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A report prepared for Heathrow

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EXECUTIVE SUMMARY

Objective

The Department for Transport has recently released updated forecasts for UK aviation[1] along with the accompanying update to the Department's cost and benefit appraisal of the various runway options considered by the Airport's Commission[2]. These new forecasts have been produced in response to the fact that the growth in air transport demand in the UK has, in the last few years, far outstripped the projections in the DfT's previous forecast (which was a key input into the AC's decision-making).

The most visible consequence of this surge in aviation demand is that Gatwick Airport is now much closer to operating at its maximum capacity than was assumed in the forecasts used by the AC. It has been suggested, not least by Gatwick Airport, that this change in the demand landscape means that the choice between Gatwick and Heathrow as the site of the next new London runway should be revisited as superficially many revised economic measures appear to show a convergence between the results for Heathrow and Gatwick, compared to the AC's results, and in certain cases, the results for Gatwick may appear to be larger than for Heathrow.

Nevertheless, both the DfT and the Government have been clear that nothing in these new reports has altered the previous conclusion for supporting a NW runway at Heathrow. Frontier agrees with this conclusion. While the deluge of information and plethora of different metrics may serve to muddy the water to some extent, higher demand in the present than was previously expected makes the case for airport expansion more urgent but does nothing to alter the relative ranking of the alternative schemes.

The purpose of this report is to consider three main areas:

- Observations on the DfT's updated forecasts and economic appraisal;
- An estimate of the 'congestion premium' at Heathrow, that is the extent to which fares are elevated at Heathrow as a direct result of existing capacity constraints; and
- A comparative estimate of the connectivity and 'catalytic' (trade and FDI) benefits of expanding Heathrow and Gatwick.

Our results draw on underlying economic theory and our conclusions are supported by a significant body of empirical analysis.

DfT's revised forecasts and economic appraisal

DfT's new forecasts for air travel from the UK reflect the increase in travel over the last few years which was not captured in its previous forecast.

[1] https://www.gov.uk/government/publications/uk-aviation-forecasts-2017.

[2] https://www.gov.uk/government/publications/airport-expansion-updated-cost-and-benefits-appraisal.

We have reviewed this evidence and conclude that the new forecast provides no reason to change the relative ranking of Heathrow and Gatwick as the best location to provide additional hub airport capacity. In particular we note that:

- While the DfT's short run forecasts are higher than previously, they broadly converge to the same trend over the long run.
- The fact that Gatwick is fuller than previously expected may make the case for a new Gatwick runway stronger in absolute terms, but this does not mean the relative case is better vs Heathrow, because the case for a new runway at Heathrow is also stronger. Heathrow cannot be fuller today, because it is already at 100% capacity, but the unexpected surge in demand means that there is even more loss occurring at Heathrow today as a result of congestion, resulting in higher fares. This is confirmed by the analysis of the congestion premium in this report.

Taking these points into account there is no reason to think the ranking of the two options would change in any way.

We also note that while the gap between some of the economic appraisal estimates for Gatwick and Heathrow appears to have narrowed, this effect is largely explained by the way in which benefits in the distant future have been extrapolated. There is some doubt over these figures, which do not show a slow-down in the cumulative growth of benefits at Gatwick in the 2 runway case after it becomes constrained again in 2050.

Impact of airport expansion on ticket prices

We have analysed how ticket prices are affected by capacity expansion at both Heathrow and Gatwick and have undertaken detailed econometric analysis to estimate the cost of the congestion premium today. We conclude that expanding Heathrow Airport provides significantly greater benefits to passengers than expanding Gatwick Airport. In particular, we demonstrate that:

- Expanding either airport is likely to have an impact on ticket prices at both airports in the long term. Overall, however, the reduction in ticket prices caused by expansion of Heathrow Airport is significantly larger than the impact on ticket prices of Gatwick expansion. This is because excess demand at Heathrow Airport is substantially higher than at Gatwick Airport and Heathrow is unique compared to other London airports because it is a hub offering a substantial long haul network.
- The reduction in ticket prices from expansion at Heathrow is substantially larger compared to Gatwick. If Heathrow were expanded today, ticket fares would decrease by 23% relative to other London airports as a result of removing the capacity constraint. On a return flight basis, this means that over the course of 2016, the congestion premium cost passengers at Heathrow roughly £2 billion.[3] By 2030, this would result in a reduction in one-way ticket prices of £64 and £247 for short and long haul flights respectively compared to a reduction in

[3] We assume that the congestion premium on inbound flights is equal to the premium on outbound flights. We apply the short haul premium of £28 to short haul flights and the mid-point of the long haul premium of £99 to long haul flights over short and long haul passengers respectively.

ticket prices as a result of Gatwick Airport expansion of £24 and £83 for short and long haul flights respectively.

Therefore, we conclude that expanding Heathrow provides a much greater reduction in ticket prices for passengers than expanding Gatwick.

Impact of airport expansion on connectivity and GDP

We have also modelled the likely impact that airport expansion would have on air connectivity by considering the impact of additional capacity on the ability to offer new direct connections from each airport. We have also quantified the catalytic impact in terms of trade and FDI of each option.

The increase in connectivity is much larger for expanding Heathrow compared to Gatwick. Expanding Heathrow Airport would provide over 40 new long haul connections for London. This contrasts with only 2 new long haul connections for London from expanding Gatwick Airport. Our analysis therefore demonstrates that passengers' choice of connections is increased by a much greater extent as a result of expanding Heathrow when compared to expanding Gatwick.

Finally, in terms of the catalytic impact provided by a new runway, the estimate for Heathrow is more than two times that for Gatwick, at £102 to £113 billion for Heathrow (depending on the speed at which the extra capacity is phased into operation) while only £41 billion for Gatwick.

Conclusion

Our assessment shows that Heathrow Airport expansion provides considerably higher benefits to passengers than expanding Gatwick Airport and that the differential between Heathrow and Gatwick is therefore substantially greater than implied in the DfT's figures. Not only is the reduction in ticket prices from expansion at Heathrow larger than compared to Gatwick, but an expanded Heathrow will provide greater connectivity and economic benefits. Our overall conclusions apply under all likely future market developments. Expanding Heathrow Airport would lead to substantially greater reductions in ticket prices and greater connectivity.

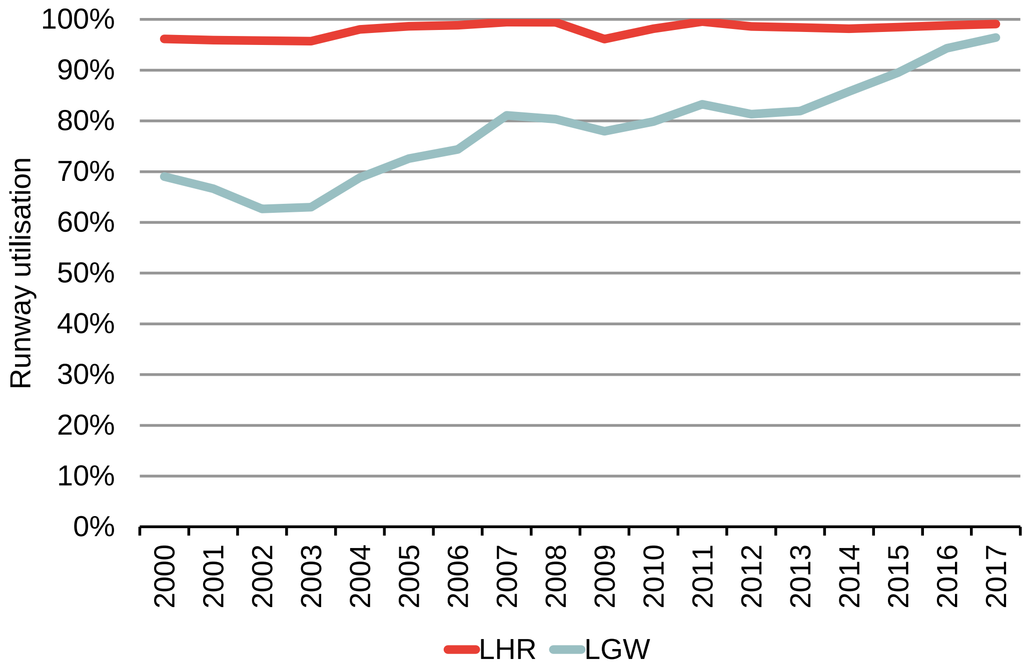
1 INTRODUCTION

In September 2012, the UK Government set up the Airports Commission (AC) to evaluate different options to deliver additional airport capacity in the South East of England. In July 2015, after nearly three years of analysis, the AC unanimously recommended that the best option for expansion was to add a third runway at Heathrow, in preference to a second runway at Gatwick

In October 2016, the Government acted upon the AC's recommendation and announced that it supported a third runway at Heathrow. In February 2017, it published its draft Airports National Policy Statement (NPS), setting out the specific requirements that Heathrow would need to meet to gain planning permission for the third runway. A revised version of the draft NPS is currently open to public consultation, closing in December 2017.

Since the AC report, the demand for air travel has grown significantly. As a consequence, while Heathrow has been acting at its effective maximum capacity in terms of runway utilisation since the middle of the last decade, Gatwick too is now approaching maximum capacity.

Figure 1 Heathrow and Gatwick are both constrained



Source: *Frontier analysis based on schedules data from OAG Analyser and capacity data from the DfT: UK Aviation forecasts (2017)*

This report updates analysis previously prepared for Heathrow by Frontier and submitted to the AC in 2014. It was commissioned by Heathrow Airport to provide support as it responds to the consultation on the draft NPS. Our analysis covers three main areas:

- Observations on the DfT's updated forecasts and economic appraisal;

- An estimate of the 'congestion premium' at Heathrow, that is the extent to which fares are elevated at Heathrow as a direct result of existing capacity constraints; and
- A comparative estimate of the connectivity and 'catalytic' (trade and FDI) benefits of expanding Heathrow and Gatwick.

The structure of this report is as follows:

- In **Section 2** we set out our observations on the DfT's recent forecasts and economic modelling.
- In **Section 3** we summarise the results of our econometric analysis to estimate the size of the congestion premium at Heathrow based on 2016 data.
- In **Section 4** we summarise the results of our network modelling. This is to compare and contrast how expansions at Heathrow and Gatwick could be expected to improve connectivity to long haul markets. We also estimate the catalytic impact of both expansion options.
- In **Section 5** we provide our overall conclusions.

We also provide further technical details underlying the econometrics analysis and catalytic impact analysis in separate annexes to this report.

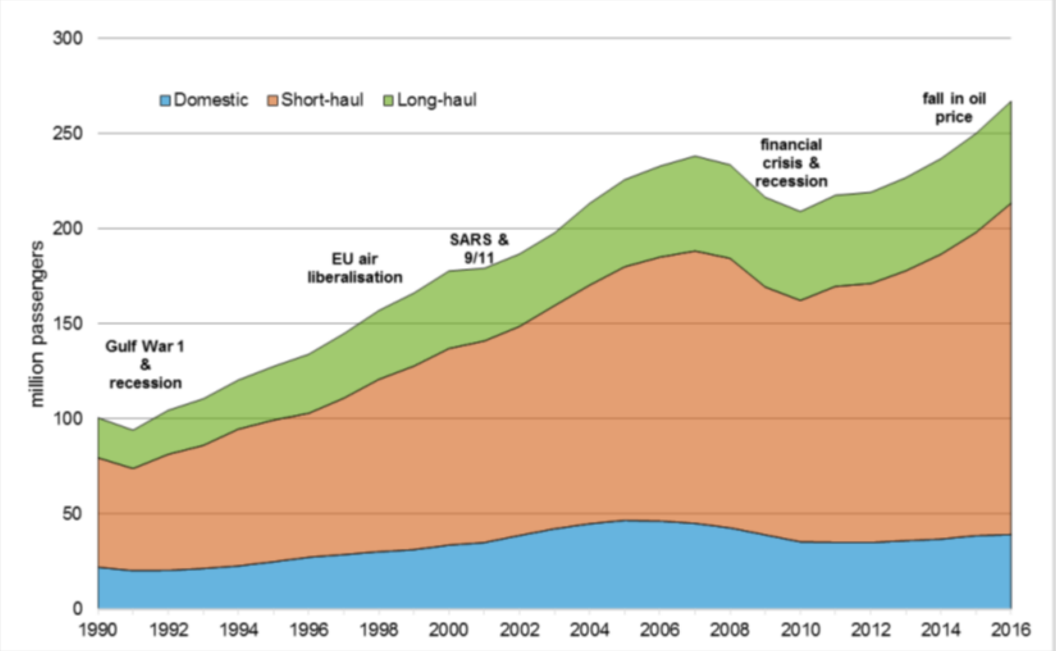
2 OBSERVATIONS ON THE DFT'S UPDATED ANALYSIS

2.1 Updated forecasts

The trigger for Frontier to update its previous analysis has been the recent publication by the Department for Transport's forecasts for UK aviation[4], and the accompanying update to the Department's cost and benefit appraisal of the various runway options considered by the Airport's Commission[5]. These new forecasts have been produced in response to the fact that the growth in air transport demand in the UK has, in the last few years, far outstripped the projections in the DfT's previous forecast (which was a key input into the AC's decision-making).

While the demand for air travel has historically developed in a fairly predictable and stable relationship to the growth in GDP, the last ten years, which encompass the financial crisis of 2008, have been particularly difficult to forecast. Turbulence in financial markets and the consequential economic downturn resulted in a significant fall in air travel. But from 2010 demand started to pick up again, powered both by general economic recovery and falling oil prices. This recovery, which is not just a UK phenomenon, has been faster than expected or would have been predicted on the basis of the relatively sluggish economic growth that Europe has experienced for the last few years.

Figure 2 Historic UK passenger demand



Source: DfT, UK Aviation Forecasts, October 2017, Figure 2.2

The most visible consequence of this surge in aviation demand is that Gatwick Airport is now much closer to operating at its maximum capacity than was assumed

4 https://www.gov.uk/government/publications/uk-aviation-forecasts-2017.

5 https://www.gov.uk/government/publications/airport-expansion-updated-cost-and-benefits-appraisal.

in the forecasts used by the AC. From 2011 to 20116 the number of passengers served by Gatwick has increased from c .34m p.a. to c. 43m p.a..

By apparent contrast, passenger traffic at Heathrow has not grown by as much (from 69m p.a. to 76m p.a. over the same period). However, this more limited growth must obviously be viewed in the context of the fact that well before even 2011 Heathrow was already effectively operating at its annual maximum for ATMs of around 480,000p.a.. Hence expansion at Heathrow has only been achieved by changes in the fleet mix of airlines operating there and the progressive displacement of short haul with long haul routes, operated by larger aircraft.

It has been suggested, not least by Gatwick Airport, that this change in the demand landscape means that the choice between Gatwick and Heathrow as the site of the new London runway should be revisited. Superficially this argument might seem to be supported by the fact that in the DfT's updated economic appraisal some of the many revised economic measures presented appear to show a convergence between the results for Heathrow and Gatwick, compared to the AC's results, and in certain cases, the results for Gatwick may appear to be larger than for Heathrow.

Nevertheless it is important to stress that both DfT and the Government have been clear that nothing in these new reports has altered the previous conclusion: the NW runway at Heathrow, unanimously supported by the AC in 2015, remains the Government's choice.

Frontier agrees with this conclusion. While the deluge of information and plethora of different metrics may serve to muddy the water to some extent, higher demand in the present than was previously expected simply makes the general case for airport expansion more urgent, while doing nothing to alter the relative ranking of the alternative schemes.

2.1.1 Short run vs long run effects

Forecasting, especially over the 60 year time horizon required by the UK government's official appraisal methodology[6], is far from a precise science. In fact, it is not so much a process of predicting the future as one of articulating the potential future consequences for demand on the basis of different assumptions: for instance whether historic long run relationships between GDP, oil price and aviation demand are maintained, or perhaps are altered due to new factors such as telecommunications substituting for business travel or saturation in the growth of available leisure time.

With this in mind, it should first be noted that DfT's new forecasts do not, broadly, suggest a change in the long run growth in aviation demand compared to its previous estimates.

Indeed, as illustrated by Figure 3, below, DfT's long run forecast is not materially different to those used by the AC, notwithstanding demand being higher in the immediate future.

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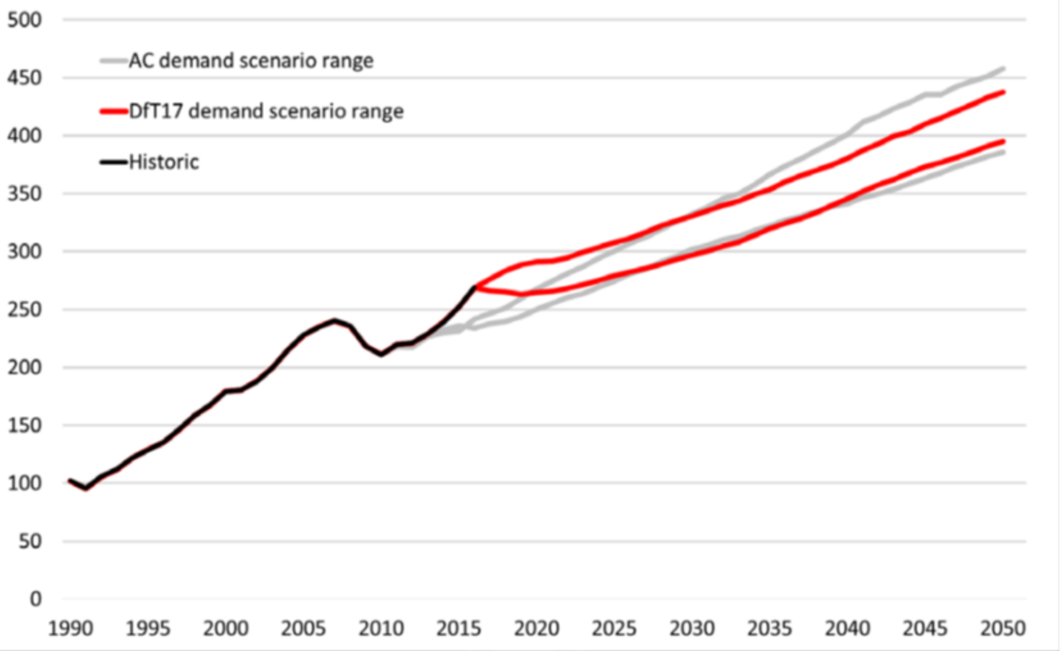
[6] Airports Commission: Appraisal Framework https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/300223/airports-commission-appraisal-framework.pdf

Figure 3 Terminal passengers at UK airports, demand range comparison (mppa)



Source: DfT, Updated Appraisal Report - Airport Capacity in the South East, October 2017, Figure 2.2

Figure 3 not only shows the extent to which demand has outstripped the previous projection in the last few years but also that DfT's new projections do not suggest a different long run path for demand. In this context, the recent surge comes to look more like a correction to previous trends. From 2030 it is anticipated that demand will be broadly in line with previous expectations.

What this tells us is that despite the current higher demand figures, there is really no significant new information here to change our view of the long run future. Given that runway capacity is a long run decision, it follows therefore that the new forecast supports, rather than challenges, the AC's recommendation.

2.1.2 Is the case for Gatwick now stronger?

Clearly, the fact that passenger demand at Gatwick is significantly higher than previously anticipated strengthens Gatwick's claim that it needs a new runway sooner rather than later, all other things being equal. But it does not follow from this that the *relative* ranking of Heathrow and Gatwick need change.

The fact that Gatwick is much closer to maximum capacity today than was previously anticipated is the *visible* consequence of the surge in aviation demand. It is clear that if demand continues on this trajectory then congestion costs will start to bite at Gatwick sooner than anticipated; this is the core of the argument for expanding Gatwick.

But as we have already discussed, it is not possible to observe an equivalent demand effect at Heathrow, because in terms of utilisation Heathrow is already effectively full, and has been since roughly 2005/06, as illustrated by Figure 1, above.

The difficulty this creates, however, is that the cost that congestion at Heathrow is imposing on passengers and on the UK is not directly observable. This cost relates to the difference between the unconstrained demand to fly through Heathrow and the level that can be served in practice. This cost was already present when the AC made its original decision. On the assumption that the underlying demand to fly through an unconstrained Heathrow has similarly grown much faster than anticipated, the cost of this constraint will also have grown and so too the benefits of expansion.

Viewed in this light, the convergence in passenger numbers between Gatwick and Heathrow is a misleading guide to the relative benefit of expanding one airport or the other. It is true that the congestion costs of failing to expand Gatwick are now greater than previously thought. But Heathrow is also much more constrained (relative to underlying unconstrained demand) than expected, so the congestion costs of failing to expand Heathrow are also now greater.

On the face of it there is no reason to consider that one effect is larger than the other, hence again there is no reason to think that the relative ranking of the two choices may have changed.

However, while we acknowledge the thoroughness and detail of the DfT's forecasting framework, Frontier does take issue with one aspect of this framework which we believe leads the DfT to understate the costs of congestion at Heathrow, and so overstate both long run demand at Gatwick and the benefits of expanding capacity there. We return to this point in section 2.3.2.

2.2 DfT's Appraisal Measures: Which ones are most relevant?

As already noted, one of the drawbacks of both the DfT's appraisal methodology and the AC's approach is the proliferation of different benefit and welfare measures, which seem in some circumstances to produce contradictory conclusions.

Some time has passed since the AC's decision so it is probably worth reiterating that while the AC performed a traditional cost benefit analysis (CBA) on the various options, this was not the result on which it placed most weight in making its decision in favour of Heathrow.

Figure 4 below summarizes the four key measures used to compare the various schemes, starting with net present value, which is the most comprehensive measure, most often cited as the result of public Cost Benefit Analysis (CBA).

Figure 4 Alternative appraisal methods in DfT report

Appraisal method	Description
Net present value	This is the discounted value of all private, public and social costs and benefits over the first 60 years of the project. Included are the direct costs and benefits to passengers and airlines, the private cost of airport construction, impacts on government revenues and environmental disbenefits.
Net social benefit	As net present value but excluding the costs of scheme construction and surface access.
Total benefits to passengers and the wider economy	As net social benefits but excluding environmental disbenefits (air pollution and noise) and losses to airlines because of reductions in fares.
Passenger benefits	The value to passengers of greater airport capacity. As above but excluding government revenues and wider economic impacts.

The AC highlighted that the appraisal process it was undertaking differs from a traditional public CBA, as presented in the official government appraisal guide, WebTAG. The WebTAG approach is designed to appraise publicly funded projects, and is not equipped to assess projects such as these runway developments which are largely privately funded.

As a result of this issue, the AC was clear in focussing its primary attention on the net social benefits created by the alternative options, rather than the full cost benefit results.

In some ways this was an unusual step in the appraisal of transport projects, but the Commission has been very clear that it is justified in this case.

> *"The overall scale of net social benefits delivered by each scheme is most relevant to the consideration of whether a National Policy Statement or Hybrid Bill should be passed through parliament, given that a large proportion of the cost will be funded privately rather than by the public purse. Because the schemes are assumed to be predominantly privately funded, benefits to international-to-international transfer passengers are included, as they would contribute to the costs of the scheme as well as supporting the delivery of a dense route network for UK travellers. In addition, a calculation including scheme costs has been carried out to provide a net present value, given the scope for some or all of these costs to displace expenditure elsewhere in the economy.*
>
> *This contrasts with publicly-funded projects for which a benefit-cost ratio is more relevant to allow government to prioritise public expenditure based on the comparative value for money of different projects. In this instance, however, even those elements which might be more likely to be publicly funded, in part or in whole, such as surface access interventions, would need*

> *to be judged on the basis of a broader benefit-cost ratio calculation which incorporates broader benefits to non airport users."*[7]

The Commission's logic for its recommendation is clear. CBA is relevant to the assessment, in that schemes that fail to generate a positive NPV in a CBA should be treated with great caution, regardless of whether they are publicly or privately funded. A negative NPV would imply that the UK overall was worse off with the scheme than without. But that is not the case here. Both schemes generate a positive NPV. Therefore both Heathrow and Gatwick developments are shown to be independently worthwhile.

