is assumed that the carbon externality still exists but is no longer internalised; so it is necessary to monetise the carbon dis-benefit using the traded price of carbon in the No Carbon Price sensitivity.

5.9 Conversely, in the High Carbon Price sensitivity, carbon prices faced by passengers are assumed to be higher than the appraisal carbon price. Therefore, the difference between the traded price of carbon and the higher carbon price is treated as an additional tax which generates revenue for government. So the tax revenue over and above the appraisal carbon price is monetised and included as a government revenue benefit. Although passengers face the higher carbon price on both the departing and arriving flight, it is assumed that the UK government receives tax revenue from only departing flights. As carbon emissions are still internalised, there is no need to monetise them.

5.10 In the No Passenger Demand Growth Beyond 2050 sensitivity, unconstrained demand growth is set to zero from 2050. This also reduces the growth rate of shadow costs, as shadow costs are driven in part by unconstrained demand growth. But shadow costs still rise in line with values of time in this sensitivity.

Results

Gatwick Airport Second Runway option

5.11 **Table 5.1** shows the estimated impact of each sensitivity test on the present value of benefits of the Gatwick Airport Second Runway option. The results from the *assessment of need* scenario are shown in the first column for ease of comparison.

Table 5.1: Gatwick Airport Second Runway option, passenger, producer and government impacts, present value (£billion), sensitivity tests

	Assessment of need	High DECC Carbon Price	No Carbon Price	High Demand	Low Demand	No growth beyond 2050
Passenger benefits excluding I to I	45.4	34.2	92.7	81.6	13.3	39.5
Producer shadow cost impact	(41.8)	(31.7)	(81.5)	(72.9)	(12.8)	(36.3)
Government revenue impact	2.5	2.8	6.2	5.3	0.0	2.5
Carbon Externality			(6.6)			
Total excluding I to I	6.1	5.3	10.8	14.0	0.5	5.7
Passenger benefits to I to I	1.7	1.2	2.8	3.6	0.6	1.5
Total including I to I	7.8	6.5	13.6	17.6	1.2	7.2

5.12 In the High Carbon Price sensitivity, fares are higher. This results in lower demand, reducing the benefit attached to adding capacity. Little additional government revenue is generated over and above the *assessment of need* scenario, despite the higher carbon price generating tax revenue, because the additional capacity generates little new demand and APD revenue. Conversely, in the No Carbon Price sensitivity, the lower fares stimulate additional demand, thus increasing the benefit attached to adding capacity compared with the *assessment of need* scenario; this is more than enough to offset the negative carbon costs.

5.13 As would be expected, the higher demand sensitivity sees an increase in benefits compared to the *assessment of need* scenario, and the reverse is found in the Low Demand sensitivity.

5.14 The No Passenger Demand Growth Beyond 2050 sensitivity shows a decrease in benefits compared with the *assessment of need* scenario. This is driven by lower passenger benefits as shadow costs are assumed to grow more slowly post 2050.

Heathrow Airport Extended Northern Runway option

5.15 Table 5.3 shows the estimated impact of the sensitivity tests on the present value of benefits of the Heathrow Airport Extended Northern Runway option in the *assessment of need* scenario.

Table 5.3: Heathrow Airport Extended Northern Runway option, passenger, producer and government impacts, present value (£billion), sensitivity tests

	Assessment of need	High DECC carbon price	No Carbon Price	High Demand	Low Demand	No growth beyond 2050	Low capacity
Passenger benefits excluding I to I	41.3	36.3	74.6	65.9	22.7	36.3	39.4
Producer shadow cost impact	(31.6)	(28.8)	(59.7)	(55.2)	(20.7)	(27.9)	(30.0)
Government revenue impact	1.5	6.4	4.4	3.9	1.2	1.7	1.4
Carbon externality			(9.6)				
Total excluding I to I	11.3	13.9	9.7	14.6	3.3	10.1	10.8
Passenger benefits to I to I	5.1	5.3	5.2	6.3	4.7	4.9	4.5
Total including I to I	16.4	19.1	15.0	20.9	8.0	15.0	15.3

5.16 In the High Carbon Price sensitivity there is an increase in benefits relative to the *assessment of need* scenario, despite demand being lower. This is because the additional tax revenue is more than enough to offset the impact of lower demand.

5.17 The No Carbon Price sensitivity results in a decrease in benefits compared with the *assessment of need* scenario, despite the additional demand generated by the lower fares, and the resulting higher passenger benefits associated with adding capacity. This is because of the carbon externality cost.

5.18 As would be expected, the High Demand sensitivity sees an increase in benefits compared to the *assessment of need* scenario, and the reverse is found in the Low Demand Sensitivity.

5.19 The No Passenger Demand Growth Beyond 2050 sensitivity shows a decrease in benefits compared with the *assessment of need* scenario. This is driven by lower passenger benefits as shadow costs are assumed to grow more slowly post 2050.

5.20 The sensitivity involving lower additional runway capacity slightly lowers benefits compared to the *assessment of need* scenario as expected. The impact is relatively small as increasing capacity by less has impacts on passenger demand only once Heathrow reaches its capacity constraint.

Heathrow Airport North West Runway option

5.21 Table 5.2 shows the estimated impact of the sensitivity tests on the present value benefits of the Heathrow Airport North West Runway option in the *assessment of need* scenario.

Table 5.2: Heathrow Airport North West Runway option, passenger, producer and government impacts, present value (£billion), sensitivity tests

	Assessment of need	High DECC carbon price	No Carbon Price	High Demand	Low Demand	No growth beyond 2050	Phase in capacity
Passenger benefits excluding I to I	48.4	42.0	84.6	73.0	25.4	42.4	47.3
Producer shadow cost impact	(38.4)	(34.8)	(69.6)	(59.7)	(23.6)	(33.8)	(37.9)
Government revenue impact	1.8	7.9	5.2	3.8	1.4	2.1	1.8
Carbon Externality			(11.8)				
Total excluding I to I	11.8	15.2	8.3	17.1	3.3	10.7	11.2
Passenger benefits to I to I	6.5	6.3	6.9	8.2	5.5	6.1	6.2
Total including I to I	18.3	21.5	15.2	25.3	8.8	16.8	17.4

5.22 In the High Carbon Price sensitivity there is an increase in benefits relative to the *assessment of need* scenario, despite demand being lower. This is because the additional tax revenue is more than enough to offset the impact of lower demand.

5.23 The No Carbon Price sensitivity results in a decrease in benefits compared with the *assessment of need* scenario, despite the additional demand generated by the lower fares, and the resulting higher passenger benefits associated with adding capacity. This is because of the carbon externality cost.

5.24 As would be expected, the High Demand sensitivity sees an increase in benefits compared to the *assessment of need* scenario, and the reverse is found in the Low Demand sensitivity.

5.25 The No Passenger Demand Growth Beyond 2050 sensitivity shows a decrease in benefits compared with the *assessment of need* scenario. This is driven by lower passenger benefits as shadow costs are assumed to grow more slowly post 2050.

5.26 Phasing in capacity reduces the available additional capacity in earlier years, and so reduces the overall benefits compared with the *assessment of need* scenario. The impact is relatively small as phasing in capacity only has a material impact during the early years of the scheme opening.

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