However, because the overwhelming majority of both schemes would be privately funded, choosing between the two alternatives on the basis of CBA is not relevant because CBA is a method for prioritising the spending of fixed sums of public money. In this case there is the choice of one private investment or the other, primarily because the Government has already stipulated that only one runway should proceed. Given that constraint, the AC's argument was that the runway that delivers the greatest net social benefit should be the one that is preferred. And that option was found to be Heathrow by a substantial margin.

In the DfT's previous analysis[8], based on the AC's "central" Appraisal of Need scenario, the DfT found that the net social benefits from expansion at Gatwick were in the range £10.1bn to 11.4bn, compared to £18.6bn to £20.4bn for the NW runway at Heathrow.

The revised forecasts produce similar results, with the relativities of the benefits roughly unchanged, which is consistent with the intuitive arguments made previously that the new demand forecasts should not be expected to alter the relativity of the two options significantly. In the revised appraisal the net social benefits of both schemes are slightly lower: £8.1bn to £9.3bn for Gatwick and £16.2bn to £17.5bn for the NW runway at Heathrow.

2.3 Does the DFT approach understate the benefits of expanding Heathrow?

While we are broadly supportive of the DfT's analysis, we nevertheless have identified a number of areas where we believe the analysis tends to understate the relative benefit of expanding Heathrow vs expanding Gatwick. This was true in the AC analysis. We believe these distortions may actually be even greater in the current appraisal, notwithstanding the fact that the results stills strongly support the choice of Heathrow.

The first two of these issues we will elaborate on at greater length in the remainder of this report. The third point is a relatively small methodological puzzle we have not been able to resolve with DfT, which places a question mark over the overall appraisal figure for Gatwick.

7 Airport Commission, 2015, Final report, p. 148.

8 Further Review and Sensitivities Report (FRSR), October 2016

2.3.1 Connectivity and catalytic economic benefits

The AC's analysis and the DfT's updated appraisal both include estimates of the wider, macro-economic benefits associated with the improvement in UK connectivity. These benefits include, among other things, the impact on trade, investment and tourism and knock-on long term impacts on productivity and GDP.

Taken over the standard 60 year appraisal time frame, these benefits are estimated to be very substantial. In the case of the AC's analysis, the estimate for Heathrow expansion in the "Assessment of Need" scenario was a boost to GDP of up to £147bn as opposed to £73bn for the Gatwick second runway.

DfT's updated analysis does not present a GDP impact, but it does present a range of estimates for the impact of connectivity on trade (Heathrow £8.8bn-£130.9bn, Gatwick £10.9bn-£59.5bn[9]). In both cases the estimates are roughly 30% higher than the figures derived by DfT in its previous FRSR report. The relativity of the benefits estimated for the Heathrow and Gatwick options remains largely unchanged.

These estimates are given for information and do not form part of the overall estimates of net benefits that the DfT presents. However, the estimates add important additional evidence that the wider benefit of Heathrow expansion significantly outstrips that of Gatwick, over and above the headline Net Social Benefit figures.

Apart for the uncertainty in quantifying these effects, DfT also justifies excluding these estimates from the overall assessment on the grounds that there is potential for double counting.

We agree there are grounds for being somewhat cautious about the use of these figures. Unlike the core WebTAG approach there is no single approved methodology for assessing wider "catalytic" benefits of connectivity, which means the potential estimates may be subject to greater uncertainty than the conventional cost benefit figures.

We are less convinced that "double counting" justifies focussing solely on CBA measures.

First, we note that the trade figures estimated by DfT are simply flows of exports and imports which cannot be added to the Net Social Benefits, because these flows are not a measure of change in either income or welfare. On the other hand, it is possible to consider adding the income or GDP effects of greater trade to Net Social Benefits, subject to certain caveats.

It is generally accepted that trade in general is economically beneficial, but trade itself, made up of imports and exports, has an ambiguous static impact on national income. So long as the UK runs a persistent trade deficit in goods it is possible that the static impact of more trade on GDP is in fact negative. However, the reason why imports benefit the economy as well as exports is down to its contribution to greater efficiency, the ability to source higher quality inputs not available domestically, or the role of distributed supply chains which may permit some

[9] Updated Appraisal Report - Airport Capacity in the South East, Table 5.2

production steps to be performed more cheaply offshore before part finished products are imported for further processing.

Trade regardless of its direction thus has the potential to raise national income via the route of improving overall productivity. This is a medium-to long term process, the benefit of which ripples through the economy and does not accrue directly. By definition, a CBA is a micro-economic measure and has difficulties in taking into account macroeconomic and long run general dynamic effects, whereas these are key features in an analysis of the long run catalytic effects of connectivity. Because there are aspects of the project that are captured by the CBA and not by catalytic analysis, and the other way around, it is reasonable to consider both types of assessments as complementary and relevant for projects with significant macroeconomic impacts. For instance, CBA typically assumes full employment, whereas in the productivity analysis additional jobs in the long run can be attributed a value.

Historically CBA has been the most common tool in policy analysis and transport appraisals[10]. However, macroeconomic modelling is also sometimes used, either on its own or as a complementary analysis, to a CBA. For instance, Governments and institutions such as the World Bank, OECD, WTO and IMF use CGE models in the policy development process, and HMRC models the UK tax system using a CGE model.[11] In investment projects, CGE models are used quite extensively, especially in Australia. An assessment based on both a CBA and a macro model has been used for major investments such as the Second Sydney Airport (Joint Study, 2012) and major road and rail links in Melbourne (e.g. Allen et al, 1995; Meyrick and Associates, 2008, High Speed Train).[12] In transport appraisals, it is most common for CBA alone to be conducted; however, in the US studies typically also report GDP per dollar and jobs per dollar metrics. In addition, the US considers a range of impacts beyond commuting, including measures that extend well beyond a CBA and are based on regional or local macroeconomic models.[13]

We note also that a further reason rationale for considering these macro-economic effects to be double counted is that they overlap with wider economic benefits, such as those of agglomeration, which, although small, were included in the DfT’s FRSR analysis. However, in the present case this argument is weakened because DfT has now chosen to exclude agglomeration from its wider economic benefits (because of the difficulty in measuring negative effects of congestion).

In Section 4, we present our own revised estimates of the additional connectivity and its GDP impact, as would be supported by the NW Runway at Heathrow, taking

[10] Peter Mackie and Tom Worsley, 2013, “International Comparisons of Transport Appraisal Practice” , University of Leeds, April 2013, Available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/209530/final-overview-report.pdf

[11] HMRC, 2013, CGE model documentation, Available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/263652/CGE_model_doc_131204_new.pdf

[12] Peter Forsyth, 2014, “Infrastructure and the Investment Evaluation Issue, Submission to the Productivity Commission, Inquiry into Public Infrastructure”, Department of Economics, Monash University, March 2014

[13] Peter Mackie and Tom Worsley, 2013, “International Comparisons of Transport Appraisal Practice” , University of Leeds, April 2013, Available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/209530/final-overview-report.pdf

into account DfT's new demand forecast. These figures are contrasted with an estimate of the equivalent effects of the proposed Gatwick expansion.

In its appraisal framework, the AC included benefits to international-to-international transfer passengers. We agree with this approach. As set out in more detail in Section 4, transfer passengers provide considerable connectivity benefits to the UK. This is because they increase total demand and therefore the overall business case for individual routes. Or in other words, without transfer passengers (which made up 36% of total demand at Heathrow in 2016), airlines may decide to reduce their flight frequency or potentially even stop operating the route altogether if total demand were to slip below the airline's minimum level of commercial viability. Clearly reduced frequencies and lost routes would be detrimental to O/D passengers. And secondly, transfer passengers will contribute to the overall cost of expansion.

2.3.2 Congestion premium

The appraisal estimates produced by DfT include "passenger benefits" from expansion that reflect, largely, the avoidance of increased ticket fares resulting from congestion at the London airports.

While we agree with the approach in principle, we believe that the DfT's results are subject to a methodological issue that significantly understates the benefit of Heathrow expansion to passengers and hence distorts the relative impact of the two main expansion options.

The DfT's approach understates the congestion premium at Heathrow today and in the future. This is due to the way the DfT's airport choice model, NAPAM, is designed. This model **requires,** by assumption, that no airport is congested in the base year. This is because NAPAM's parameters are calibrated so that in the base year realised (met) demand is, by definition, less than technical capacity. This implies that NAPAM treats all airports as uncongested in the base year. As a consequence, passenger choices between Heathrow and other airports are modelled as their preferred choices, whereas in reality, Heathrow has been operating at capacity for many years and so choices in the base year already represent a response to existing constraints.

As a result, this approach significantly understates the current congestion premium at Heathrow, and, by extension, the premium in future years. Put differently, existing shadow costs are mistakenly represented by the unconstrained demand estimation as a lower preference for flying from Heathrow than is in fact the case. As a consequence this process also distorts the modelling of how demand would respond to new capacity in the future, to the detriment of Heathrow, by understating the pent-up demand to use Heathrow, were the capacity available.

DfT's projection of future airport choice introduces a "shadow cost" for future years which is calibrated to choke off demand for a given airport to its technical capacity. This is by definition zero in the base year, regardless of how much traffic is actually already being diverted or choked off as a result of existing excess demand. As the unconstrained demand forecast rises in the future, these shadow costs ramp up. The alleviation of these shadow costs by expansion is the major passenger benefit identified in DfT's modelling. But by treating the starting point as zero for both

Heathrow and Gatwick the results are significantly skewed against Heathrow which clearly already operates under conditions of excess demand.

This problem was present in the forecast used by the AC, but has simply been exacerbated in the new forecast, because Gatwick is now so near to capacity. As a result, the DfT's projections suggest that the passenger benefits from expanding Heathrow are now very slightly smaller than those of expanding Gatwick. Given evidence of the current congestion premium at Heathrow, this clearly cannot be the case.

In a previous report[14], we presented results of an extensive econometric analysis that demonstrated a significant congestion premium already existing at Heathrow in 2012. In this report we repeat and extend that analysis for 2016 and confirm the result that Heathrow passengers are paying an increasing premium due to congestion, while there is no robust evidence of a similar effect at Gatwick.

Distributional impacts

While the congestion premium at Heathrow may be under-stated, it could be argued that this has a limited effect on the overall appraisal, because most of this premium is interpreted as a transfer between passengers and airline shareholders, which can be viewed as neutral in CBA terms. In our view there is a case for not treating these transfers as neutral and focussing more on passenger benefits.

While a strict application of microeconomics would suggest that the overall welfare impact should disregard any transfers, from a macroeconomic point of view it is clear that the impact is not the same. For example, the impact on the economy is not the same when considering a lower dividend for an airline's shareholders compared to a reduction in fares that is spread across passengers using Heathrow.

In addition, recognising the greater importance of consumer compared to producer surplus is a common procedure for most UK regulatory bodies as they generally have statutory duties towards consumers. In the case of aviation, the UK CAA has the duty to further the reasonable interests of airport users. As a result, the benefits of economic regulation include the overall welfare improvement but also the transfer from producer surplus to consumer surplus.

Overall, we therefore believe that there is a case for focusing more on the passenger benefits of expansion, which combined with a more accurate assessment of the congestion premium, clearly indicates the benefits of expanding Heathrow to be far in excess of those from expanding Gatwick. We detail our estimates of the congestion premium in Section 3.

2.4 Extrapolated results

In some of the measures presented by DfT, Gatwick appears to generate greater overall benefits over the full 60 year appraisal period. We note that this has not changed the Government's clear conclusion to back the NW runway at Heathrow.

[14] Frontier Economics, 2013, Competition and choice, Available http://www.frontier-economics.com/documents/2014/05/impact-of-airport-expansion-options-on-competition-and-choice-frontier-report.pdf

In reviewing these results it is clear that the driver of these apparently contradictory results lies in the way future benefits have been extrapolated. For instance, Figure 4.1 of the appraisal shows that cumulative passenger benefits of the Gatwick expansion overtake those of the Heathrow NW runway in c. 2070.

However, it should be noted that DfT's demand forecasts only run to 2050. The period from 2050 top 2085 is not covered by the modelling, and so is subject to "extrapolation". Unfortunately DfT's report contains very little detail; as to how this extrapolation has been carried out.

But examining these findings, as illustrated by DfT's figure 4.1, it is not clear how it is possible for the passenger benefits of Gatwick expansion to accelerate the way they appear to into the future at a faster rate than Heathrow.

Up to 2050 the faster growth of benefits at Gatwick is understandable: Even with a third runway, Heathrow is expected to be full again around 2030. So after that date and before Gatwick becomes congested the faster growth at Gatwick would be expected to accrue more benefits at the margin, albeit starting from a lower base.

However, under DfT's assumptions, a 2 runway Gatwick would be full from 2050. Therefore, from 2050 onwards, it is not clear how Gatwick could be expected to catch up and overtake Heathrow at such a rate if both airports are assumed to be constrained. The growth in benefits during the "Extrapolated Period" clearly drives the overall result that Gatwick eventually overtakes Heathrow. However, there is no discussion in the DfT's analysis on how these extrapolated growth rates have been derived. The growth rate appears to be c. 4.3% per annum for Gatwick and 3.4% per annum for Heathrow. It is not clear why this should be the case. And clearly, over such a long appraisal period, even small differences in growth rates become compounded and can lead to diverging results.

We understand from DfT that the primary cause of the differential growth rate is that the Gatwick option provides fractionally more capacity in the long run than the Heathrow option.

However, on consideration we find it hard to reconcile this with the figures in DfT's demand forecast. Table 34 of the DfT's latest forecast[15] does show total London passengers in 2050 higher in the Gatwick expansion scenario, but only fractionally (249m vs. 248m), while nationally total passengers are lower (432m vs 435m). It is hard to reconcile this with a projection that shows benefits from Gatwick growing at almost 1% p.a. faster for the following 35 years.

Furthermore, as we attempt to demonstrate below, our view is that DfT mis-states the difference in the *level* of passenger benefits generated by the two runway options by failing to take in to account the congestion premium currently existing at Heathrow. Add this in to the mix and the long run projection of benefits growing much faster at Gatwick seems quite unlikely.

Given these discrepancies, we consider it unwise to place significant weight on benefits occurring in the distant future that may be the artefact of extrapolation assumptions. In conclusion we think the DfT have been wise therefore to stress the importance of the earlier benefits generated by Heathrow expansion.

[15] UK Aviation forecasts, Oct. 2017, p. 104

3 IMPACT OF EXPANSION ON TICKET PRICES

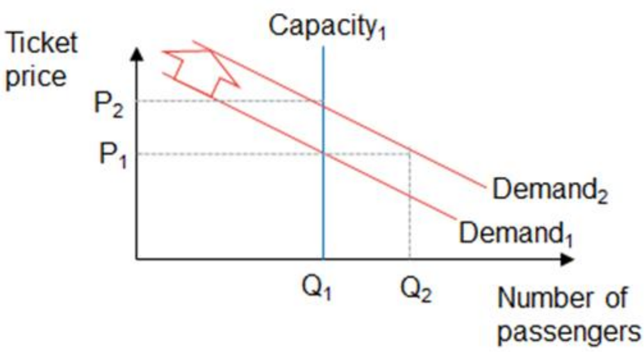
This section assesses the benefits to passengers from airport expansion in terms of the likely impact that expansion would have in reducing ticket prices. We first explain the theory of why the capacity constraints may result in increased ticket prices and how this relates to the London airports. We next present and compare the empirical evidence on the cost of the capacity constraint at Heathrow and Gatwick in 2016 and 2030.

3.1 Economic theory of capacity constraints

To understand the effects of capacity constraints on ticket fares, it is useful to think of price setting in terms of supply and demand. In a perfectly competitive, unconstrained situation, ticket fares would be set by the intersection of supply and demand. However, when demand for flying from an airport exceeds the airport's capacity, the competitive ticket price is not possible because the demand exceeds supply. As a result, market prices rise to "choke-off" demand.

This scenario is illustrated in Figure 5 below. The vertical blue line indicates the number of passengers the constrained airport can accommodate (Q1 in the figure). The red lines provide the demand function, which is downwards sloping as more people want to fly at lower prices. Over time the demand function shifts outward as income increases and more people want to fly. When the demand curve shifts, more people (Q2 in the figure) want to fly to and at the existing price (P1). As capacity is fixed, the number of passengers cannot increase so the price rises to ensure that demand equals capacity (P1 to P2).

Figure 5 Excess demand leads to increased prices



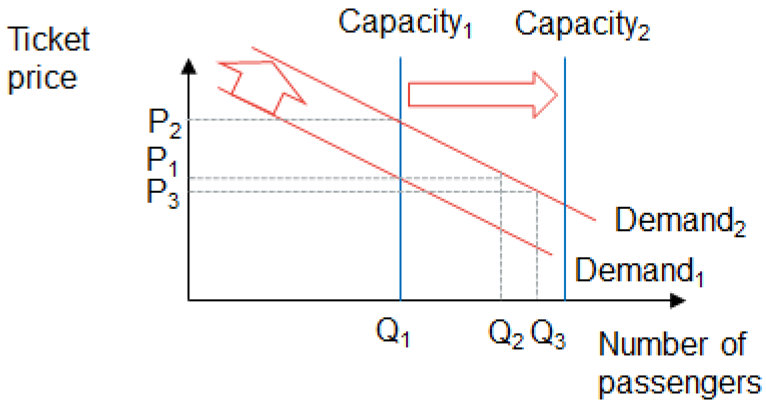
Based on the economic theory, we can identify the following relationship between excess demand (Q2-Q1) and the cost of the constraint (P2-P1):

- greater excess demand before the expansion leads to a higher cost of the constraint; and
- higher than average fares and a lower price elasticity lead to a higher cost of the constraint as the price needs to rise by more to reduce excess demand.

When a capacity constraint at an airport is removed, the benefit to passengers is equal to the cost of the constraint. Figure 6 shows the same situation as in Figure

5 but with an increase in capacity. Increased capacity (such as from a new runway) shifts the supply curve outward as a greater number of passengers can now be accommodated (Q3). At the new capacity level, there is no excess demand so the price falls to P3. The difference between P2 and P3 represents the benefit to passengers as on average they now pay lower ticket prices.

Figure 6 Removing capacity constraints benefits passengers



Given that we expect expanding capacity would lead to lower ticket prices, it is important to clarify the mechanism that leads to the reduction in ticket prices by considering both airport and airline pricing. For regulated airports (such as Heathrow and Gatwick), the airports cannot adjust their pricing to ensure that demand equals supply in the constrained case.

As a regulated airport does not capture any of the scarcity rents that result from a capacity constraint, competition in the airline market plays an important role in adjusting prices so that demand equals supply. At an unconstrained airport, the conditions of entry and exit can ensure that ticket prices remain at the fully competitive level. However, with restricted access, this process cannot function. Free entry cannot occur if slots are not available, and the restricted capacity leads to rising ticket prices so as to match passenger numbers to the seats available. The extent of the increase will depend on the magnitude of the excess demand and the extent to which services from other airports are either available or represent an acceptable alternative for passengers. This last point means that if the constrained airport is subject to effective competition from a neighbouring airport fares may not rise very much, even if the airport is constrained, because a rise in fares would simply cause passengers to choose to fly from the other airport. Furthermore, these conditions of competition may differ between different market segments. For instance, two airports may be viable substitutes for short haul traffic but less so for long haul. If this is the case congestion may lead to a significant long haul premium, but little or no premium on short haul fares.

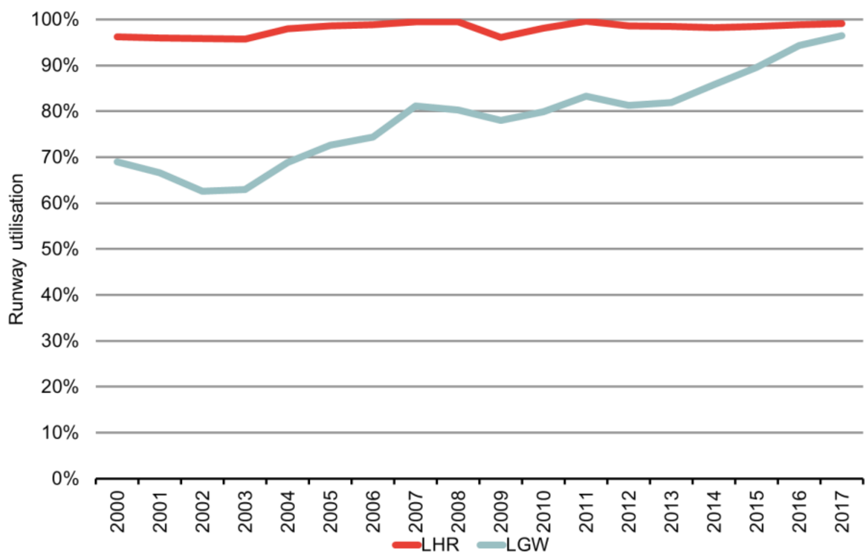
If the capacity constraint is removed, new airlines can enter existing routes and this increase in airline competition ensures that prices fall. The change in ticket prices at the expanded airport therefore depends both on the level of excess demand and the substitutability of alternative airports. This complicates the relationship between capacity and ticket prices. Using a model of differentiated competition between airports, we have identified that:

- Capacity constraints at one airport lead to higher prices not just at the airport itself, but at other airports that compete with the constrained airport. In these circumstances, expanding capacity at the unconstrained airport has no expected effect on ticket prices or passenger welfare.
- If both airports are constrained, then expanding capacity at either airport will lead to a fall in ticket prices at both airports and a benefit to passengers, but the effect is much greater if the expansion is focussed on the airport with a higher level of excess demand.[16]

3.2 Capacity constraints and their effect in London

The effects of capacity constraints are relevant for London airports because both Heathrow and Gatwick face capacity constraints. As demonstrated by Figure 7, Heathrow has been capacity constrained in terms of runway utilisation for over 10 years while Gatwick is now approaching full capacity for the first time.

Figure 7 Runway utilisations at Heathrow and Gatwick

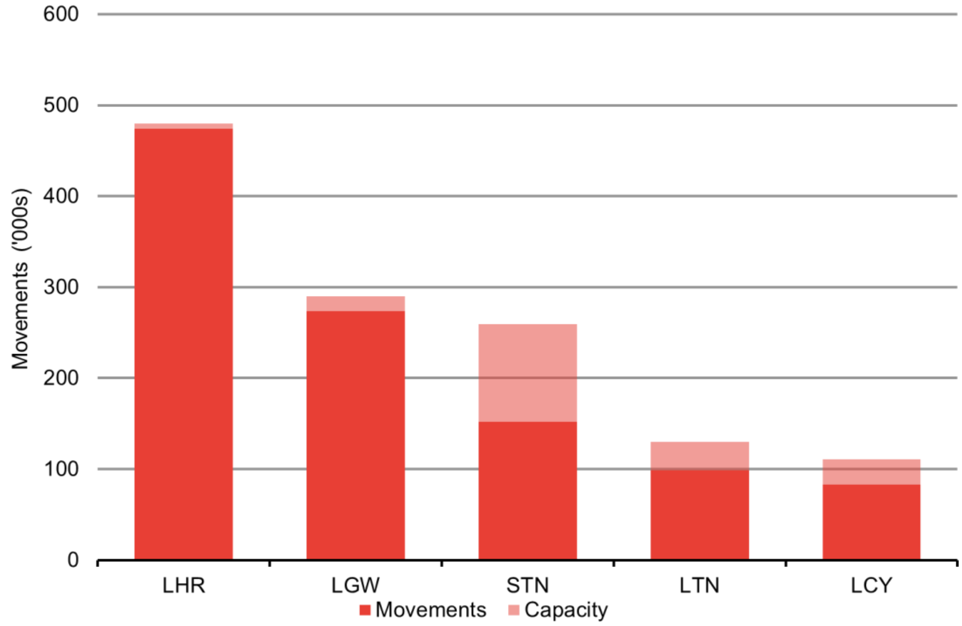


Source: *Frontier analysis based on schedules data from OAG Analyser and capacity data from the DfT: UK Aviation forecasts (2017)*

Furthermore, considering the total movements across the London airports in Figure 8, we see that again Heathrow is at maximum capacity while Gatwick is also near maximum capacity in terms of movements. However, by considering movements by hour as in Figure 9 and Figure 10, we see that Heathrow is at maximum movements for most hours of the day while Gatwick is not. This suggests that Heathrow faces a greater capacity constraint.

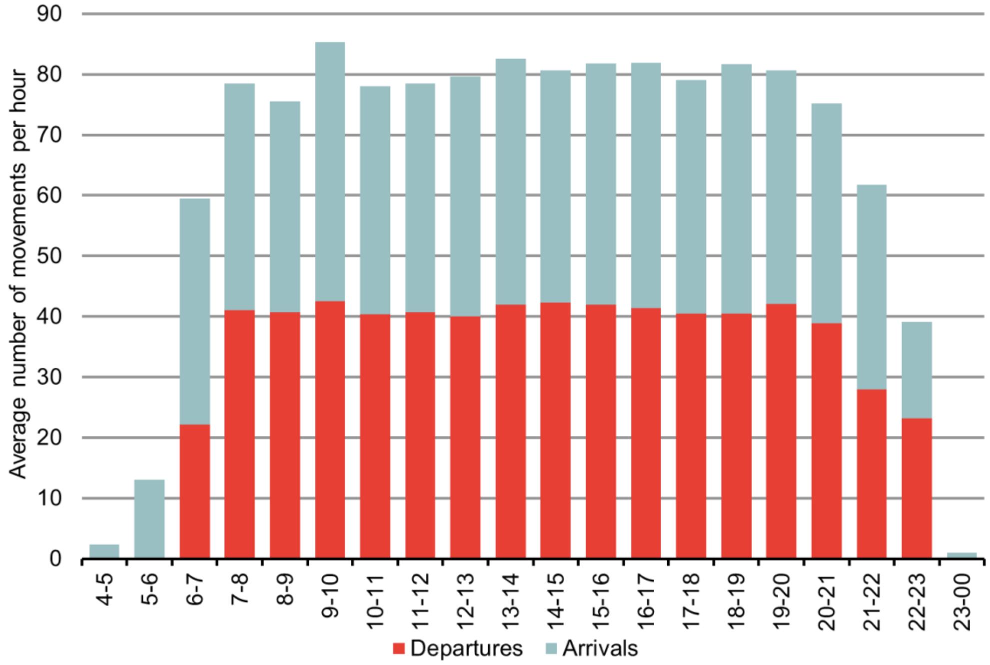
[16] Furthermore, Gatwick is not an appropriate substitute for Heathrow's capacity because Heathrow is a major hub. This will be explored further in Section 4.

Figure 8 Movements across the London airports 2017



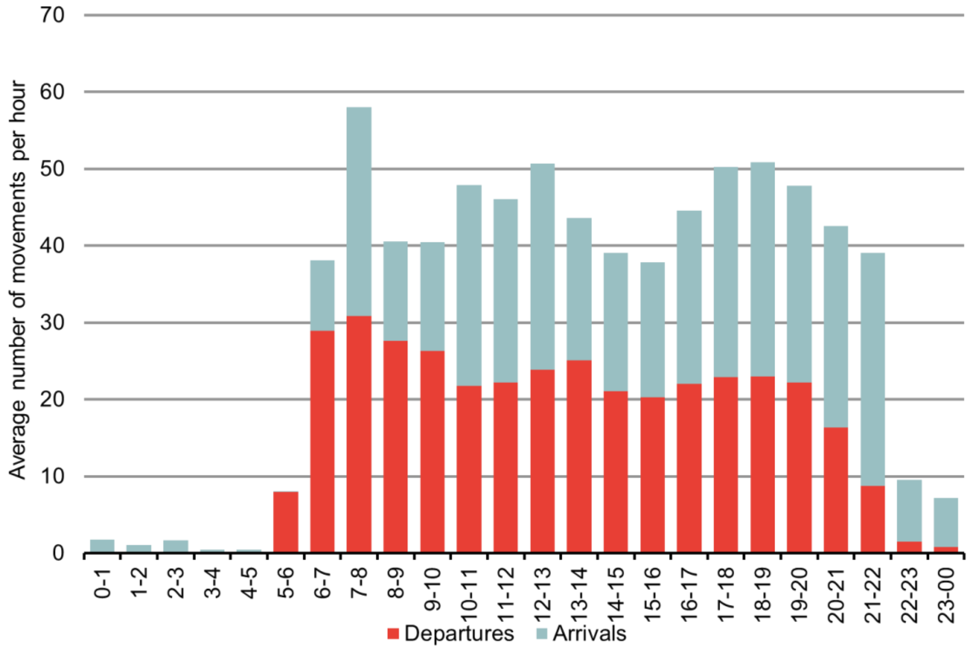
Source: Frontier analysis based on schedules data from OAG Analyser and capacity data from the DfT: UK Aviation forecasts (2017)

Figure 9 Hourly movements for Heathrow in 2016



Source: Frontier analysis based on schedules data from OAG Analyser.

Figure 10 Hourly movements at Gatwick in 2016



Source: Frontier analysis based on schedules data from OAG Analyser.

As a result of the current capacity constraints, the economic theory presented above leads us to expect that by 2030 a new runway at Heathrow Airport is likely to provide substantially greater benefits than adding another runway at Gatwick Airport because:

- By 2030 Heathrow Airport's excess demand is likely to be significantly higher than Gatwick's as it will have been constrained for more than 20 years while Gatwick would only have been constrained for about 10 years.
- Heathrow Airport's average fare is higher; passengers have a lower price elasticity because it offers a much greater proportion of long-haul flights and serves a higher number of business and premium passengers.

The following sections provide empirical evidence that demonstrates that the impact on ticket prices is indeed bigger for Heathrow.

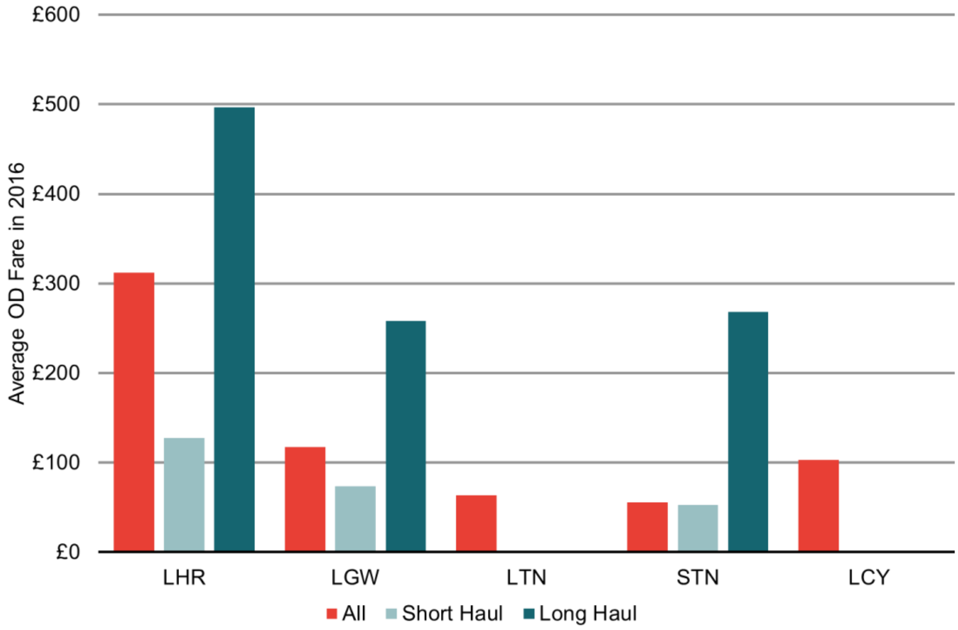
3.3 Descriptive analysis of ticket fares

Before beginning the econometric analysis, we first compared the average OD fares at Heathrow versus other airports in London and Europe. Furthermore, we considered fares to destinations served by Heathrow that are also served by other airports, meaning there is an overlap between airports on the route.

3.3.1 Average fare analysis

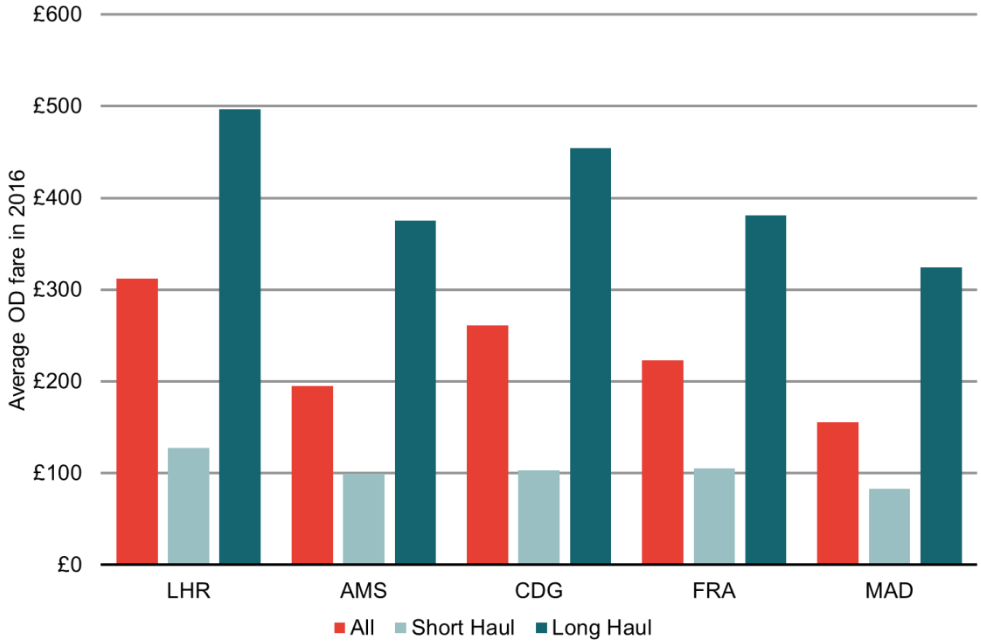
The average OD fares for all, short haul and long haul flights are shown in Figure 11 and Figure 12 for London airports and for European hub airports respectively. As shown in the figures, fares at Heathrow are on average higher than the other airports for all flights, including both short and long haul. However, the difference in fares is smaller for European hub airports than for other London airports with Paris Charles de Gaulle Airport having the fares closest to Heathrow.

Figure 11 Average OD fares at London airports in 2016



Source: Frontier Economics and IATA.

Figure 12 Average OD fares at European hub airports in 2016

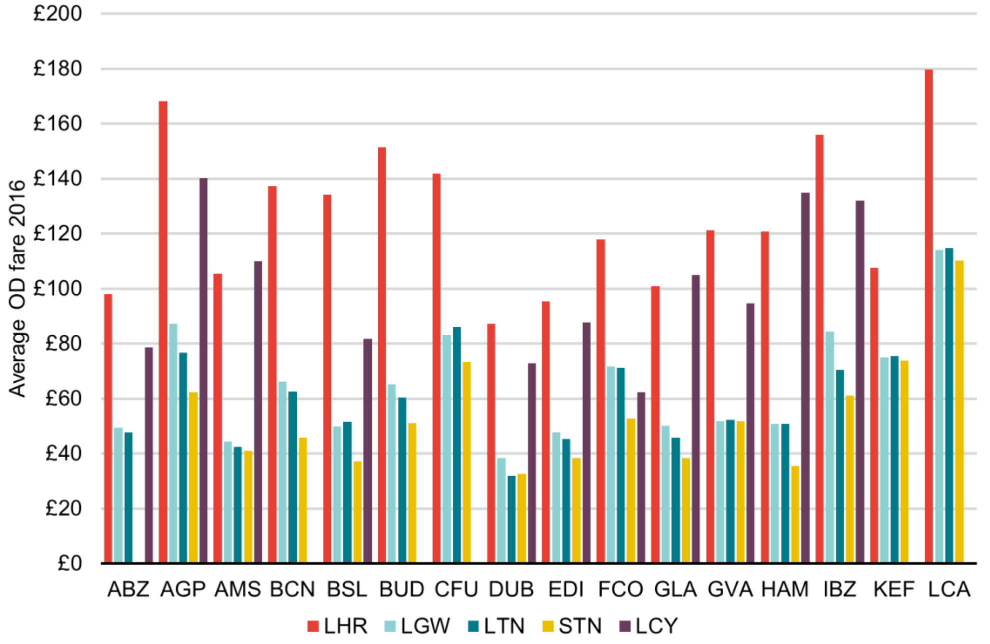


Source: Frontier Economics and IATA.

3.3.2 Overlap fare analysis

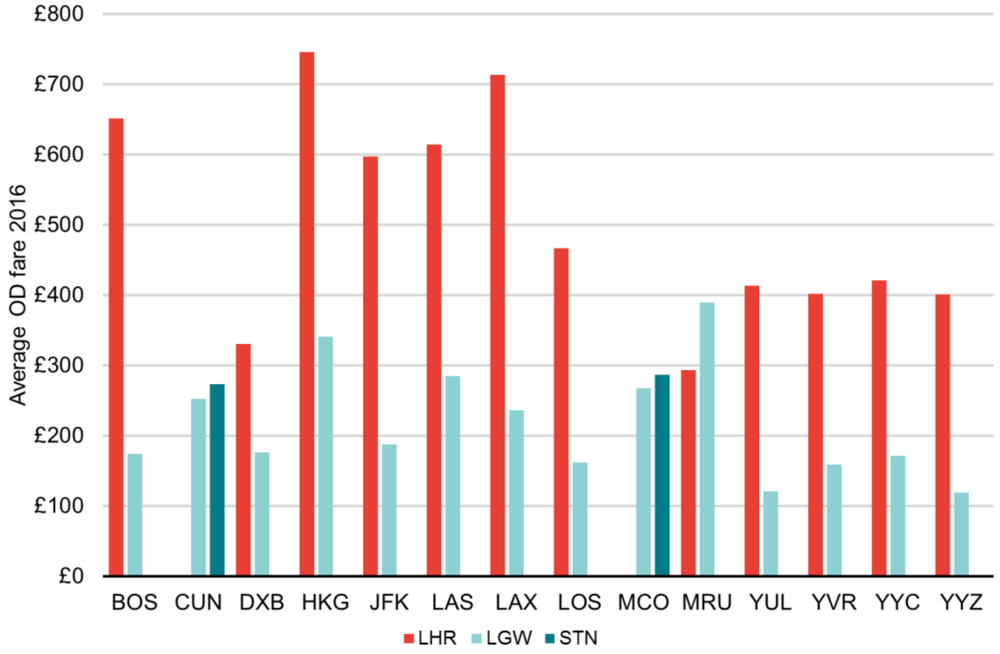
Similarly, we can consider fare differences between the airports on specific overlapping routes. Figure 13 and Figure 14 below compare fares on routes shared at the London airports for short haul and long haul routes respectively. As expected, Heathrow offers the most expensive fare for almost all of the overlaps, though the fare premium varies. Heathrow is not the most expensive to Hamburg, Lisbon and Zurich for short haul and to Mauritius for long haul.

Figure 13 Subset of short haul overlaps between London airports 2016



Source: Frontier Economics and IATA.

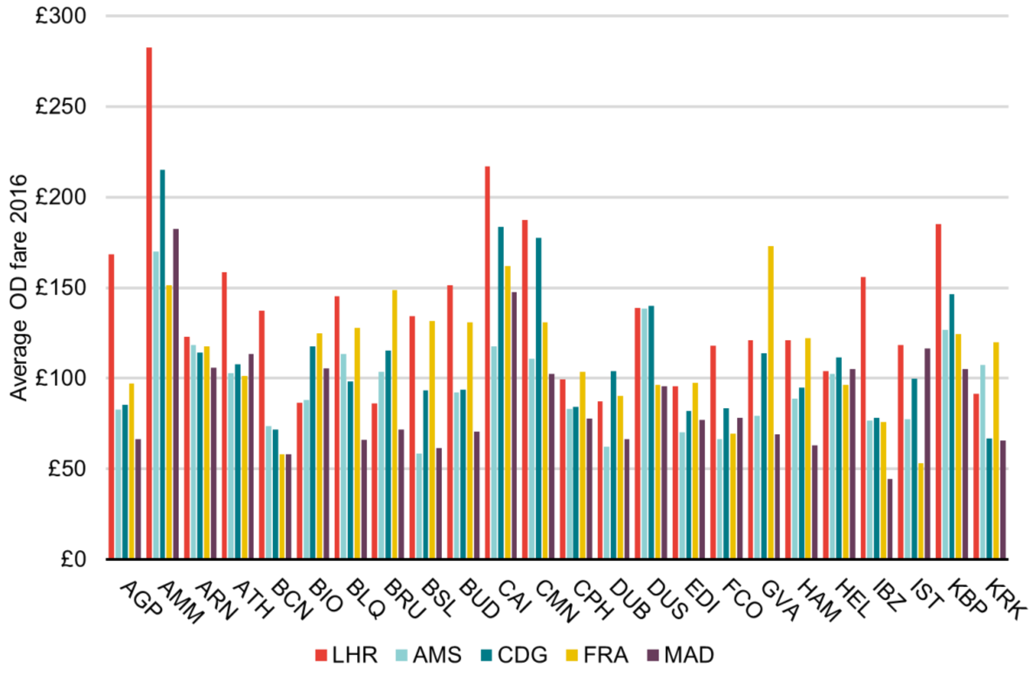
Figure 14 Long haul overlaps for London airports 2016



Source: Frontier Economics and IATA.

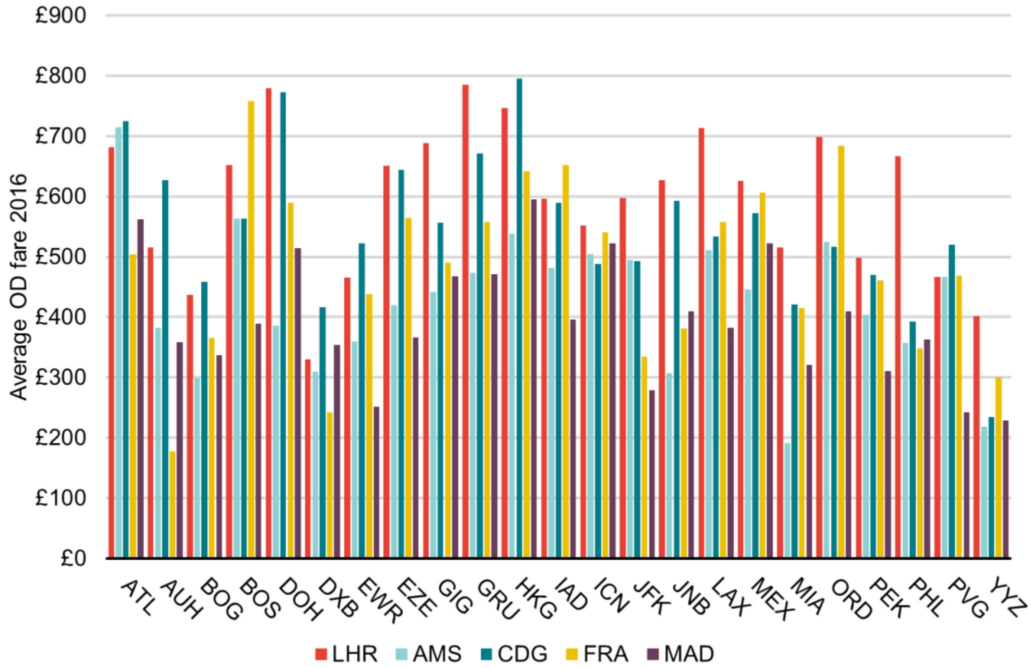
Figure 15 and Figure 16 below show the average OD fares for short haul and long haul overlapping routes respectively. While Heathrow often offers the most expensive fares, other airports, especially Paris Charles de Gaulle, also offer high fares that for some routes are even greater than the Heathrow fares. Thus, from graphical analysis alone, Heathrow appears to face a fare premium.

Figure 15 Subset of short haul overlaps between European hubs 2016



Source: Frontier Economics and IATA.

Figure 16 Long haul overlaps for European hubs 2016



Source: Frontier Economics and IATA.

3.4 Benefits of an expanded Heathrow

To determine the effect of congestion on ticket prices, we have undertaken a detailed econometric analysis of ticket prices at Heathrow compared to other London and European hub airports. Our analysis controls for other relevant factors that influence ticket prices including journey purpose, distance, frequency, and low cost carriers, meaning that the remaining difference between Heathrow fares and other airport fares can be interpreted as a premium resulting from Heathrow's congestion constraint. A full description of the econometric methodology and results from all sensitives can be found in Annex A.

As presented in Figure 17 and Figure 18, we estimated that in 2016, ticket fares at Heathrow were on average 23.3% higher than at other London airports and 24.4% higher than at other European hub airports due to the congestion premium. Put differently, because Heathrow is capacity constrained, passengers face higher ticket prices compared to both London and other European hub airports. On a return flight basis, this means that over the course of 2016, the congestion premium cost passengers at Heathrow roughly £2 billion.[17] Thus, even if the congestion premium remains stable in the future, the cost to passengers of Heathrow expansion could be offset in only eight years by alleviating the congestion premium.

Figure 17 Congestion premium results: London airport sample

Routes	2016 Estimates	2016 Range	2016 Range (£)
All flights	23.3%***	23.3%*** to 35.7%***	£59-£82
Short haul only	28.3%***	23.9%*** to 28.8%	£25-£29
Long haul only	9.44%	9.44% to 40.5%***	£43-£143

Source: Frontier Economics

Figure 18 Congestion premium results: European hub airport sample

Routes	2016 Estimates	2016 Range	2016 Range (£)
All flights	24.5%***	15.0%*** to 25.8%***	£41-£64
Short haul only	22.8%***	12.4%*** to 22.8%***	£14-£24
Long haul only	18.8%***	7.3% to 31.9%***	£34-£120

Source: Frontier Economics

To determine how the congestion premium varies by short and long haul flights, we have repeated the estimation of both equations on short and long haul flights separately for both flight samples. The results of this are also reported in Figure 17 and Figure 18.

From this analysis, it appears that both short and long haul flights face a significant and large premium of 22.8% and 18.8% respectively compared to other European hub airports.[18] This translates to £24 and £79 premium on a one-way flight compared to other European hub airports for short haul and long haul flights

[17] We assume that the congestion premium on inbound flights is equal to the premium on outbound flights. We apply the short haul premium of £28 to short haul flights and the mid-point of the long haul premium of £99 to long haul flights over short and long haul passengers respectively.

[18] As described on page 61 of the 2014 report "Impact of airport expansion options on competition and choice," the short and long haul congestion premiums need not lie between the average premium estimate due to the matrix estimations and covariances that are taken into account.

respectively. Thus, regardless of the type of flight from Heathrow, passengers face a congestion premium compared to other European hub airports.

Compared to other London airports, Heathrow faces a significant congestion premium on short haul flights of up to 28%, which is equivalent to a £28 premium on a one-way flight. For long haul flights, the results are less clear. At first glance, the premium on long haul flights appears smaller at 9.44% or £42 per one-way flight and statistically insignificant. However, this interpretation is not straight forward for three reasons.

First, the sample size for long haul flights is small, at only 126 observations. Thus, we should not expect to find a significant result due to the small sample size so we cannot conclude that there is not a premium on long haul flights. Second, Heathrow accounts for approximately 66% of all long haul observations making it more difficult to isolate the specific Heathrow effect. Finally, all of the regressions, but especially the long haul only regressions, are subject to multicollinearity. That is, the regressors are extremely correlated. For example, for long haul flights, 30% of passengers are transfer passengers at Heathrow while only 7% are transfer passengers at Gatwick, meaning that the transfer passenger variable is highly correlated with the Heathrow dummy variable. Because of the high correlation among regressors, the actual effect from the capacity constraint might not be picked up fully by the Heathrow dummy variable as our regression specifies. Thus, the premium on long haul flights may well be understated.

To determine whether our results are sensitive to multicollinearity, we test other sensitives to observe how the congestion premium estimates change. We use sensitivities that omit one variable at a time as well as run sensitivities including only observations for routes shared by at least two of the other London airports. From this analysis, we observe a range of long haul estimates from 9.8% to 40.5%. Thus, we can conclude that although the premium for long haul flights is difficult to estimate precisely, a premium clearly exists that could be as large as 40.5%, which is equivalent to a £143 premium on a one-way flight.

While our estimates on the congestion premium vary as shown by the ranges presented in Figure 17 and Figure 18, this does not cast doubt on our conclusion that Heathrow faces a congestion premium as a result of its restricted capacity. There does not exist a perfectly correct and unique model for this estimation as it faces problems such as multicollinearity as described above. Thus, testing different specifications and comparing the range of results is a robust method to ensure conclusions remain valid. In all cases, Heathrow's estimates show a large congestion premium that is statistically significant in most specifications, meaning that while the exact size of the estimate can be questioned based on the chosen model, a congestion premium clearly exists.

Furthermore, our estimate of Heathrow's congestion premium seems broadly in line with other analyses. For example, a 2013 report by PWC focusing on European airports found that when an airport becomes severely constrained, average fares increase by 18%.[19] A 2017 report by SEO Amsterdam Economics found that on average congestion premiums cost passengers in Europe €5.65 for a return flight

[19] PWC (2013). Fare differentials. Analysis for the Airports Commission on the impact of capacity constraints on air fares.

in 2014.[20] However, as this is an average figure, they note that the relationship between capacity constraints and air fares is likely to be exponential with excessively higher air fares at the most congested airports. Thus, as the most constrained airport in Europe, Heathrow is likely to have a much higher premium.[21]

3.4.1 Heathrow's capacity constraint over time

While we find that Heathrow has a congestion premium on all routes in comparison to both other London airports as well as other European hub airports, we can also compare our 2016 estimates to 2012 estimates to see how the congestion premium has developed over time. Figure 19 and Figure 20 show the 2012 and 2016 estimates for the London and European hub samples respectively.

Figure 19 Congestion premium over time: London airports

Routes	2012 Estimates	2016 Estimates
All flights	18.0%***	23.3%***
Short haul only	-4.3%	28.3%***
Long haul only	16.8%	9.44%

Source: *Frontier Economics and "Impact of airport expansion options on competition and choice" (2014).*

Note: **** means the result is statistically significant at the 1% level. ** means significant at the 5% level. * means significant at the 10% level.*

Figure 20 Congestion premium over time: European hub airports

Routes	2012 Estimates	2016 Estimates
All flights	23.8%***	24.5%***
Short haul only	22.9%***	22.8%***
Long haul only	20.3%***	18.8%***

Source: *Frontier Economics and "Impact of airport expansion options on competition and choice" (2014).*

Note: **** means the result is statistically significant at the 1% level. ** means significant at the 5% level. * means significant at the 10% level.*

As shown in the tables, since 2012, the overall congestion premium at Heathrow has increased. Compared to the other London airports, the premium is approximately 5% higher in 2016, and compared to European hubs, the premium is almost 1% higher. In terms of actual fares, this translates from a one-way mark-up on the average ticket price of £45 in 2012 to a one-way mark-up of £59 in 2016.[22] Additionally, it appears that compared to other London airports, short haul flights at Heathrow have become constrained since 2012, as in 2016, there is a large and statistically significant congestion premium. Finally, compared to other European hub airports, short haul flights face a similar premium in 2016 as in 2012 while the premium on long haul flights has decreased by about 1.5%.

We can also use DfT demand forecasts and the price elasticity of demand to estimate that if Heathrow remains constrained without an additional runway, by 2030, ticket fares at Heathrow should be 50% higher than they are currently, which

20 SEO Amsterdam Economics (2017). The impact of airport capacity constraints on air fares.

21 In addition the SEO report takes its measure of congestion as the ratio of capacity utilisation. Hence it does not necessarily measure "excess demand" at all. Arguably it is only a measure of the additional costs imposed on airlines by operating at very busy airports, which is a different issue.

22 *Frontier Economics and "Impact of airport expansion options on competition and choice" (2014).*

corresponds to a one-way price increase of £64 and £247 for short and long haul flights respectively. Across all estimated passengers, this corresponds to a congestion premium cost of roughly £8 billion in 2030 valued in 2016 GBP.[23] This means that in the future without expansion, the effect of congestion on ticket prices will only grow larger.

3.5 Benefits of an expanded Gatwick

We have undertaken the same econometric analysis for Gatwick and found that, as in 2012, there is still no evidence that ticket prices are higher than the average fares from other London airports after controlling for all relevant factors such as trip purpose, low cost carriers, and distance. As shown by Figure 21, the estimated congestion premium is small in magnitude and negative for all flights and short haul flights and is small in magnitude but positive for long haul flights. However, in all cases the estimates are not statistically different from zero. This implies that the reduction in ticket prices from releasing the constraint at Gatwick would be non-existent today.

Figure 21 Gatwick congestion premium estimates

Routes	2016 Estimates
All flights	-2.6%
Short haul only	-1.3%
Long haul only	3.2%

Source: Frontier Economics.

*Note: *** means the result is statistically significant at the 1% level. ** means significant at the 5% level. * means significant at the 10% level.*

However, as Gatwick's constraint will continue into the future without expansion, we have applied the same methodology as for Heathrow to identify the impact of the constraint at Gatwick in 2030. We have used the DfT demand forecast to calculate the difference between unconstrained and constrained demand at Gatwick in 2030 and have applied the same price elasticity of demand. Using this approach, we find that by 2030, fares at Gatwick would be 32% higher than today, which is equivalent to a £24 and £83 increase in one-way fares for short and long haul flights respectively. Across all estimated passengers, this corresponds to a congestion premium cost of roughly £1 billion in 2030 valued in 2016 GBP.[24] Thus, the benefits for passengers from expanding Gatwick continue to be lower in the future compared to the benefits of expanding Heathrow.

[23] This figure corresponds to multiplying the estimated premiums of £64 and £247 by DfT's estimated passengers at a 2 runway Heathrow in 2030 (86 million) after removing 36% of passengers which are transfer and accounting for the proportion of short and long haul passengers based on 2016 figures. Thus, this figure is not a discounted value over time but is the actual cost in 2030 valued in 2016 GBP. .

[24] This figure corresponds to multiplying the estimated premium of £24 and £83 by DfT's estimated passengers at a non-expanded Gatwick in 2030 (45 million) after removing 8% of passengers which are transfer and accounting for the proportion of short and long haul passengers based on 2016 figures. Thus, this figure is not a discounted value over time but is the actual cost in 2030 valued in 2016 GBP.

3.6 Comparing Heathrow and Gatwick Expansion

Considering the effects of capacity constraints on ticket prices, we conclude that expanding Heathrow Airport would provide greater benefits to passengers than expanding Gatwick Airport. In particular, we have demonstrated the following:

- While expanding Gatwick would have some impact on the prices at Heathrow, the same applies in reverse. Overall, the effect of a Heathrow Airport expansion on ticket prices is larger than the impact of a Gatwick expansion on prices.
- Releasing the capacity constraint at Heathrow today (if it were possible) would result in a reduction of one-way ticket prices of 23%. In contrast, additional capacity at Gatwick today would not reduce ticket prices.
- Expanding Heathrow Airport in 2030 would result in a reduction in one-way ticket prices of £64 and £247 for short and long haul flights respectively compared to a reduction in ticket prices as a result of Gatwick Airport expansion of £24 and £83 for short and long haul flights respectively. Across all estimated passengers in 2030, this corresponds to a congestion premium cost of roughly £8 billion and £1 billion at Heathrow and Gatwick respectively.

4 CONNECTIVITY AND CATALYTIC BENEFITS

In this section we summarise the results of our analysis to estimate the long haul connectivity benefits of expanding Heathrow and Gatwick and to quantify the catalytic impact of each option.

4.1 Connectivity analysis

4.1.1 Heathrow is the UK's key gateway to long haul markets

The AC set out the importance of the UK maintaining its international hub status and of the need to provide extra capacity to connect to long haul markets.

Figure 22 The AC recommended Heathrow because it is best for long haul

2012

"We are responsible for recommending options for **maintaining the UK's status as an international hub for aviation**. We will assess the environmental, economic and social costs and benefits of various solutions to increase airport capacity - considering operational, commercial and technical viability

2015

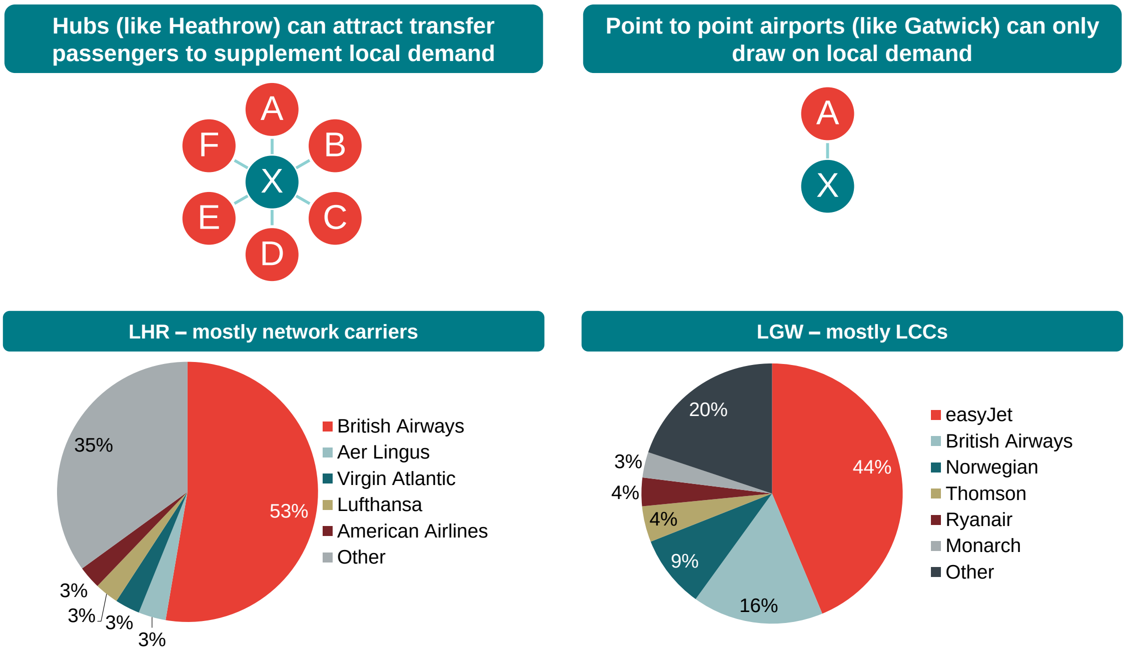
"At the end of this extensive work programme our conclusions are clear and unanimous: **the best answer is to expand Heathrow**'s capacity through a new northwest runway. Heathrow is best-placed to provide the type of capacity which is most urgently required: **long haul destinations to new markets**.

Source: Airports Commission

The hub and spoke model provides a boost to long haul connectivity. Network carriers operating at hubs attract transfer passengers which supplement the O/D demand, thereby increasing the total demand for individual flights. For some more marginal destinations, this extra demand may make the difference between a connection being viable, or not being viable and therefore not being provided.

The vast majority of airlines at Heathrow are network carriers, whereas Gatwick is dominated by low cost carriers (LCCs). The hub and spoke model requires airlines to coordinate arrivals and departures across the network, with a wave of short haul arrivals typically preceding a wave of long haul departures. LCCs tend to not provide connecting services, and prefer instead to concentrate on having short turnaround times and operating as many rotations as possible per day, with little regard for coordinating the timing of departures and arrivals across different routes.

Figure 23 The hub and spoke model boosts long haul connectivity



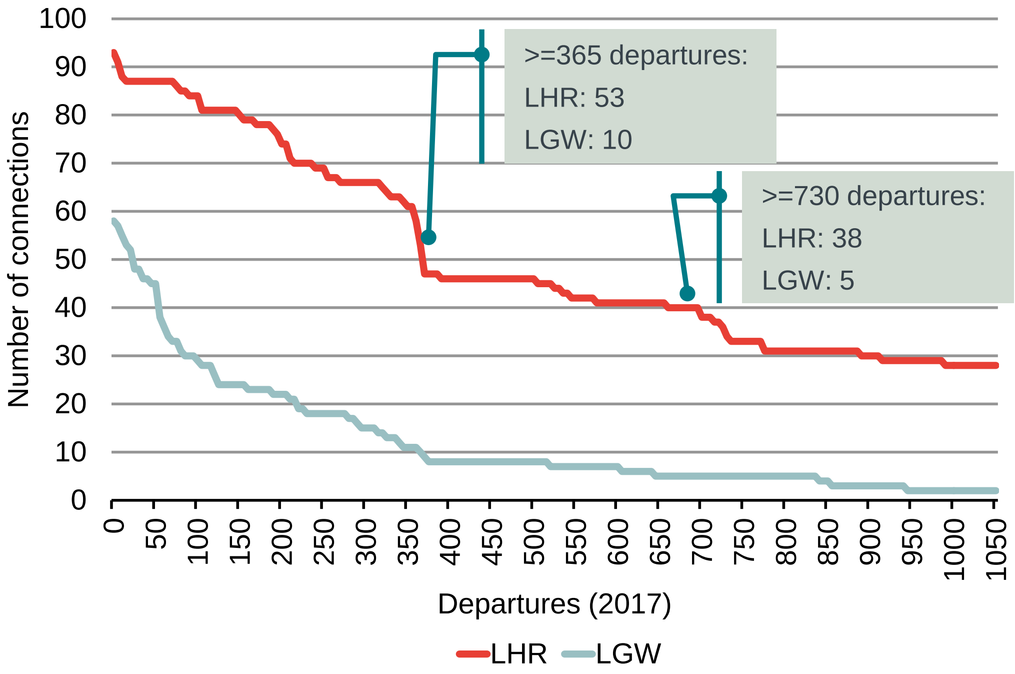
Source: Frontier analysis based on 2017 schedules data from OAG Analyser

It is for this reason that Heathrow has emerged as the UK's key gateway to long haul markets. There are a grand total of 115,000 long haul departures scheduled across all UK airports in 2017. Around 75% are at Heathrow. Only 11% are at Gatwick.

Gatwick states that it serves more than 50 long haul destinations.[25] However, this statistic overlooks frequency. As illustrated below, if we only count long haul destinations that have at least 365 departures scheduled in 2017 (i.e. on average at least daily), Heathrow has 53 long haul connections, and Gatwick only has 10. If we increase this frequency threshold to at least 730 departures in 2017 – equal to twice daily on average – Heathrow has 38 and Gatwick has 5.

[25] For example, see Gatwick's press release from 2016: http://www.mediacentre.gatwickairport.com/press-releases/2016/2016-03-10-gatwick-to-launch-20-new-long-haul-routes-this-year.aspx

Figure 24 Gatwick claims to serve more than 50 long haul destinations but this overlooks frequency

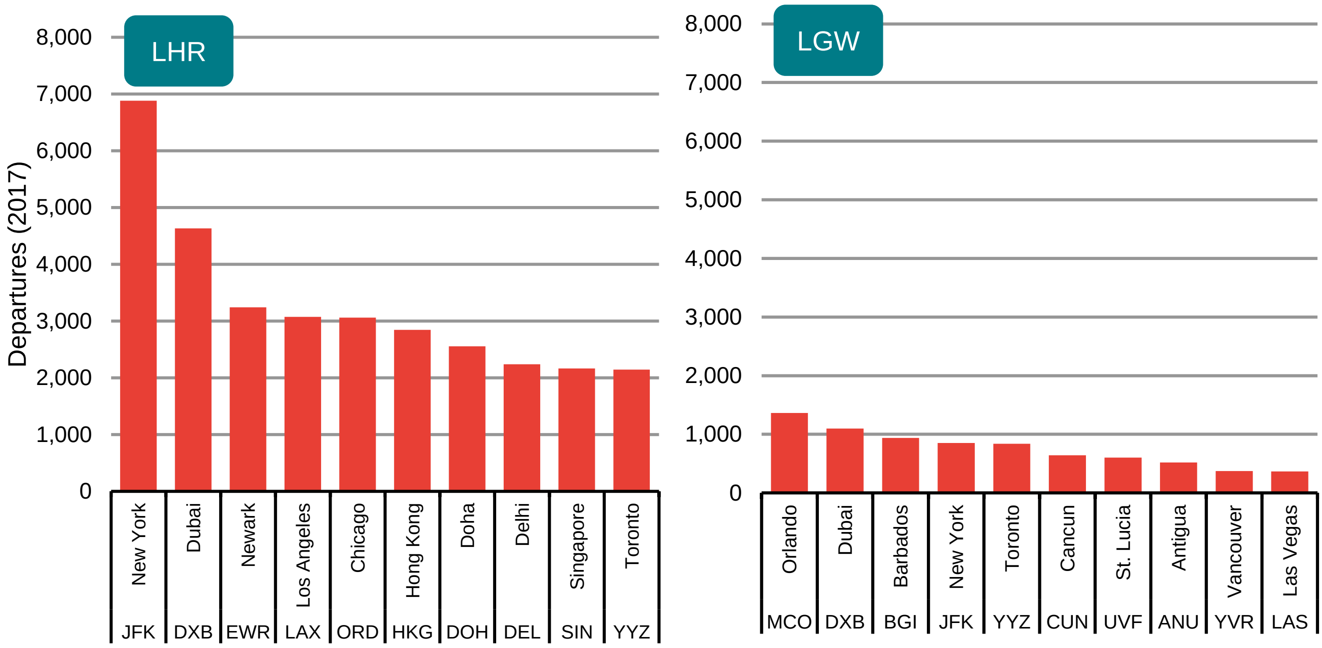


Source: Frontier analysis based on 2017 schedules data from OAG Analyser

If we count all destinations regardless of frequency, then Gatwick does serve nearly 60 long haul destinations. However, by way of illustration, this includes Krabi, Thailand which has just two departures scheduled for the whole of 2017.

Gatwick's long haul connections are less frequent than those at Heathrow, and they tend to be to leisure destinations. Gatwick's top 10 most frequent long haul destinations include Orlando (which is its most frequent with around 3.7 departures per day on average), Barbados, Cancun, St Lucia, Antigua and Las Vegas.

Figure 25 Top 10 most frequent long haul destinations at Heathrow and Gatwick in 2017



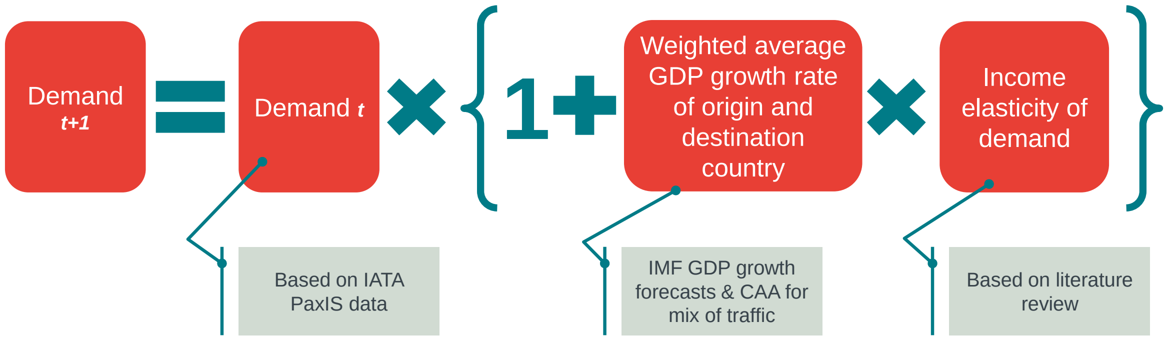
Source: Frontier analysis based on 2017 schedules data from OAG Analyser

4.1.2 Forecasting new long haul connections

We have estimated the number of new long haul connections which could be added in the future following expansions at Heathrow and Gatwick. This is based on analysing 2016 PaxIS data on passenger flows at both airports.

We have extrapolated demand at the route level at each airport individually by multiplying current demand by a growth rate which takes into account the forecasts for GDP growths of the origin and destination countries and income elasticities of demand.

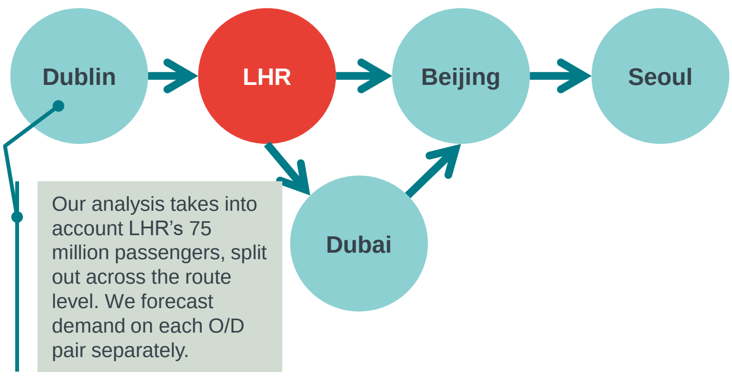
Figure 26 We extrapolate demand at the route level



The analysis below provides a worked example for O/D passengers flying between Heathrow and Beijing, China (PEK).

Figure 27 Worked example LHR-PEK

We can observe a detailed breakdown of demand



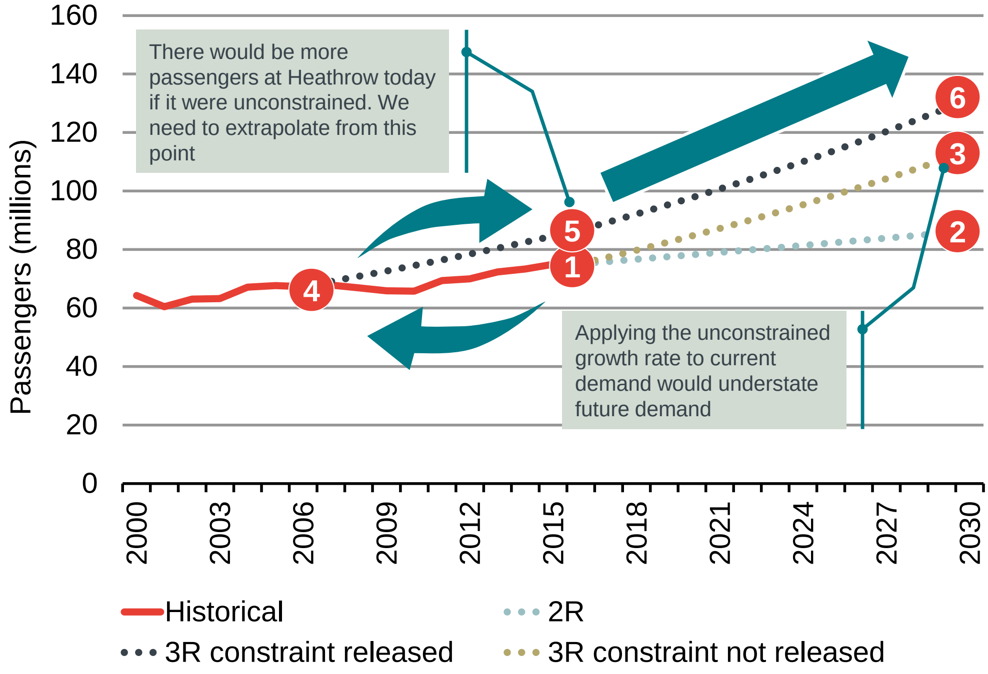
Example: LHR-PEK O/D

	Value	Source
UK GDP growth forecast	1.7%	IMF
China UK GDP growth forecast	6.0%	IMF
Share of UK demand	54%	CAA
Weighted average GDP growth forecast	3.7%	
Income elasticity of demand	1.39	IATA
Annual unconstrained growth forecast	**5.1%**	

Source: Frontier analysis

However, in the case of forecasting demand at Heathrow, because it is constrained, we need to ensure that we are extrapolating from an unconstrained starting point. Or in other words, if we applied the unconstrained growth rate to current passenger volumes we would be understating future demand. Therefore, we first need to estimate where demand would be today if Heathrow were not constrained. To do this, we have first considered demand at Heathrow in 2006 (the year Heathrow first became constrained). Since this point, demand has only grown at a constrained rate. Therefore, we have applied the historical unconstrained growth rates (e.g. the same approach described above but using historical GDP growth rates) to volumes in 2006 back to the present day. Having estimated unconstrained demand today, we have then extrapolated from this point. This approach is illustrated below.

Figure 28 We need to extrapolate from an unconstrained starting point



Source: Frontier analysis

We have not performed the same calculation for Gatwick because it was not constrained during this period – as evidenced by its recent growth from 39.6 million passengers in 2015 to 42 million passengers in 2016 (6%).

We have used 2030 as the focus year in our analysis. This is because the DfT has forecasted that an expanded Heathrow would be constrained by around this time, and therefore demand can only grow at unconstrained rate up to this point. Our forecasts are in line with estimates from the DfT, and the underlying growth forecasts are broadly in line with those from Airbus and Boeing as shown in Figure 29.

Figure 29 Our forecasts are broadly in line with those from other sources

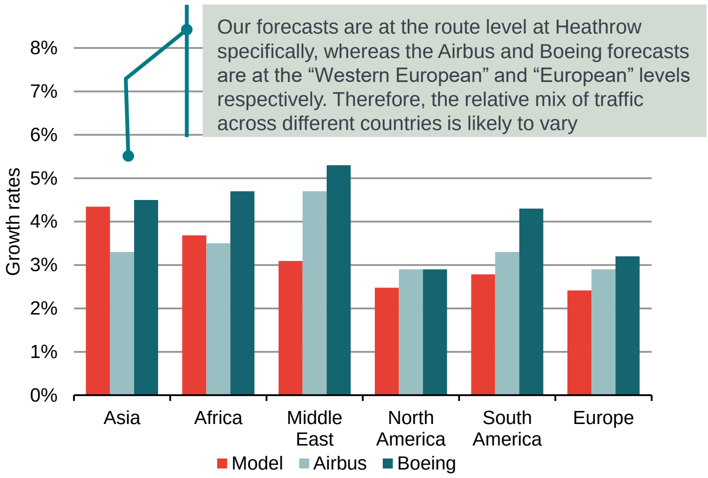
In 2030, we forecast 86 million passengers at LHR 2R and 132 million passengers at LHR 3R. This is in line with the DfT's forecasts

Our implied growth rates are also broadly in line with those from Airbus and Boeing

Table 34 Passenger demand by airport, central demand, mppa

	2030			
	Baseline	LGW 2R	LHR ENR	LHR NWR
Gatwick	45	58	45	45
Heathrow	86	85	125	132
London City	6	7	5	4
Luton	18	18	18	18
Stansted	31	25	23	22
London total	187	192	216	222
Birmingham	18	18	16	15
Bristol	10	9	9	9
East Midlands	6	6	7	7
Edinburgh	13	13	13	13
Glasgow	12	12	12	12
Liverpool	4	4	5	5
Manchester	31	31	30	29
Newcastle	5	5	5	5
Larger regional airport total	98	97	95	94
Other regional	28	27	27	27
Total outside London	126	124	122	121
Total	313	317	337	343

Weighted average O/D demand by global region – annual growth



Source: *Frontier analysis of data from the DfT UK Aviation forecasts 2017; Airbus Global market forecast 2017-2036; and Boeing Current Market Outlook 2017*

Next, we have considered the volume of 'beyond' passengers at each airport flying to destinations which are currently not served by direct flights. Beyond passengers are O/D passengers who depart an airport and fly indirectly to their final destination (and are counted as transfer passengers at the connecting airport). If there are a sufficiently high number of passengers flying indirectly to a given destination, there could be enough demand to justify adding a new connection.

However, we do not assume that all beyond passengers would switch to a new direct connection. For example, in 2016 at Heathrow, 22% of O/D passengers flying to long haul destinations where a direct connection does exist still chose to fly indirectly. At Gatwick, the corresponding figure is 5%. This is largely because indirect ticket fares tend to be cheaper than direct fares. Therefore, to estimate the potential O/D demand for a new direct connection we have multiplied the total beyond demand by a switching factor of 78% at Heathrow and 95% at Gatwick.

In assessing beyond passengers, we have considered demand at Heathrow and Gatwick separately, rather than pooling them together. This is because – as discussed in the next subsection – we believe that there is no evidence to suggest that demand at a Heathrow would 'overflow' to Gatwick.

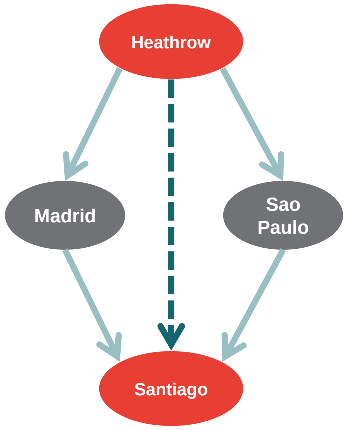
We have then considered potential additional demand from transfer passengers. According to the 2016 CAA Passenger Survey, 36% of passengers at Heathrow were transfer passengers in 2016. At Gatwick, the corresponding figure was 8%.[26] Therefore we have applied an uplift to the O/D beyond demand assumed to switch to the direct connection.

[26] CAA Passenger Survey Report 2016 https://www.caa.co.uk/uploadedFiles/CAA/Content/Standard_Content/Data_and_analysis/Datasets/Passenger_survey/CAA%20Passenger%20Survey%20Report%202016.pdf

A walked-through example of our approach, using the case of Santiago, Chile is set out below. This analysis is based on 2016 PaxIS data. In 2017, BA announced a new connection to Santiago – suggesting that the approach has some predictive power.

Figure 30 Worked example – Santiago, Chile

- In 2016, **33,000** O/D passengers flew indirectly from LHR to Santiago, Chile.
- We estimate that if LHR were unconstrained there would have been around **41,000** passengers.
- We estimate future unconstrained growth at **3%** per year.
- By 2030 demand would increase to around **63,000** O/D passengers.
- At LHR, where direct long haul connections exist **22%** of O/D passengers still choose to fly indirectly. Therefore, we would expect that **49,000** passengers would switch to a direct flight if it were added.
- Also, transfer passengers represent **36%** of passengers at Heathrow. Therefore, we estimate a further **28,000** transfer passengers would fly on the route.
- This brings total demand to around **77,000** passengers per annum.



Source: Frontier analysis based on 2016 PaxIS data

Finally, we assume a new connection is added if the potential demand for a direct flight (O/D plus transfer) is greater than a passenger threshold. Clearly, the threshold depends on the assumed frequency of the new flight. At Heathrow in 2016, the average long haul departure carried around 220 passengers. We have assumed that average load per departure increases by 1%, which is broadly in line with the increase since 2006. Therefore, by 2030, a daily long haul connection could be expected to carry around 90,000 passengers. A twice weekly connection could be expected to carry 26,000.

The chart below sets out the long haul connections which we estimate could have enough demand to satisfy at least a twice-weekly connection.[27] This does not include new connections at Heathrow which already exist at Gatwick today – e.g. we also identified Orlando and Havana as potential new long haul connections at Heathrow but they are already available at Gatwick today.

[27] Different frequency thresholds could be applied, where clearly the higher the threshold, the lower the number of connections that meet the definition and vice versa. Analysis of schedules data at Heathrow and Gatwick over the period 2010-2017 suggests that when a new long haul connection was added at Heathrow the frequency was about 2.6 times per week on average, and about 1.0 times per week on average at Gatwick.

Figure 31 We estimate that an expanded Heathrow could add over 40 long haul connections by 2030

Source: Frontier analysis

Note: Heathrow to Australasia is over 9,000 miles. However, we note that Qantas has announced plans to start a non-stop flight from Heathrow to Perth in 2018, suggesting that over time very long haul distances may be achievable.

Whereas for Heathrow we identified over 40 new long haul connections, for Gatwick, we identified just two connections:

- St George's, Grenada; and
- Port of Spain, Trinidad & Tobago.

(We also identified Bangkok, Thailand. However, this connection already exists at Heathrow). The table below summarises our results.

Figure 32 New connections following expansion

	Twice weekly
LHR 3R	46
LGW 2R	2

Source: Frontier analysis

The results clearly show a large gap in long haul connectivity benefits between an expansion at Heathrow versus Gatwick.

We note that this approach is conservative. The new connections would likely stimulate additional O/D demand (above and beyond the volume assumed to switch from indirect routings) – i.e. passengers who only choose to fly because there is a direct connection and who would not have flown otherwise. However, to be conservative we have not included this demand in our analysis.

4.1.3 "Why can't the new connections at Heathrow just fly from Gatwick instead?"

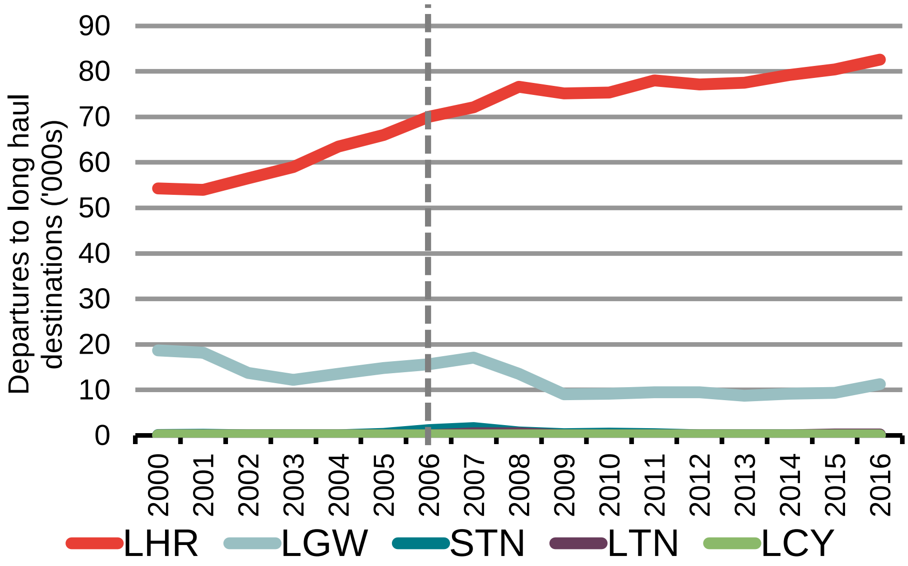
It could be argued that the 40+ new long haul connections identified at Heathrow could simply fly from Gatwick instead. After all, these would be new connections for London. However, we do not believe this is valid.

First, Heathrow attracts a significantly larger volume of transfer passengers than Gatwick (c36% of total passengers at Heathrow versus only 8% at Gatwick), meaning that even if all other things were equal, demand would be higher at Heathrow than at Gatwick.

Secondly, there is limited evidence to suggest that underserved O/D demand at Heathrow would 'overflow' to Gatwick. Heathrow has been constrained for over 10 years and Gatwick has had spare capacity during this time. Therefore, we might have expected to see an increase in long haul connectivity at Gatwick. However, in this time, long haul has failed to develop in any real significance at Gatwick.

In fact, since 2006, Gatwick has actually seen a decrease in the total number of long haul departures – from nearly 16,000 in 2006 to only 13,000 scheduled in 2017. And there has actually been an increase at Heathrow over the same period from 70,000 long haul departures in 2006 to 83,000 departures in 2017 – despite being constrained. Clearly, this has come at the cost of squeezing out some short haul traffic. If this continues, it runs the risk of disturbing the balance between short haul and long haul that airlines need to operate a successful hub and spoke model.

Figure 33 Long haul has not taken off at Gatwick



Source: Frontier analysis based on schedules data from OAG Analyser

It is difficult to argue that passengers are indifferent between London airports when there a congestion premium at Heathrow and spare capacity at other London airports.

New and lost long haul connections

We have analysed schedules data at the route level at Heathrow and Gatwick over the period 2010-2017 to identify the change in the number of long haul connections at each airport.

Figure 34 The change in the number of 'frequent' long haul connections at Heathrow and Gatwick[28]

	Heathrow	Gatwick
New long haul connections	18	11
Lost long haul connections	8	11
Net change	+10	0

Source: Frontier analysis based on schedules data from OAG Analyser

The results show that despite there being capacity constraints at Heathrow and spare capacity at Gatwick, Gatwick did not see an increase in its number of long haul connections, while Heathrow actually saw an increase.

Figure 35 Gatwick lost 11 long haul connections over the period 2010-2017

Source: Frontier analysis based on schedules data from OAG Analyser

Note: In addition to the 11 'frequent' connections which were lost, Gatwick also lost direct connections to Hanoi and Ho Chi Minh City (but they did not meet the ">=100 departures" threshold). Incidentally these routes were switched to Heathrow and then became more frequent. Gatwick also had a connection to Jakarta – but it had a scheduled stop over at Amsterdam along the way. However, this was also lost at Gatwick, and switched to Heathrow where it became a direct connection.

[28] In assessing which long haul routes have been added we have only considered routes which went from having zero departures in one year to at least 100 departures in later years. For lost connections, we have only considered routes which went from having at least 100 departures in one year, and then zero departures in later years. Applying this threshold weeds out routes which were served with only very low frequency. For example, there are some routes which had just one departure in a year.

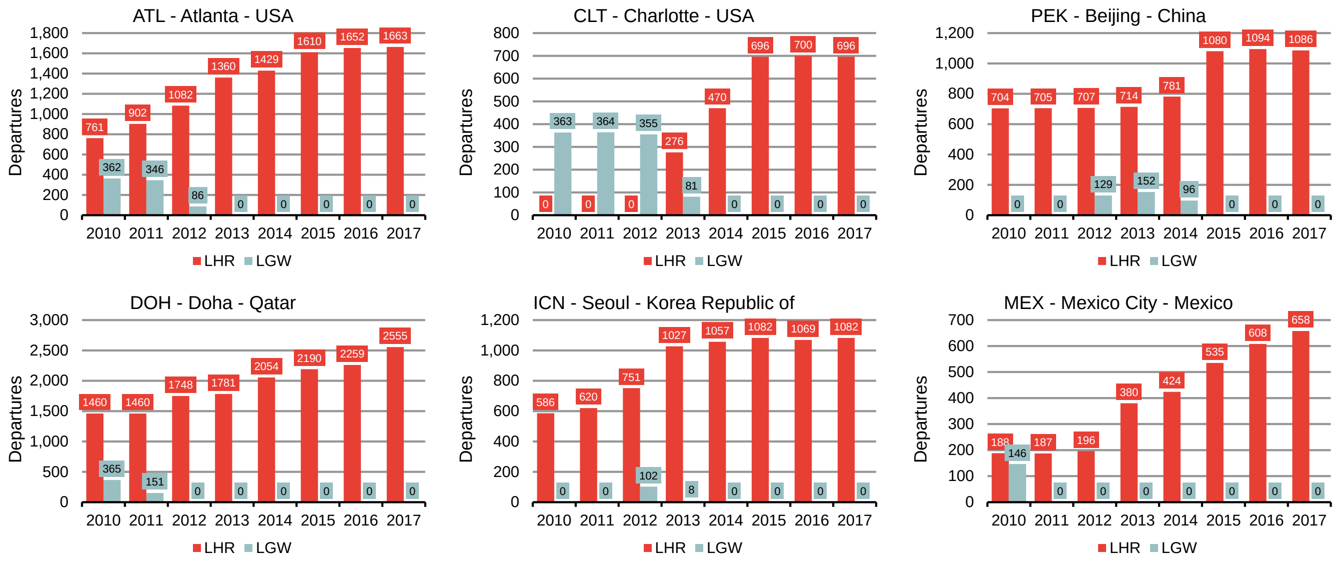
The details of the lost connections at Gatwick highlight that it struggles to sustain long haul connectivity. Many of the lost connections at Gatwick were switched to Heathrow, where airlines can attract a greater volume of transfer passengers.

For example, US Airways [later American] operated a daily connection between Gatwick and Charlotte Douglas, North Carolina. However, this was switched to Heathrow in 2013 and later became a twice-daily connection:

- "From our perspective, if you look at the portfolio of flying we already do to Heathrow, it made a lot of sense," Chuck Schubert, American's vice president of network planning [American subsequently merged with US Airways. American is also a member of oneworld, alongside BA].
- "Our new daily flight between our Charlotte hub and Heathrow connects customers in markets throughout the East Coast to London's preferred business and tourism hub." Suzanne Boda, US Airways Senior vice president

Other examples are illustrated below.

Figure 36 Many of the lost connections at Gatwick switched to Heathrow and became more frequent



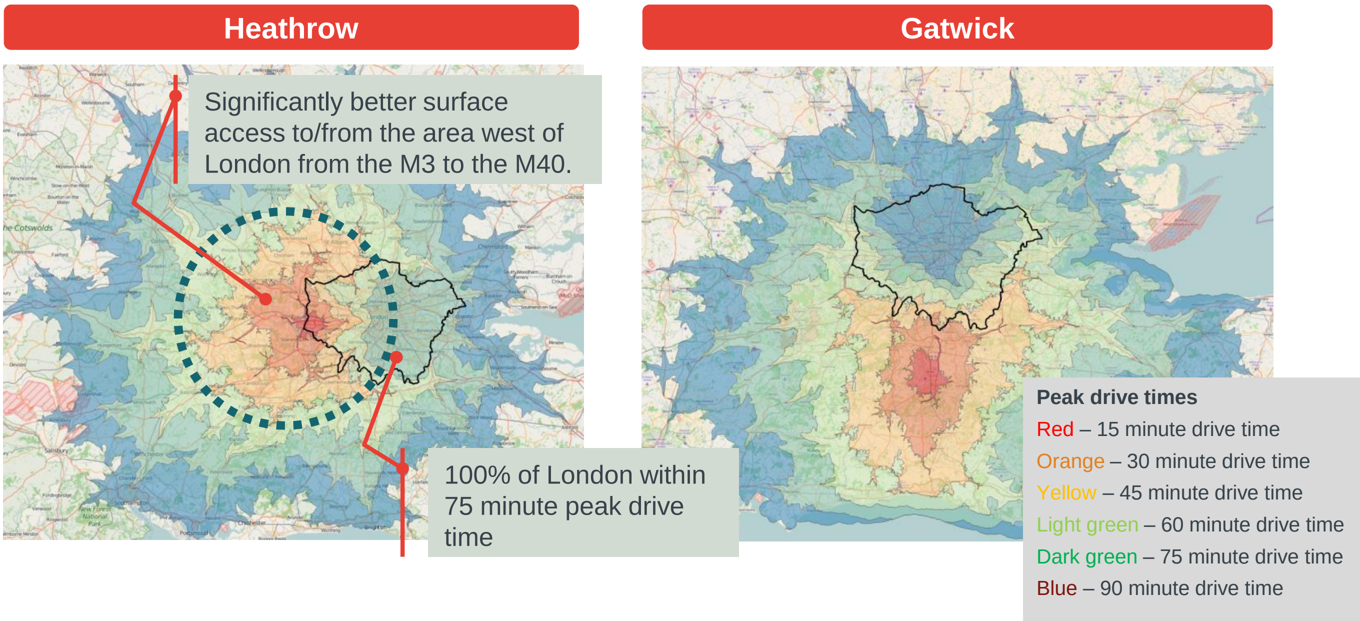
Source: Frontier analysis based on schedules data from OAG

This highlights that airlines are unwilling to develop long haul operations at Gatwick.

Heathrow is best placed to serve London demand

In addition to being a hub airport, Heathrow also benefits from having better surface access links than Gatwick. 100% of London lies within a 75 minute peak drive time of Heathrow. However, for Gatwick, large parts of north London lie beyond a 75 minute peak drive time.

Figure 37 Heathrow is best placed to serve London demand



Source: Quod

Heathrow is accessible on the Piccadilly Line, and the upcoming Elizabeth Line / Crossrail. (There are also tentative plans for a new connection between Heathrow and Old Oak Common, with Old Oak Common being a station on HS2 that will provide a high speed rail connection from London to Birmingham and then on to Manchester, Sheffield and Leeds). Additionally, the Heathrow Express provides a quicker service to central London (15 minutes to Paddington) than the Gatwick Express (30 minutes to Victoria). These points combined suggest that Heathrow will continue to be best placed to serve London demand – and beyond.

The concept of generalised travel cost (GTC) argues that when passengers consider whether to fly, they take into account ticket fares and the monetised value of travel time. Therefore, all other things being equal, given that Heathrow is more conveniently located and accessible than Gatwick, we would expect O/D demand to be greatest under a Heathrow expansion scenario.

4.1.4 Split hubs deliver inferior connectivity outcomes

Given that hub airports provide a boost to long haul connectivity, it could be argued that an expanded Gatwick could also develop into a hub. For example, Heathrow could operate as the long haul hub for the Americas, and Gatwick could operate as the long haul hub for the rest of the world. At first glance, this may sound like a sensible option. However, there are several short comings with a two-hub or split-hub model.

- Intercontinental transfers would not be possible: The first issue with such an approach is that it would not provide for intercontinental transfers – e.g. passengers wishing to connect from North America to Africa. In 2016 at Heathrow, over 3.5 million transfer passengers flew between the Americas and rest of the world destinations (excluding Europe). And by 2030, we estimate that, without capacity constraints, there could more than 10 million passengers flying on these routes. Therefore, a Heathrow expansion would be able to attract more transfer passengers than a Gatwick expansion. This will increase the overall demand for individual routes, and will provide the UK with more direct connections. Clearly this a benefit to O/D demand in the UK, (as well as to transfer passengers who may have more convenient connections via Heathrow).

Some routes are only viable because of these passengers. For example, in 2016, nearly 70% of all passengers flying on the connection from Heathrow to Hyderabad were transfer passengers from North America. The Hyderabad connection is daily, and clearly it would not be possible (at least at the same frequency) without this demand. Losing this route would represent a weakening of connectivity for O/D passengers and ultimately be a loss for the UK.

Other routes may still survive even without these transfer passengers. However, because total demand would be lower without these passengers, frequency would therefore have to be reduced. This too would represent a weakening of connectivity for O/D passengers who would lose the flexibility and choice of having multiple frequencies.

- Short haul routes would have to be duplicated: Under the split hub model, European connections would have to fly to both Heathrow and Gatwick – otherwise not all long haul connections would be possible. E.g. passengers wishing to fly from Inverness to the US would need to fly via Heathrow, and passengers wishing to fly from Inverness to Asia would need to fly via Gatwick. Similar to the above, some marginal routes may not have enough demand to support two separate routes. And those which did would still have a reduction in frequency.

We have repeated the analysis above to model the number of long haul connections which would be possible under the split hub approach.

Figure 38 New long haul connections under different expansion scenarios (twice weekly frequency)

	LHR 3R	LGW 2R	Split hubs
Long haul	46	2	26

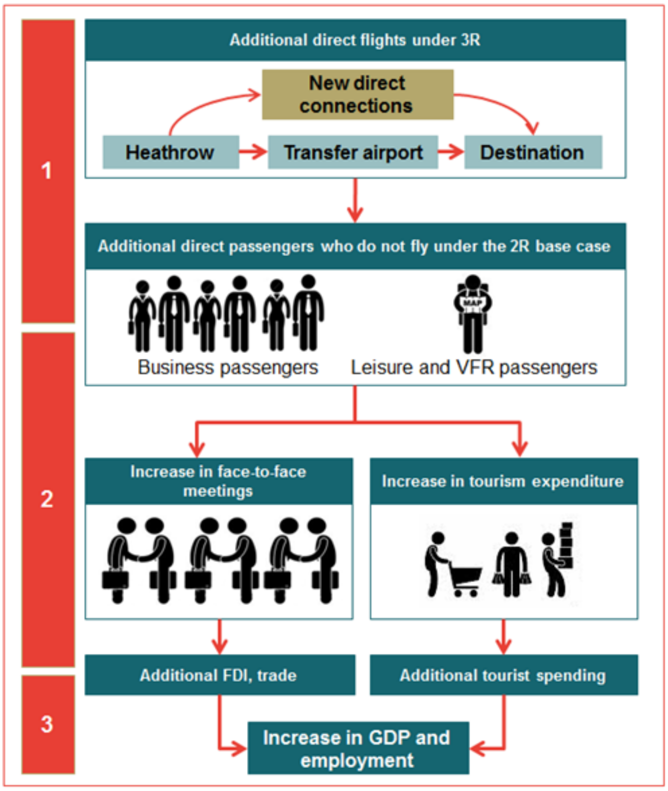
Source: Frontier analysis

The results highlight that a split hub scenario would be an inferior outcome compared to a Heathrow expansion. This is driven by the fact that the system as a whole would lose a considerable volume of transfer passengers. The results are also likely to be an overestimate because the analysis implicitly assumes that O/D demand will fly from Gatwick – e.g. if all long haul connections to Asia are moved to Gatwick that the O/D demand will follow. However, as set out in the previous subsection, we consider this to be a stretch.

4.2 Catalytic impact

The logic behind 'catalytic' impacts is that if Heathrow were to expand, more passengers would be able to fly directly to their final destination. Given that this is quicker and more convenient than flying indirectly, this would lead to an overall increase in O/D demand – or in other words, some passengers would only chose to fly because there is a direct connection. This in turn would lead to an increase in the number of face to face business meetings, and consequently facilitate more trade, foreign direct investment and tourism – and ultimately GDP. This is illustrated below in Figure 39, which provides greater detail on the underlying methodology.

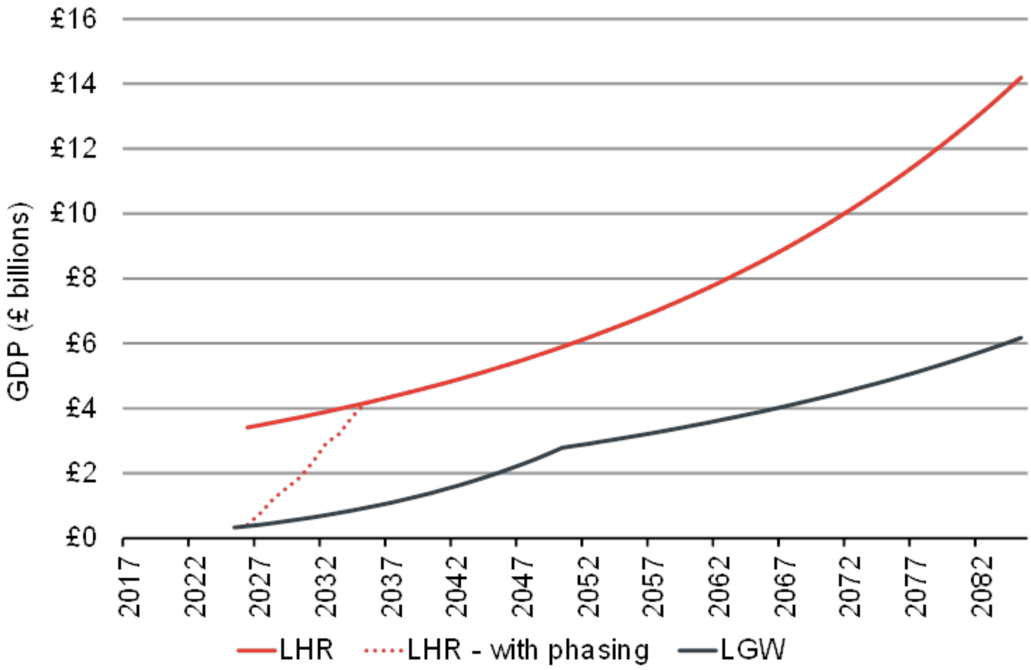
Figure 39 The catalytic impact of third runway at Heathrow



We have estimated the catalytic impact under both expansion options. Our results are shown below in Figure 40.

We estimate that by 2030, the catalytic impact of the third runway at Heathrow would be equal to around £3.7 billion, driven predominantly by an increase in O/D demand to the USA and China which combined represent more than 50% of the total impact.

Figure 40 Catalytic impact under expansion options



Source: Frontier analysis

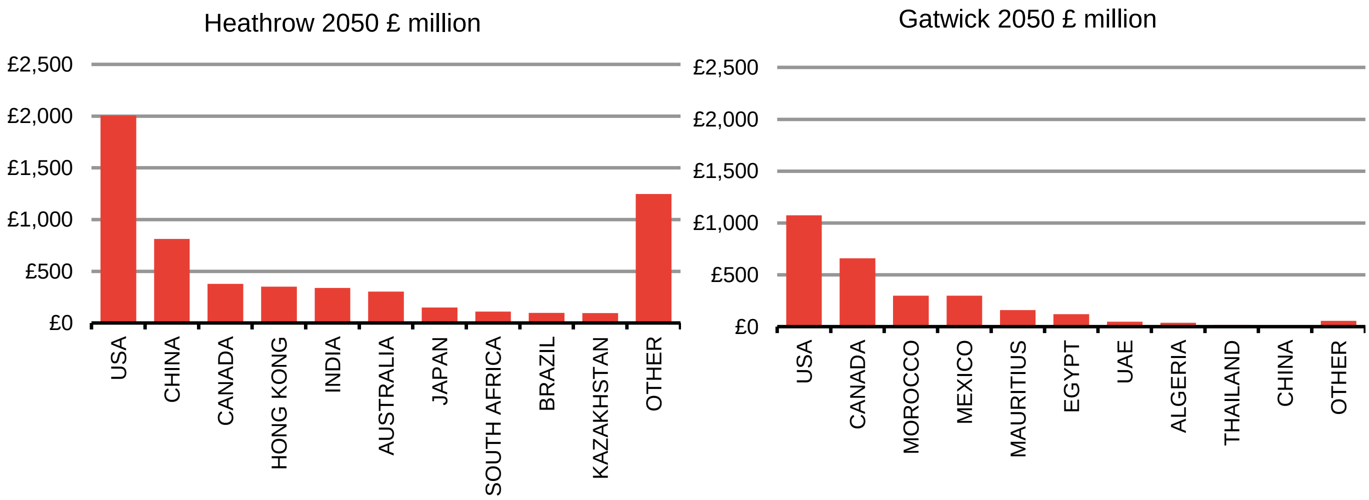
From 2030 onwards, we assume that the catalytic impact associated with each individual partner country grows at a constrained rate equal to the average GDP growth rate between the UK and the partner country. This is to reflect that as productivity grows over time, the GDP benefits associated with a given volume of traffic would also be expected to grow. The total impact grows at around 2.5% per annum.

The DfT has also produced a 'phased' capacity profile which assumes that by 2030, just over 50% of the incremental capacity will have been phased into operation, gradually reaching 100% by around 2035. To reflect this gradual phasing of incremental capacity, we have multiplied the catalytic impact results by the percentage of incremental capacity assumed to be introduced in each year. This has the effect of reducing the catalytic impact in the early years (given by the dotted red line in the illustration above).

For Gatwick, we estimate that in 2030 the catalytic impact would be equal to around £0.6 billion (or around 16% of the potential total under the Heathrow expansion scenario) – with the USA and Canada representing around 70% of the total figure. The DfT assumes that Gatwick will only become constrained by 2050, meaning that the catalytic impact would grow at an unconstrained rate each year up until that point, rising to around £2.8 billion by 2050, or just under 50% the size of the impact at Heathrow at that time. From this point however, the catalytic impact with each partner country would grow at a constrained rate. The total figure increases by around 2.3% per annum – marginally lower than the growth at Heathrow. This is because of differences in the relative mix of traffic at both airports – e.g. Heathrow has a greater share of traffic to faster growing economies such as China and India, whereas Gatwick's impact largely comes from North America.

The chart below shows a snapshot of the results in 2050, at which point both Heathrow and Gatwick are assumed to be fully constrained.

Figure 41 Catalytic impact in 2050



Source: Frontier analysis

Again, we note that in our analysis we do not assume that unserved demand at a constrained Heathrow would overflow to an expanded Gatwick, and vice versa. This is based on the evidence presented in the previous subsection that Gatwick has not emerged as a substitute for Heathrow with respect to long haul connectivity. Therefore, the benefit from expansion at Gatwick effectively arises from extrapolating the long haul demand which already exists there today. Given that comparatively few passengers fly indirectly from Gatwick to China, the catalytic impact of a Gatwick expansion with respect to China is virtually zero. There is a reasonable share of traffic to North America at Gatwick. However, this is still dwarfed by the size of North American traffic at Heathrow.

4.2.1 Estimating the net present value of the impacts

In its analysis, the DfT estimated the net present value (NPV) of the economic impacts of both expansion options over a 60 year appraisal period, starting from the assumed opening year of each option (2025 to 2084 for Gatwick, and 2026 to 2085 for Heathrow). A discount rate of 3.5% was used for the first 30 years, and 3.0% thereafter.

Therefore, for comparability, we have performed the same calculation. The NPV for the catalytic impacts are as follows:

- Heathrow (assuming immediate phasing of capacity): **£113 billion**
- Heathrow (assuming a gradual introduction of capacity): **£102 billion**
- Gatwick (assuming immediate phasing of capacity): **£41 billion**

The results for Heathrow are therefore more than twice that of Gatwick, further highlighting the case for expansion at Heathrow.

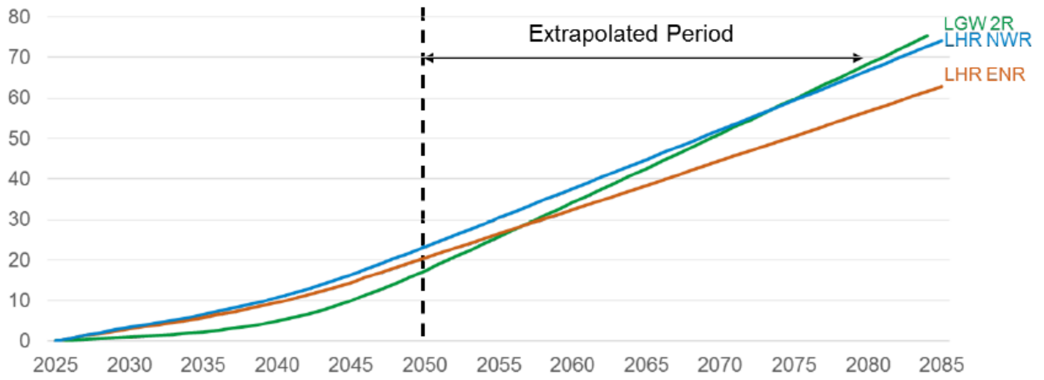
4.2.2 How do our results compare to other estimates?

The figures above represent only the catalytic impact of expansion. However, there are other benefit types. The DfT has estimated the "total benefits to passengers and the wider economy" of both the Heathrow and Gatwick expansions, which covers the following benefit types:

- Passenger benefits. This includes the reduction in the congestion premium, and time saving benefits associated with there being fewer delays and greater frequency. This component represents the majority of the DfT's figures; and
- Government revenue. For example, this includes the extra revenue generated from APD associated with the increased demand.
- Wider Economic Benefits. These include increased business output and a tax component.

The DfT estimated an impact of up to £74 billion in NPV terms at Heathrow, and up to £75 billion in NPV terms at Gatwick.

Figure 42 DfT: Cumulative benefits to passengers and the wider economy by forecast year (present value, £bn, 2014 prices)



		Total benefits to passengers and the wider economy			
		2030	2040	2050	2084/5
LGW Second Runway	FRSR (AC Forecasts)	0.9	4.9	14.3	52.4 to 53.7
	DfT17	1.0	4.9	17.3	74.1 to 75.3
LHR Extended Northern Runway	FRSR (AC Forecasts)	2.4	10.0	19.0	50.1 to 51.7
	DfT17	3.0	9.4	20.5	61.7 to 62.8
LHR Northwest Runway	FRSR (AC Forecasts)	2.5	11.0	21.5	59.2 to 61.1
	DfT17	3.3	10.7	23.2	72.8 to 74.2

Source: *DfT: Figure 9.3. Updated Appraisal Report. Airport Capacity in the South East*

Note: *The chart shows total benefits to passengers and the wider economy using the upper end of the wider economic impact range.*

We note that the two impacts – our catalytic impact and those estimated by the DfT – are based on separate methodologies and capture different benefit types. We consider the results to be largely additive. Following expansion, passengers of all trip purposes will pay lower air fares (captured by the DfT's passenger benefits), and in parallel, additional trade and FDI would be facilitated because more business passengers will be able to fly (catalytic). These two impacts occur in parallel.

Therefore, taken together, based on our latest figures, the catalytic impact and the DfT's impacts could lead to a total benefit of up to £187 billion for Heathrow and £116 billion for Gatwick.

To further place this result in context, the AC also produced various GDP impact estimates based on PWC's spatial computable generated equilibrium (S-CGE) model of the UK economy. In principle, the CGE approach is designed to be a holistic one and captures how an expansion at each airport would impact on the UK's GDP – recognising that there would be lower air fares, more passengers, a reduction in journey times, and greater productivity brought about by there being more trade and FDI. The AC considered various future scenarios and states of the world, which varied in terms of operational assumptions (e.g. the 'low cost is king' scenario assumed that low cost travel would be especially more prominent going forward), and macroeconomic assumptions (e.g. the 'global growth' scenario assumed that GDP growth rates would be higher than the more base case conservative assumptions). The table below sets out the AC's results for both expansion options based on the S-CGE approach:

Exhibit 1. The AC's NPV GDP impacts from expansion at LHR and LGW (£bn)

Table 11: LGW 2R Present Value of real GDP impacts, by scenario (£bn, 2014 prices)

	Assessment of Need	Global Growth	Relative Decline of Europe	Low Cost is King	Global Fragmentation
Total	89.0	114.7	62.8	127.4	41.7

Source: PwC analysis

Table 29: LHR NWR Present Value of real GDP impacts, by scenario (£bn, 2014 prices)

	Assessment of Need	Global Growth	Relative Decline of Europe	Low Cost is King	Global Fragmentation
Total	147.2	211.4	111.7	209.6	118.3

Source: PwC analysis

Source: 'Airports Commission 2. Economy: Wider Impacts Assessment' Tables 11 & 29.

The AC estimated that the potential impact of expansion at Heathrow could lie within the range of £112 billion - £211 billion, while the expansion at Gatwick could lie within the range of £42 billion - £127 billion. While these estimates were based on the older DfT passenger forecasts, we see that our new NPV estimates of £187 billion at Heathrow and £116 billion at Gatwick lie within these ranges and help to highlight further that the third runway will have a significant impact on the UK economy.

5 CONCLUSION

The purpose of this report is to assess the impact of both expansion options on passengers in light of DfT's updated passenger demand forecasts. We consider three main areas:

- Observations on the DfT's updated forecasts and economic appraisal;
- An estimate of the 'congestion premium' at Heathrow, that is the extent to which fares are elevated at Heathrow as a direct result of existing capacity constraints; and
- A comparative estimate of the connectivity and 'catalytic' (trade and FDI) benefits of expanding Heathrow and Gatwick.

Our assessment shows that Heathrow Airport expansion provides substantially higher benefits to passengers than expanding Gatwick Airport because:

- The reduction in ticket prices from expansion at Heathrow is substantially larger compared to Gatwick. If Heathrow were expanded today, ticket fares would decrease by 23% relative to other London airports as a result of removing the capacity constraint. In terms of one-way ticket fares, that's a reduction of £59. By 2030 the impact of the capacity constraint will have risen, increasing fares at Heathrow by 50%. Gatwick, on the other hand, does not currently face a congestion premium, and by 2030 will face a fare increase of only 32%.
- The increase in connectivity is much larger for expanding Heathrow compared to Gatwick. Expanding Heathrow Airport would provide over 40 new connections for London. This contrasts with only 2 connections for London from expanding Gatwick Airport.
- Finally, in terms of the catalytic impact provided by a new runway, the estimate for Heathrow is more than two times that for Gatwick, and £102 to £113 billion for Heathrow while only £41 billion for Gatwick.

Our overall conclusions apply under all likely future market developments. Expanding Heathrow Airport would lead to substantially greater reductions in ticket prices and greater connectivity.

ANNEX A CONGESTION PREMIUM ANALYSIS

A.1 Introduction

This annex sets out the methodology used in estimating the congestion premium at Heathrow. As described previously, because Heathrow is capacity constrained, ticket fares have increased in order to choke off excess demand. To understand the magnitude of this fare increase, we have used empirical evidence from 2016.

We have found that in 2016, ticket fares at Heathrow were on average 23.3% higher than at other London airports and 24.4% higher than at other European hub airports, despite controlling for other factors that affect fares. This translates to a mark-up in one-way ticket fares of approximately £59. Furthermore, we did not find a mark-up on ticket fares from Gatwick in comparison to the other London airports. The full set of results for Heathrow is presented in Figure 43.

Figure 43 Congestion premium estimates at Heathrow 2016

Sample	Main premium estimate	Implied one-way mark-up	Range of estimates
London 2016	23.3%***	£58.99	23.3%*** to 35.7%***
European hubs 2016	24.5%***	£61.43	15.0%*** to 25.8%***

Source: Frontier Economics

*Note: *** means the result is statistically significant at the 1% level. ** means significant at the 5% level. * means significant at the 10% level.*

The remainder of this annex sets out the full methodology of the estimation, followed by a discussion of secondary results not reported in Section 3.

A.2 Methodology

To estimate the cost of the congestion premium at Heathrow, we have used an econometric model with 2016 data. Such an approach allows us to control for various factors that also influence ticket fares and therefore isolate the effect of the congestion premium. In this section, we detail the regression specifications, the interpretation of the specific coefficients, data sources used and the key assumptions for the analysis.

A.2.1 Regression specification

Our baseline ordinary least squares (OLS) regressions are presented in below in Equation 1 and Equation 2. Equation 1 estimates the price difference between Heathrow and the other London airports, namely Gatwick, Luton, Stansted and City airports. Equation 2 estimates the price difference between Heathrow and other European hubs, namely Paris Charles de Gaulle, Amsterdam-Schiphol, Frankfurt and Madrid airports.

Equation 1 London airports regression

$$\ln(Fare)_i = \beta_0 + \beta_1 Distance_i + \beta_2 Long\ haul_i + \beta_3 \ln(Frequency\_Own)_i + \beta_4 \ln(Frequency\_Other)_i + \beta_5 Business_i + \beta_6 VFR_i + \beta_7 Transfer_i + \beta_8 LCC_i + \beta_9 LHR_i + u_i$$

Equation 2 European hub airports regression

$$\ln(Fare)_i = \beta_0 + \beta_1 Distance_i + \beta_2 Long\ haul_i + \beta_3 \ln(Frequency\_Own)_i + \beta_4 \ln(Frequency\_Other)_i + \beta_7 Transfer_i + \beta_8 LCC_i + \beta_9 LHR_i + u_i$$

We have selected our baseline regression specifications because they fit best with the data and are consistent with our approach used to estimate the 2012 premium.[29] While there are some explanatory variables included in the regression model that are not statistically significant, they are included to allow a clearer interpretation of the other explanatory variables. For example, the coefficient on business passengers is not significant in some of the regressions. However, we include it to control for the possibility that Heathrow's premium is caused by Heathrow's attractiveness to business passengers.

Our specifications employ heteroskedasticity-robust standard errors because the standard errors in our regression models are unlikely identically distributed. The price differences between Heathrow and other London airports depend on the other London airport in question, as shown in the graphs of fares on overlapping routes (Figure 13 to Figure 16). Thus, we use heteroskedasticity-robust standard errors to control for the likely occurrence of heteroskedasticity. Using robust standard errors increases the magnitude of the standard errors, lowering the significance levels in our results and ensuring our results are conservative.

We modify our baseline specifications to test various sensitivities. First, to test whether results differ by airport, we repeated the regression individually for each airport. Second, we replaced the Heathrow dummy variable with a Gatwick dummy variable to test whether Gatwick faces a congestion premium. Third, we tested whether the congestion premium varies by short and long haul flights by running the specifications on short haul and long haul flights separately. Finally, we have tested various sensitivities of our baseline model to confirm our results.

Finally, there does not exist a perfectly correct and unique model for this estimation as it faces problems such as multicollinearity as described above in Section 3.4. As a result, testing different specifications and comparing the range of estimated premiums is a robust method to ensure conclusions remain valid across different possible specifications. Estimates of other coefficients besides the premium may vary significantly across the regressions, but in all cases, we would expect to observe a congestion premium at Heathrow.

A.2.2 Interpretation of coefficients

The interpretation of coefficients is described in Figure 44. Because we are interested in the congestion premium at Heathrow, our primary coefficient of

[29] Frontier (2014), "Impact of airport expansion options on competition and choice."

interest is β_9. β_9 tells us how much on average fares at Heathrow are higher or lower than at other airports in our sample.

Figure 44 Coefficient interpretations

Coefficient	Explanatory variable	Interpretation
$\widehat{\beta_0}$		Constant
$\widehat{\beta_1}$	**Distance**	Holding everything else constant, an increase in distance of one nautical mile will increase the price by $\widehat{\beta_1}$**%.**
$\widehat{\beta_2}$	**Long haul**	Holding everything else constant, on average, the fare for long haul flights is $\widehat{\beta_2}$**%** higher than the fare for short haul flights.
$\widehat{\beta_3}$	**ln(Frequency_Own)**	Holding everything else constant, a 1% increase in the number of flights to the same destination at the same airport is associated with a $\widehat{\beta_3}$% increase in fare.
$\widehat{\beta_4}$	**ln(Frequency_Other)**	Holding everything else constant, a 1% increase in the number of flights to the same destination at other airports is associated with a $\widehat{\beta_4}$% increase in fare.
$\widehat{\beta_5}$	**Business**	Holding everything else constant, a one percentage point increase in business passengers on this route is associated with a fare increase of $\widehat{\beta_4}$**%.**
$\widehat{\beta_6}$	**VFR**	Holding everything else constant, a one percentage point increase in passengers who visit friends and relatives on this route is associated with a fare increase of $\widehat{\beta_5}$**%.**
$\widehat{\beta_7}$	**Transfer**	Holding everything else constant, a one percentage point increase in transfer passengers on this route is associated with a fare increase of $\widehat{\beta_7}$**%.**
$\widehat{\beta_8}$	**LCC**	Holding everything else constant, a one percentage point increase in passengers who fly with low cost carriers on this route is associated with a fare increase of $\widehat{\beta_8}$**%.**
$\widehat{\beta_9}$	**LHR**	Holding everything else constant, on average, the fare for a flight on this route from Heathrow is $\widehat{\beta_9}$**%** more expensive than the same flight from the other airports in the sample.

Source: Frontier Economics.

A.2.3 Data sources

In order to construct the variables for our regression analysis, we have relied on a range of different data sources. A variable-by-variable summary is presented in Figure 45. Note that all variables are defined as departure airport-arrival airport combinations. For example, the observation Heathrow-Peking would be included in the data set but the observation Peking-Heathrow would not be included.

In selecting our data sources, we have aimed to ensure consistency between our 2012 analysis and our updated analysis in 2016. In all but one case, we have used the same data source for defining the explanatory variables. The one exception to this is the definition of the LCC (low cost carrier) explanatory variable. Previously in 2012, we used the SRS analyser definition of low cost carriers to determine what percentage of passengers from the IATA data travelled on these low cost carriers. However, low cost carriers have changed significantly since 2012, both in terms of new low cost carriers entering the market to airlines switching from mainline to low cost carriers, or vice versa. As a result, we have used the OAG Schedules Analyser for new up-to-date categorisation of carriers by mainline or low cost and have then applied these categorisations to IATA passenger data to determine the percentage of low cost carriers on a given route.

Furthermore, we have constructed data sets for two samples of observations, London airports and European hub airports, corresponding to Equation 1 and Equation 2 above. In the London airport sample, we have included all routes departing from the following airports: Heathrow, Gatwick, Luton, Stansted and City. Similarly, for the European hub scenario, we have included all routes departing from the following airports: Heathrow, Paris Charles de Gaulle, Amsterdam-Schiphol, Frankfurt and Madrid.

Figure 45 Data sources by explanatory variable

Variable	Description	Source
Fare	Average fare for a route from a departure airport. Calculated as Fare = (Total revenue) / (Total estimated passengers) Excludes passenger-related airport charges	IATA Fare Data
Distance	Distance in nautical miles between departure airport and arrival airport.	IATA Lookup Table
Long haul	Dummy variable equal to 1 if route is long haul or greater than 2200nm.	IATA Lookup Table
Frequency_Own	Number of annual flights on the route at the same airport.	OAG Schedules Analyser
Frequency_Other	Number of annual flights on the route at the other airports in the sample.	OAG Schedules Analyser
Business	Percentage of O/D passengers on the route whose purpose is business.	CAA Passenger Surveys
VFR	Percentage of O/D passengers on a route whose purpose is visiting friends and relatives.	CAA Passenger Surveys
Transfer	Percentage of passengers on the route who are transfer passengers. Calculated as the number of transfer passengers/ the sum of OD, transfer and beyond passengers.	IATA Fare Data
LCC	Percentage of passengers on the route on flights operated by low cost carriers. The inclusion of this variable helps capture that LHR has more premium passengers than other London airports.	IATA Fare Data and OAG Schedules Analyser
Airport dummy variables (e.g. LHR, LGW, LTN, etc.)	Dummy variable equal to 1 if the departure airport is the airport of the dummy variable.	

Source: Frontier Economics.

A.2.4 Assumptions

In the process of constructing the data sets for analysis, we have relied on a variety of assumptions. We detail each of the assumptions in the following discussion.

Inclusion of observations

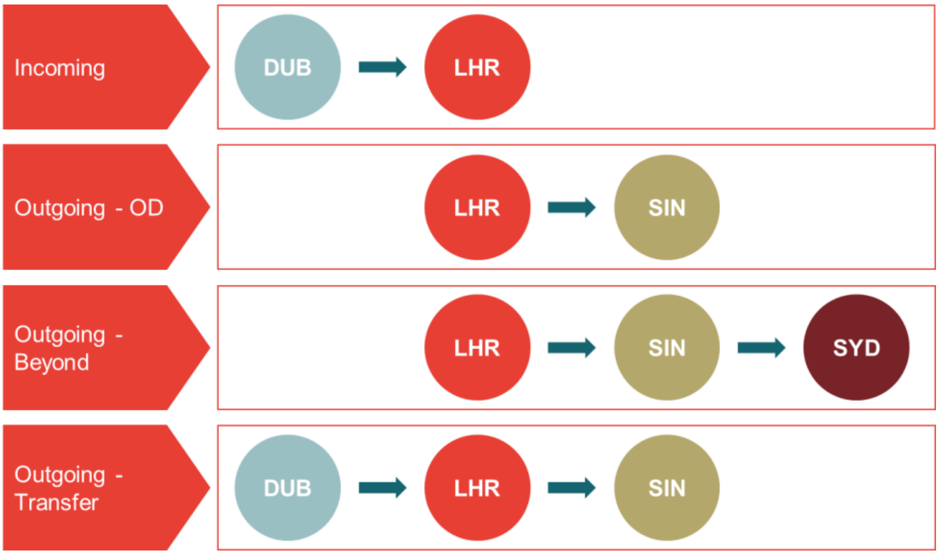
We have made three primary assumptions regarding the inclusion of observations. First, as mentioned previously, our analysis uses only flights departing from the airports of interest. That is, we do not include inbound flights to the airports in our sample. This approach assumes that inbound flights are comparable to outbound flights.

Second, we have considered only origin-destination (O/D) passengers. The IATA data includes the following four types of passengers:

- Incoming passengers
- Outgoing – O/D passengers
- Outgoing – Beyond passengers
- Outgoing – Transfer passengers

Incoming passengers are passengers whose journey terminates once they arrive at the particular airport of interest. O/D Passengers depart from the airport of interest and travel directly to their final destination. Beyond passengers depart from the airport of interest and travel indirectly to their final destination. Transfer passengers are those passengers who depart from a different airport and travel through the airport of interest on their way to their destinations. These definitions are summarised in Figure 46.

Figure 46 Summary of passenger types



Source: Frontier Economics.

The IATA data provides revenues for the total journey and does not break this down for different flight segments. To include beyond or transfer passengers, additional assumptions would be required on how revenues are allocated across different flight segments of the journey. As these assumptions would be tenuous at best, we have avoided these assumptions and have instead considered only OD passengers for which we have actual revenue estimates.

Third, we only included routes which had more than 10,000 passengers. This is equivalent to 3 long haul flights or 6 short haul flights per month.[30] This cut-off point was chosen in order to exclude chartered and irregular flights from the analysis to prevent the model from picking up effects due to outliers in the data. For example, in 2016, 2476 passengers flew from Heathrow to Lambert Airport in St. Louis, United States. This is equal to just under 10 flights per year, which cannot be considered a regular connection. Therefore we exclude it from our analysis. A full breakdown of the number of observations in our sample as well as number of observations excluded is presented in Figure 47.

Figure 47 Sample size and excluded observations

Sample	Final sample size	Excluded observations
London airports	656	178
European hub airports	1051	375

Source: Frontier Economics.

Trip purpose

As the passenger surveys are only conducted in the UK, we were not able to control for trip purpose in the analysis of the European hub airports. For the London airports, we assumed a threefold distinction between different trip purposes:

- Business
- Visiting friends and relatives
- Leisure

This does not correspond to the trip purpose definition in the CAA Passenger survey. 'Purpose' in the CAA survey divides passengers between 'Business' and 'Leisure'. We have used the 'Business' passengers from this category and then further divided 'Leisure' into 'Visiting friends and relatives' and 'Leisure' using the information provided in the 'Main Purpose' description.[31] By including the trip purpose variable, we can control for the effect on ticket prices resulting from the fact that Heathrow serves more premium or business passengers compared to other London airports.

A.2.5 Estimating the premium in 2030

We can also forecast the congestion premium in 2030 if Heathrow was not expanded. We calculate the cost of the constraint from the excess demand by using the definition of the price elasticity of demand, which is:

[30] This calculation assumes that the average capacity of a short-haul airplane is 120 passengers and the average capacity of long-haul airplane is 250 passengers. This also assumes that airplanes fly 365 days a year.

[31] Note that we do not include all three categories of trip purpose in our regression specification in order to avoid perfect collinearity among the regressors. That is, if all three were included their sum would equal to one, and therefore, the model would be unable to estimate all three coefficients. While we omit the leisure category, it is statistically equivalent to omit any of the three.

$$Price\ elasticity\ of\ demand = \frac{Percentage\ change\ in\ demand}{Percentage\ change\ in\ fares}$$

The price elasticity of demand for flights is defined as the percentage change in demand resulting from a 1% change in fares. This elasticity is negative as demand will decrease if prices go up. Rearranging this equation gives us:

$$Percentage\ change\ in\ fares = \frac{Percentage\ change\ in\ demand}{Price\ elasticity\ of\ demand}$$

The percentage change in demand is estimated as the difference in the 2030 pasenger figures between the 2 runways and 3 runways scenarios while the price elasticity of demand is defined as in the catalytic impact analysis to be -0.7.

A.3 Discussion of other results

The following section discusses our results related to other variables and not the estimated congestion premiums, which are discussed in Section 3. The full set of regression estimates is shown in Figure 50 to Figure 53. Note that while the specific estimates on the various coefficients may vary across the specifications, this is not a worry due to the reasons described in Section A.2.1.

A.3.1 Impact of other variables

Long haul and distance

As can be seen in Figure 50 and Figure 51, the coefficient on distance is positive and significant in every case. This results matches expectations as distance is a key determinant of flight costs.

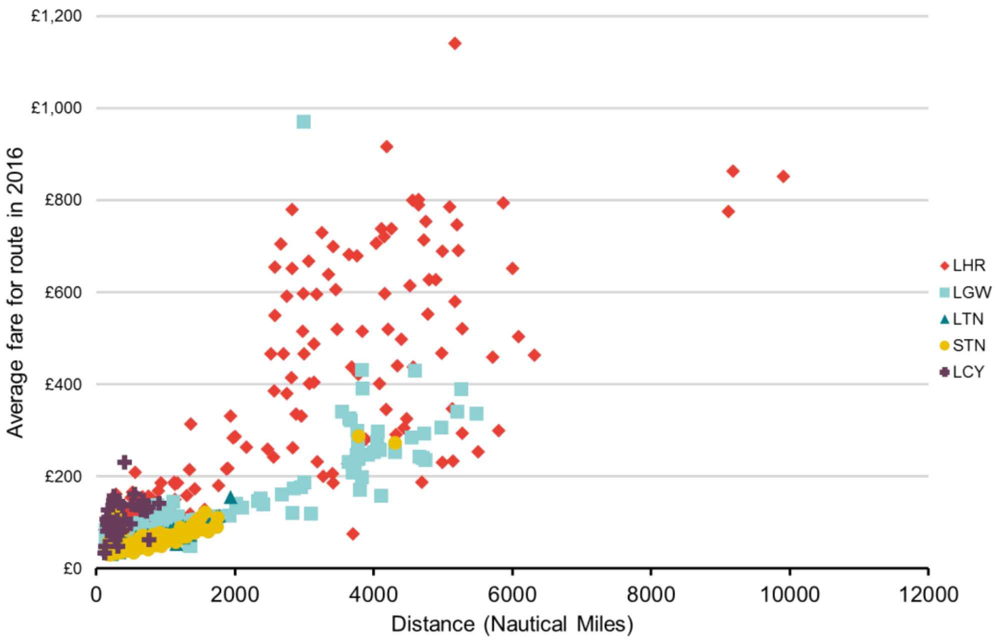
The coefficient on the long haul dummy variable is positive and significant for all but one regression, which means that holding everything else constant, long haul flights are 27% more expensive according to the results in Figure 50. This is an interesting result as we have already controlled for the extra distance that is covered during the flight. This could, perhaps, be interpreted as reflecting the additional operational differences between long haul and short haul flights, including larger aircraft and over-night stops meaning longer turnaround times.

It is also interesting to note that the premiums for long haul flights are different at Heathrow than at Gatwick. Whereas at Heathrow, holding everything else constant, long haul flights are more expensive than short haul flights, at Gatwick the coefficient on long haul flights is not statistically different from zero. It is possible that this reflects a competitive effect, resulting from the capacity constraint at Heathrow. That is, the impact of capacity constraints on competition and ticket prices is particularly marked for long haul at Heathrow, because these are the routes on which additional competitive entry is not possible and passengers have no viable alternative option at other airports.

To investigate the fare pricing based on distance at Heathrow and Gatwick further, we investigated the relationship between distance and fares at both airports in 2016. Figure 48 shows a scatterplot of the average fares and distance for the different destinations for all London airports in 2016. Figure 49 shows a scatterplot of the log fares of the different destinations of short haul and long haul destinations at Heathrow and Gatwick. From the scatterplots it is clear that Heathrow has higher fares than Gatwick for both short and long haul destinations, although Heathrow has more destinations with a longer distance than Gatwick does.

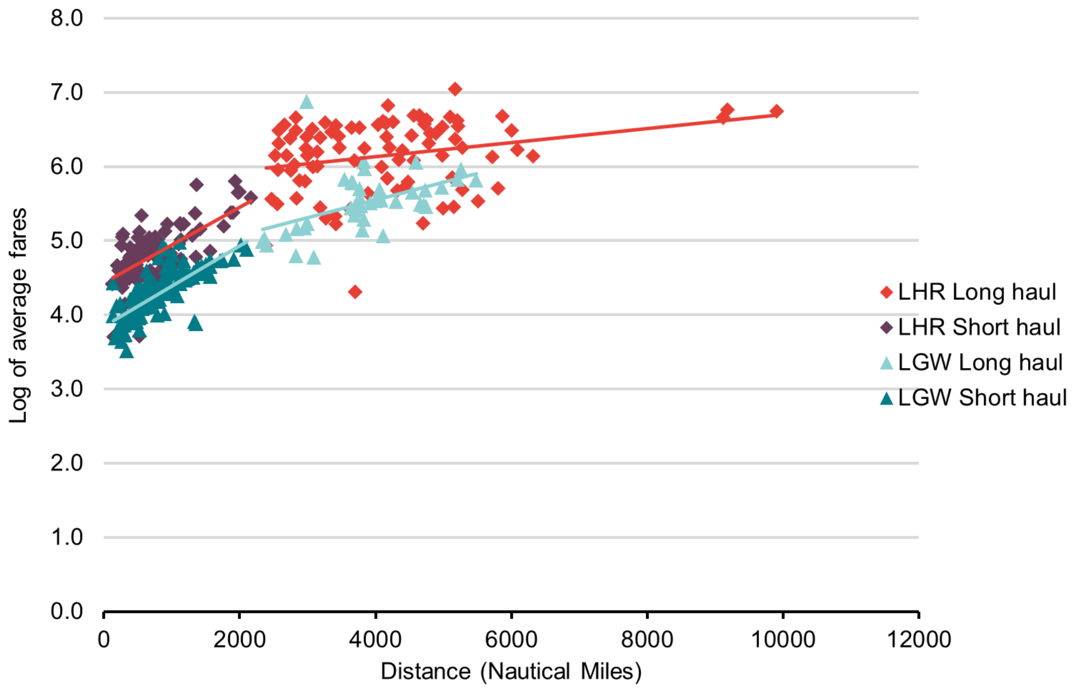
We also observe in Figure 49 that there is seemingly a break between short and long haul flights in terms of the relationship between fares and distance. This break, however, is much more pronounced at Heathrow than Gatwick, which could explain why the long haul dummy variable is not significant for Gatwick while it is for Heathrow.

Figure 48 Distance and average fares at London airports in 2016



Source: Frontier Economics and IATA.

Figure 49 Distance and log fares at London airports in 2016



Source: Frontier Economics and IATA.

Frequencies

We had expected the coefficients on frequencies to be negative, as a greater supply of flights might be expected to bring down prices. Nevertheless, it could be the case that increased frequency of flights represents the higher demand for a flight, as airlines supply more flights if a particular route turns out to be profitable.

In fact, our results show mixed effects for both frequency of flights at the same airport and frequency of flights at other airports. In some cases the results are not statistically different from zero, while in other cases the results are either positive or negative and statistically different from zero. For example, for the main London airport regressions, own frequency is positive and statistically significant suggesting that holding everything else constant, more flights to the same destination from the airport in question is associated with higher fares on that particular route. This could be consistent with higher frequencies being associated with higher demand and therefore increased fares.

Trip purpose

Trip purpose proves to be a significant determinant of fares in most regressions. Business has a positive and in many specifications statistically significant effect. For example, at the London airports in 2016 for short haul flights, holding everything else constant, a 1 percentage point increase in passengers with the trip purpose of business is associated with a 0.64% increase in average fares.

Moreover, more passengers visiting friends and relatives are associated with lower fares. This is also a significant result that is robust across many airports and sample and model specifications. This suggests VFR passengers may be the most price sensitive passenger group.

Transfer passengers

The coefficient on transfer passengers is generally positive and significant. For example, at the London airports in 2016 across all flights, holding everything else constant, a 1 percentage point increase in transfer passengers on a particular route is associated with a 0.41% increase in average OD fares. This could be consistent with transfer passengers being more price sensitive, and so the market allocating a smaller share of fixed (e.g. aircraft) costs to this group.

Low cost carrier passengers

The coefficient on low cost carrier passengers is negative and significant. This is a result we would expect.

Figure 50 Regression results London airports 2016

Haul Airports	All LHR	All LGW	All LTN	All STN	All LCY	All All	LH All	SH All	All All	LH All	SH All
Dependent Variable	Log fare	Log fare	Log fare	Log fare	Log fare	Log fare	Log fare	Log fare	Log fare	Log fare	Log fare
Distance	0.000153***	0.000355***	0.000682***	0.000652***	0.000892**	0.000306***	8.01e-05**	0.000612***	0.000313***	7.86e-05**	0.000630***
Long haul	0.781***	-0.0949		-1.043***		0.269**			0.247**		
Log Frequency own	0.106***	0.0284	0.00239	-0.0533***	0.0801	0.0306*	0.114**	-0.00188	0.0441***	0.113**	-0.00190
Log Frequency other	-0.0204	-0.0396***	-0.00230	0.00686	0.0192	-0.00182	-0.0302**	0.00968**	-0.00375	-0.0307***	0.0101**
Business	-0.309	0.183	0.212	0.929***	0.329	0.215	1.152*	0.634***	0.190	1.124*	0.634***
VFR	-0.585***	0.0659	-0.0960*	-0.129**	-0.779	-0.203***	-0.389*	-0.132***	-0.160***	-0.401**	-0.0877*
Transfer	0.401**	0.571	-2.219	15.30	-0.325	0.411**	0.657***	-0.185	0.739***	0.643***	0.537***
LCC	0.0413	-0.230***	0.0999	-0.210*		-0.382***	-0.268**	-0.379***	-0.469***	-0.241**	-0.432***
LHR						0.233***	0.0944	0.283***			
LGW									-0.0256	-0.127	0.0316
Constant	4.536***	4.430***	3.784***	4.168***	3.890***	4.356***	5.031***	4.177***	4.351***	5.156***	4.180***
Observations	172	179	102	159	33	645	126	519	645	126	519
Adj. R-squared	0.751	0.860	0.831	0.845	0.230	0.860	0.557	0.752	0.855	0.560	0.739

Source: Frontier Economics.

*Note: *** means the result is statistically significant at the 1% level. ** means significant at the 5% level. * means significant at the 10% level.*

Figure 51 Regression results European hub airports 2016

Haul	All	All	All	All	All	All	LH	SH
Airports	LHR	AMS	CDG	FRA	MAD	All	All	All
Dependent Variable	Log fare	Log fare	Log fare	Log fare	Log fare	Log fare	Log fare	Log fare
Distance	0.000196***	0.000183***	0.000146***	0.000171***	0.000142***	0.000158***	4.51e-05**	0.000490***
Long haul	0.735***	0.519***	0.865***	0.758***	0.621***	0.760***		
Log Frequency own	0.0576*	0.000959	0.0355	0.0447	-0.0517*	0.0201	0.131***	0.0306*
Log Frequency other	0.0287	-0.00729	-0.00603	0.0158*	0.0124	0.00852	0.0158**	-0.00911
Transfer	0.486***	0.577***	0.783***	0.488***	0.0351	0.487***	0.532***	0.594***
LCC	0.0584	-0.246**	-0.181*	0.105	-0.647***	-0.272***	-0.882	-0.294***
LHR						0.245***	0.188***	0.228***
Constant	4.175***	4.625***	4.368***	4.131***	5.038***	4.407***	4.912***	4.196***
Observations	172	221	231	231	165	1,020	402	618
Adj. R-squared	0.744	0.822	0.813	0.810	0.854	0.806	0.296	0.533

Source: Frontier Economics.

*Note: *** means the result is statistically significant at the 1% level. ** means significant at the 5% level. * means significant at the 10% level.*

Figure 52 Robustness regression results London 2016

Haul	All	All	All	All	All	SH	SH	SH	SH	SH	LH	LH	LH	LH	LH
Airport	All	All	All	All	Overlaps	All	All	All	All	Overlaps	All	All	All	All	Overlaps
Dependent variable	Log fare	Log fare	Log fare	Log fare	Log fare	Log fare	Log fare	Log fare	Log fare	Log fare	Log fare	Log fare	Log fare	Log fare	Log fare
Distance	0.000306 ***	0.000310 ***	0.000242 ***	0.000243 ***	0.000439 ***	0.000612 ***	0.000615 ***	0.000605 ***	0.000607 ***	0.000554 ***	8.01e-05**	8.97e-05**	0.000101 ***	0.000102 ***	0.000202 ***
Long haul	0.269**	0.288***	0.441***	0.474***	-0.150										
Log Frequency own	0.0306*	0.0325**			0.0165	-0.00188	-0.00286			0.00111	0.114**	0.119**			-0.00544
Log Frequency other	-0.00182	-0.00205			-0.0299***	0.00968**	0.0100**			-0.0171*	-0.0302**	-0.0273**			-0.0179
Business	0.215	0.277**	0.210*	0.282**	0.581***	0.634***	0.622***	0.653***	0.637***	0.733***	1.152*	1.517**	1.315**	1.701**	3.181***
VFR	-0.203***	-0.215***	-0.240***	-0.255***	-0.266***	-0.132***	-0.128***	-0.160***	-0.155***	-0.252***	-0.389*	-0.425**	-0.414**	-0.452**	-0.459
Transfer	0.411**		0.468***		0.160	-0.185		-0.213		-0.0835	0.657***		0.634***		0.402
LCC	-0.382***	-0.376***	-0.378***	-0.372***	-0.323***	-0.379***	-0.377***	-0.379***	-0.376***	-0.343***	-0.268**	-0.212*	-0.336***	-0.278**	-0.317**
LHR	0.233***	0.326***	0.250***	0.357***	0.270***	0.283***	0.241***	0.288***	0.239***	0.270***	0.0944	0.211	0.295**	0.405***	0.319
Constant	4.356***	4.338***	4.590***	4.586***	4.484***	4.177***	4.176***	4.235***	4.231***	4.397***	5.031***	4.995***	5.458***	5.484***	5.027***
Observations	645	645	653	653	446	519	519	519	519	418	126	126	134	134	28
Adj. R-squared	0.860	0.858	0.863	0.860	0.824	0.752	0.752	0.750	0.750	0.747	0.557	0.516	0.536	0.499	0.836

Source: Frontier Economics.

*Note: *** means the result is statistically significant at the 1% level. ** means significant at the 5% level. * means significant at the 10% level.*

Figure 53 Robustness regression results European hub airports 2016

Haul	All	All	All	All	All	SH	SH	SH	SH	SH	LH	LH	LH	LH	LH
Airport	All	All	All	All	Overlaps	All	All	All	All	Overlaps	All	All	All	All	Overlaps
Dependent variable	Log fare	Log fare	Log fare	Log fare	Log fare	Log fare	Log fare	Log fare	Log fare	Log fare	Log fare	Log fare	Log fare	Log fare	Log fare
Distance	0.000158 ***	0.000158 ***	0.000141 ***	0.000135 ***	0.000152 ***	0.000490 ***	0.000424 ***	0.000476 ***	0.000409 ***	0.000448 ***	4.51e-05**	5.88e-05***	5.38e-05***	6.31e-05***	6.17e-05***
Long haul	0.760***	0.783***	0.793***	0.814***	0.834***										
Log Frequency own	0.0201	0.0463***			-0.00329	0.0306*	0.0448***			0.0133	0.131***	0.169***			0.0833***
Log Frequency other	0.00852	0.00431			0.0464***	-0.00911	-0.0153**			0.00918	0.0158**	0.0130			0.0706***
Transfer	0.487***		0.435***		0.400***	0.594***		0.490***		0.564***	0.532***		0.620***		0.436***
LCC	-0.272***	-0.488***	-0.301***	-0.518***	-0.271***	-0.294***	-0.562***	-0.349***	-0.580***	-0.271***	-0.882	-2.200***	-0.943	-2.640***	0.544
LHR	0.245***	0.150***	0.258***	0.175***	0.252***	0.228***	0.124***	0.218***	0.127***	0.233***	0.188***	0.0728	0.319***	0.199***	0.244***
Constant	4.407***	4.489***	4.626***	4.841***	4.282***	4.196***	4.470***	4.386***	4.668***	4.201***	4.912***	4.911***	5.679***	5.947***	4.770***
Observations	1,020	1,020	1,051	1,051	878	618	618	623	623	547	402	402	428	428	331
Adj. R-squared	0.806	0.789	0.796	0.782	0.831	0.533	0.464	0.484	0.438	0.518	0.296	0.204	0.201	0.067	0.264

Source: Frontier Economics.

*Note: *** means the result is statistically significant at the 1% level. ** means significant at the 5% level. * means significant at the 10% level.*

ANNEX B CATALYTIC IMPACTS

This annex provides more detail on our methodology to estimate the catalytic impact and the literature we reviewed to inform our assumptions. It is structured as follows:

- Overview of key steps in the methodology;
- Key relationship 1 – Air connectivity (i.e. the number of direct routes) and passenger volumes: detailed approach and evidence to underpin assumptions;
- Key relationship 2 – Passenger volumes and FDI, trade and tourism: detailed approach and evidence to underpin assumptions; and
- Key relationship 3 – Tourism, FDI, trade and productivity, GDP and employment: detailed approach and evidence to underpin assumptions

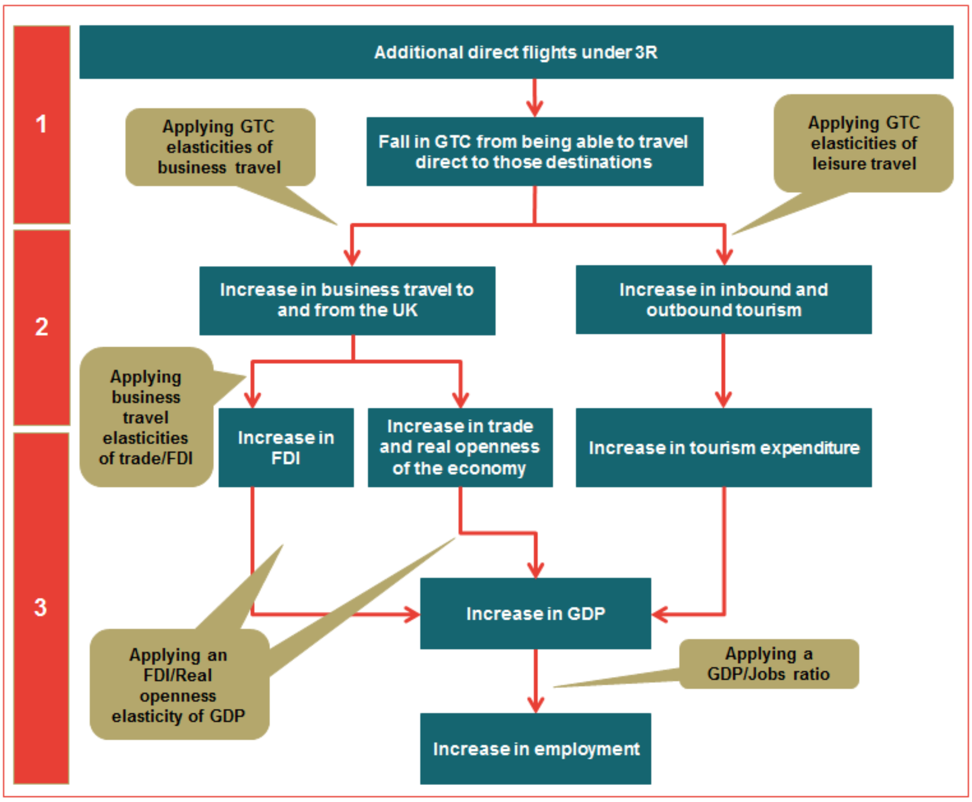
B.1 Overview of methodology

Our methodology follows the steps illustrated in Figure 54. Our starting point is the additional direct flights that could be added if there was a third runway. For FDI and trade, we undertake the analysis at a country level, rather than a city level, because trade and FDI data is provided at the country-level. For tourism, we carry out the analysis at a city-level.

We determine the additional travel time for the indirect connection by considering the additional distance flown and connecting time at the transfer airport. Distance is determined using a great circle route mapping tool. Switching from a direct to an indirect flight leads to a greater percentage increase in travel time for destinations that are closer to Heathrow. For example, adding 3 hours of travel time to a 5 hour journey represents a bigger percentage increase than adding 3 hours of travel time to a 12 hour journey. As a result, the impact of an indirect flight is greater for destinations that are closer.

We convert the additional travel time into a monetary value by applying the value of time derived from the Department for Transport's (DfT) analysis of values of time and hourly wage rates. The change in the travel cost is then related to the price of the original ticket to determine the percentage change in the travel cost. Using a price elasticity of demand, we can determine the change in total demand for travel to each destination. We then relate the percentage increase in passengers to a change in trade, FDI and tourism spending by using the elasticities discussed in the sections that follow. Changes in trade, FDI and tourism spending can then be related to the impact on GDP and employment.

Figure 54. Overview of the three key relationships in calculating the employment facilitated by having a third runway



We use data on FDI flows by partner country (both inward and outward FDI) for the UK from the OECD. Data on exports and imports between the UK and the rest of the world is available from the HMRC. We used ONS data published in Overseas Travel and Tourism releases on tourist spending and purpose of visit in order to estimate the impact on tourism.

B.2 Key relationship 1: Air connectivity and passenger volumes

Additional direct connections imply that passengers will save time spent travelling by choosing to fly direct rather than indirect. By monetising the travel time saved, we can estimate the change in demand for direct travel, and hence the number of additional passengers that will fly direct. This then enables us to estimate their impact on trade, FDI and tourism.

The methodology behind monetising the travel time and estimating the increase in direct passengers is outlined in the formula below:

*((Additional travel time * Value of time)/ Ticket price) * Travel cost elasticity of demand =*

Change in number of passengers

The change in travel time is calculated on the basis of additional travel distance multiplied with average speed. We distinguish speed for take-off and landing from the speed during the flight and use the following assumptions:

- average speed during flight: 500 mph; and
- average speed for take-off and landing: 250mph.

Distance is calculated on the basis of great circle routes. We add additional connecting time at the airport. Our results are based on an assumption of an average of 1 hour of connecting time for a short-haul flight and an additional 3 hours on average of connecting time for a long-haul flight. This implies that passengers would need 1-3 hours between landing and take-off for their connecting flights. We consider this assumption to be conservative, as this is likely to be close to the minimum rather than the average connecting time. The total additional connecting time is therefore equal to the additional flight time plus the connecting time. Our results show that the additional travel time varies from 1.1 hours to 3.5 hours.

We monetise the value of time by using hourly wage rates from the ONS and the DfT's estimates of values of time. For business travellers our value of time is £53 which is informed by the DfT's estimate of Value of Working time per person for a rail passenger (Tag Unit 3.5.6, Values of Time and Vehicle Operating Costs, October 2012) of £50, inflated to 2016 using UK GDP growth forecasts. We estimate that the value of working time of an air passenger would be as much, if not more, than a rail passenger. While recent estimates suggest a working time for a rail passenger closer to £30, this is likely to be based on increased use of mobile internet access. As this does not generally apply to air travel (even though wifi is available on some flights), we use the rail passenger value of time of £50. For non-business travel, we use the hourly wage rate to estimate the value of time saved by travelling direct. This is based on the ONS estimate of £16 for mean hourly earnings from their analysis of Patterns of Pay[32]. We adjust wage rates for other countries using Purchasing Power Parity.

Ticket prices are based on IATA data. We reviewed a number of studies on the price elasticity of demand. The most disaggregated values are available from IATA (2007). We have used these to estimate a travel cost elasticity of -0.70.

B.3 Key relationship 2: Passenger volumes and FDI, trade and tourism

In this section, we describe the link between passenger volumes and FDI, trade and tourism as follows:

- Relationship between face-to-face meetings and trade and FDI
- Relationship between leisure passengers and tourist spending

[32] "Patterns of Pay: Estimates from the Annual Survey of Hours and Earnings, UK, 1997 to 2013", 27 February 2014, ONS

B.3.1 Relationship between face-to-face meetings and trade and FDI

Our analysis requires us to make an assumption on the relationship between face-to-face meetings, trade and FDI. Face-to-face meetings increase the likelihood of closing business deals which has a positive impact on trade and FDI. Face-to-face meetings are also important to manage increasingly globalized supply chains. This relationship is supported by qualitative literature, but it is difficult to quantify the relationship.

B.3.2 Concept

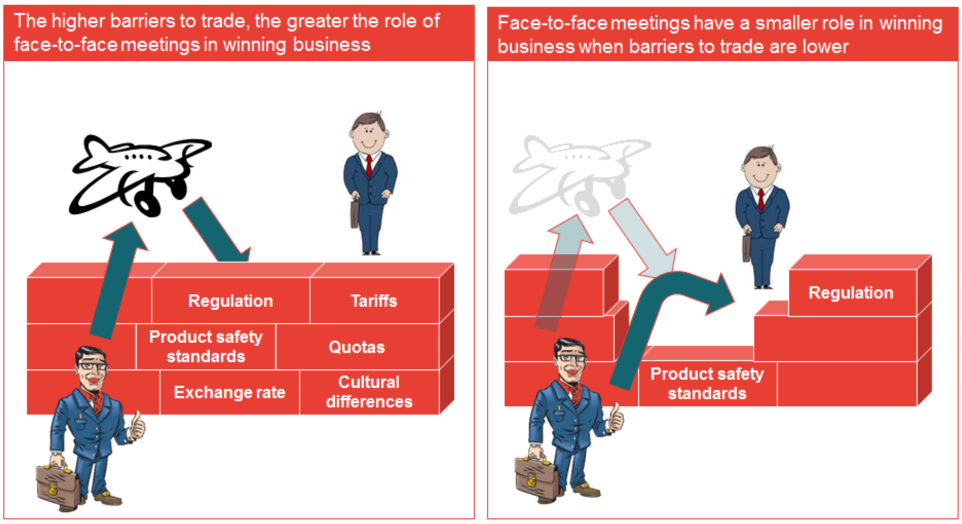
Despite the rise of technologies such as videoconferencing, face-to-face meetings still play an important role in developing and maintaining successful business relationships. Most relationships are built on trust between business partners and face-to-face meetings are still the most effective way to build and establish trust. In addition, in-person meetings can be used to inspect production sites and meet larger teams which cannot be done through videoconferencing.

This is because face-to-face meetings play role in overcoming trade and FDI barriers between economies. The most common barriers include:

- **Product market regulation –** a range of different types of regulation (product standards, safety regulation, etc.) can inhibit trade and FDI across borders;
- **Tariffs and quotas, local content requirements** – formal trade barriers such as tariffs also reduce the likelihood of trade;
- **Exchange rate** – the risk of changes in the exchange rate can pose a significant barrier to trade and FDI, as exchange rate volatility can increase the spread of potential returns; and
- **Cultural differences** – language differences and different business cultures can impede business relationships across cultures as it is more difficult to build trust.

Business travel can reduce or overcome some of these barriers, as face-to-face meetings enable a better understanding of local product market regulation and formal trade barriers. Face-to-face meetings are also one of the key ways to build trust across cultures. Figure 55 illustrates this concept.

Figure 55. Illustration of differences in trade barriers



These barriers are much lower when considering trade and FDI between the UK and Europe compared to other international transactions. This is because cultural differences are much smaller (for example, common language), and the trade links between the UK and Europe are well-established. Therefore, face-to-face meetings to build mutual trust and understanding are likely to have a smaller effect. For this reason, we assume that additional direct travel to and from Europe has no impact on trade and FDI.

B.3.3 Review of evidence

There is a range of qualitative, survey-based evidence that suggests face-to-face meetings play an important role in business relationships. We discuss these below. The importance of in-person meetings for trade facilitation is also supported by the existence of trade missions. For example, UK Trade and Investment (UKTI) helps UK-based businesses in establishing links with overseas partners. Among other events, they organise trade missions for different sectors/industries involving workshops, fairs, speakers, etc. which facilitate networking and business opportunities.

The World Travel and Tourism Council (2012) finds that sales conversion rates with an in-person meeting are 50 per cent, compared to conversion rates of 31 per cent without an in-person meeting. The results are based on surveys in Brazil, China, Germany, the UK and the USA and are consistent across these countries. In 2011, the WTTC conducted another survey on the importance of business travel and found that 28 per cent of existing business could be lost without face-to-face meetings and sales conversion rates are estimated to be 20-25 per cent higher with face-to-face meetings. This is further supported by a range of qualitative studies.

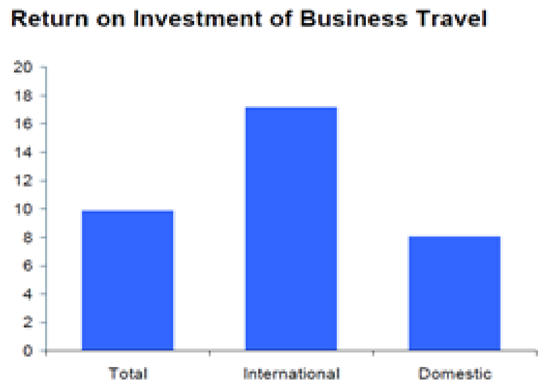
- Frankel (1997) illustrates the importance of face-to-face meetings as follows:
- *Consider a kind of export important to the United States: high-tech capital goods. To begin sales in a foreign country may involve many trips by engineers,*

marketing people, higher ranking executives to clinch a deal, and technical support staff to help install the equipment or to service it when it malfunctions.

- A survey by the UK Institute of Directors (2008) asked about the impact on businesses if the amount of business travel by air was significantly curtailed. 30 per cent of respondents said that there would be significant adverse effects while 44 per cent indicated small adverse effects.
- Poole (2010) finds that business travel to the United States by non-resident, non-citizens has a positive impact on export margins. This report has also been cited by the Airports Commission.
- Aradhyula & Tronstad (2003) find that their results support the hypothesis that both formal business exploration and casual exposure to cross-border business opportunities have a positive impact on trade.
- Strauss-Kahn & Vives (2005) find that headquarters relocate to metropolitan areas with good airport facilities, low corporate taxes, low average wages, high levels of business services, and an agglomeration of headquarters in the same sector of activity. The effects are quantitatively significant (for airport facilities in particular).
- The City of London (2008) surveyed finance and insurance companies on the importance of air travel. They found that 69 per cent of firms consider air travel to be critical for business travel by their staff, with only 2 per cent viewing it as not important.
- Boeh & Beamish (2012) demonstrate that travel time between different locations has a significant predictive power in firm governance and location decisions, as travel time could otherwise be employed for productive purposes.
- Napier University (2004) finds that *"[…] air transport per se is not a necessary condition, but what is important are: the extent to which that area is plugged directly into other major international hubs - availability and efficiency of routes (direct, hubbed); costs and the level of competition in global transport market, and; perceived and actual interchange efficiencies. This is a key consideration in the level of foreign investment into an area and is most important for firms with international trading or contacts such as, high-tech firms, financial services and pharmaceutical firms".*
- Survey-based evidence also suggests that the importance of face-to-face meetings depends on differences between business partners. Evidence from the World Travel and Tourism Council (WTTC) and the Harvard Business Review indicates that international business travel plays a more improtant role in generating and sustaining business than domestic travel. The WTTC (2012) found that:
- One extra dollar invested in international business travel would generate on average US$17 in trade; and
- One extra dollar invested in domestic US business travel by companies results in an increase in revenue of US$9.50.

This implies that the return on investment for international travel is roughly half of domestic travel. Figure 56 illustrates the difference in the return on investment.

Figure 56. Return on investment



Source: World Travel and Tourism Council, 2011

Similarly the Harvard Business Review (2009) confirms the role of face-to-face meetings in facilitating and sustaining business deals and also provides some evidence for the specific role of business travel to overcome barriers to trade across different cultures. For example, it found that:

- 93 per cent of survey respondents agreed that in-person meetings are helpful in negotiating with people from different language and cultural backgrounds;
- One survey respondent said that *"Communicating with our Chinese partners is enough of a challenge without face-to-face, because it is very difficult to explain a difference in perspective without body language"*; and
- A number of respondents described the need to work with clients in their own environment to get a full picture of the challenges and opportunities they face.

There is a small amount of literature that supports this view.

- Cristea (2011) found robust evidence that the demand for business-class air travel is directly related to volume and composition of exports in differentiated products. The paper finds that trade in R&D intensive manufactures and goods facing contractual frictions is most dependent on face-to-face meetings. Contractual frictions are more likely to occur with higher trade barriers so this would support a conservative assumption of an elasticity of zero for trade between the UK and Europe compared to the rest of the world.
- Poole (2010) finds that business travel for the purpose of communication acts as an input to international trade. The effect is stronger for differentiated products and for higher-skilled travellers, reflecting the information intensive nature of differentiated products. The effect is driven by travel from non-English speaking countries, for which communication with the U.S. by other means may be less effective. The findings therefore also confirm our view that business travel plays a bigger role when connecting firms from different cultural backgrounds.

B.3.4 Selection of assumption values

Quantitative evidence on the relationship between face-to-face meetings and trade/FDI is difficult to obtain. This is because it is difficult to pick out the impact of face-to-face meetings from the other factors that influence trade and FDI.

The World Travel and Tourism Council (WTTC) performed an econometric analysis on the relationship between flights and trade/FDI for a range of countries as shown in Figure 57. The figure shows the correlation coefficient as well as the results of the Granger test for causality. The figure shows that the correlations vary between 0.17 for outbound business travel from Italy to 0.98 for outbound business travel from Brazil.

Figure 57. Trade and business travel by country

Trade & Business Travel by country

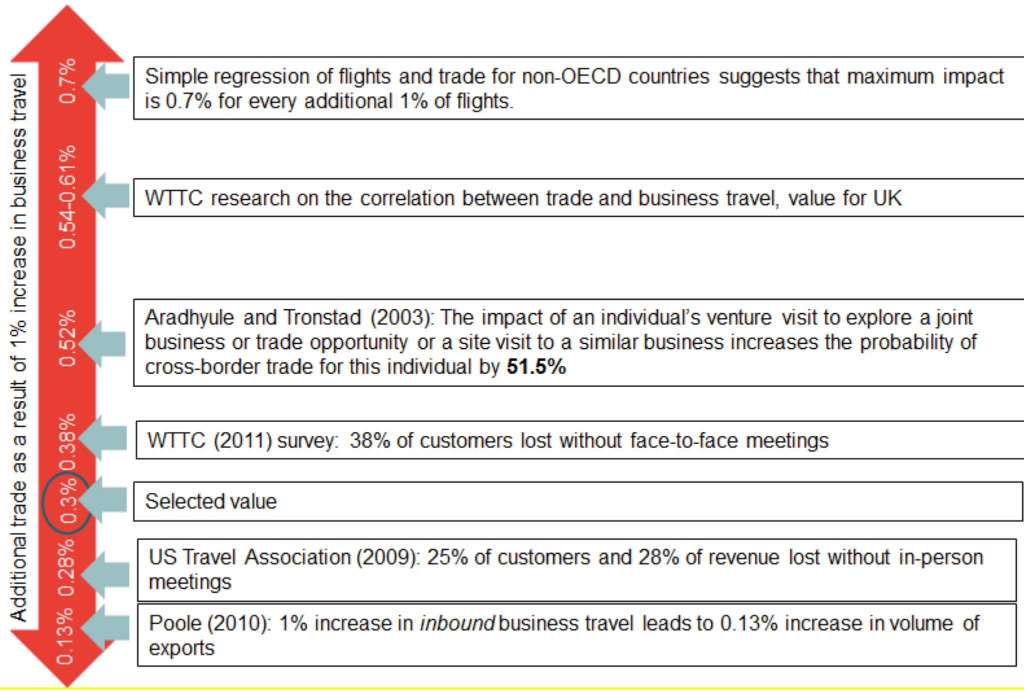
	Inbound business travel vs imports			Outbound business travel vs exports		
		Causality (% confidence)			Causality (% confidence)	
	Correlation	Travel causes Trade	Trade causes Travel	Correlation	Travel causes Trade	Trade causes Travel
US	0.87	95%	26%	0.65	82%	86%
Canada	0.92	100%	99%	0.85	98%	87%
UK	0.54	65%	85%	0.61	95%	80%
France	0.49	57%	85%	0.63	61%	92%
Germany	0.97	90%	81%	0.69	60%	98%
Italy	0.52	99%	100%	0.17	58%	99%
Spain	0.20	75%	99%	0.74	91%	80%
Japan	0.91	97%	53%	0.40	74%	92%
China	0.32	92%	95%	0.67	90%	99%
Russia	0.83	50%	90%	0.52	100%	95%
Brazil	0.57	100%	100%	0.98	88%	87%
India	0.72	84%	66%	0.46	99%	58%
UAE	0.42	83%	49%	0.82	95%	64%
Singapore	0.70	96%	94%	0.74	83%	53%
Hong Kong	0.67	95%	100%	0.43	86%	78%

Note: causality is shown as the probability that the identified casual relationship is true

Source: WTTC, 2012

We acknowledge that it is difficult to select an appropriate estimate for the relationship between trade and business travel. We have considered a range of evidence as illustrated in Figure 58 and have selected 0.3% as the elasticity. In the context of the available evidence, this is a conservative estimate.

Figure 58. Evidence on relationship between face-to-face meetings and trade



It is even more difficult to select an appropriate estimate for the relationship between FDI and flights as little research has been done on this topic. For example, a survey of businesses in Munich indicated that 55% of foreign businesses would not be located in the region around the airport if air connectivity was not satisfactory. Regressions of inbound passengers and inward FDI for different country/airport combinations suggest that the elasticity may be as high as 0.67. As these regressions suffer from omitted variable bias and endogeneity issues, we consider this an upper bound only. In order to select a conservative estimate, we have selected 0.3 as the elasticity of business travel to FDI.

B.3.5 Relationship between leisure passengers and tourist spending

The additional direct connections and travel time savings imply more tourist visits to the UK as well as more UK tourists abroad. In order to estimate the impact of connectivity on tourism spending we have obtained data on spending by purpose of visit from the ONS Overseas Travel and Tourism Quarterly Release. We estimate the average spend per passenger (for overseas visitors to the UK and for UK citizens abroad), and then multiply these values by our tourist passenger increase following expansion. This provides an estimate of the value of inbound and outbound tourism spending facilitated by expansion. The net impact is obtained by subtracting outbound spending from inbound spending, and this feeds straight into the GDP for the year under consideration.

B.4 Key relationship 4: Tourism, FDI, trade and productivity, GDP and employment

We break this section into separate relationships:

- Trade, productivity and GDP;
- FDI, productivity and GDP;
- GDP and employment

B.4.1 Trade, productivity and GDP

A large body of academic research investigates the positive impact of trade on productivity at the firm level. At the economy-wide level, there are also some studies which suggest additional trade leads to higher productivity. The key mechanisms by which trade influences productivity can be characterized in three ways:

- **Innovation** – trade is one of the key "transmitters" of innovation as it exposes companies to a wider range of products and processes in other countries. This applies regardless of whether the partner country is a developed or developing economy.
- **Competition** – as trade increases the market size companies that export or import are faced with more intense competition. Competition puts pressure on companies to be more efficient. This applies to trade with any partner country.
- **Economies of scale** – larger market sizes imply that production processes can benefit from economies of scale. This also applies to trade any partner country.

For example, the OECD (2012) found that: "A main channel through which trade increases income is productivity growth. Importing creates competition that forces domestic firms to become more efficient and provides access to inputs of international calibre; exporting creates incentives for firms to invest in the most modern technologies, scales of production and worker training. The combined effect is to spawn a process of continual resource reallocation, shifting capital and labour into activities with higher productivity".

Importantly, the impact of trade on productivity holds for both exports and imports. This is because we are considering the long-term impact on trade on productivity instead of the short-term. In the short-term import substitution can lead to structural changes in the economy that require some adjustments. However, once resources are allocated to more productive uses, imports have a long-term positive impact on productivity. The study that underpins our main assumption uses a measure of "real openness" which is the sum of exports and imports over GDP.

The OECD has undertaken a study with data from 21 high-income countries over nearly 30 years controlling for other factors: every 10-percentage point increase in trade exposure (as measured by trade share of GDP) contributes a 4-percent increase in GDP per capita. Similarly, in 2007 the European Commission stated that *"For instance, empirical analysis indicates that, on average, a 1% increase in the openness of the economy, as measured by the ratio of imports to value added, results in an increase of 0.6% in labour productivity in the following year".* To select a conservative assumption, we have used the lower figure of 0.4 as indicated by the OECD research.

B.4.2 FDI, productivity and GDP

Both inward and outward FDI have a positive impact on productivity and competitiveness. Our research suggests that access to new markets, cheaper inputs and new technology or know-how boosts the scale and efficiency of domestic production. The underlying theory is similar to that applied to free trade agreements. Figure 59 summarizes how FDI can impact on productivity.

Figure 59. Impact of FDI on productivity

	Rationale	Long term impact of FDI
Horizontal FDI	Direct access of new markets	• In the long run firms gain competitiveness by accessing new markets or penetrating existing ones • Productivity and hence domestic production increases
Vertical FDI	Access to cheaper inputs	• Firms can import intermediate goods from foreign plants at lower costs • Firms can produce a greater volume of final goods at lower costs • This new production chain is more efficient • Competitive positive improves and domestic output increases
Technology-sourcing FDI	Access to new technologies	• Firms acquire foreign firms or establish R&D facilities in "foreign centres of excellence" • Transfer of technological know-how, management techniques and other knowledge back to parent company • Productivity and hence domestic production increases

Evidence on the specific impact of FDI on productivity is limited. We have found the following studies:

- DIW (2009) studies the relationship between outward FDI and economic growth. They find that FDI enables firms to enter new markets, import intermediate goods from foreign affiliates at lower costs and access foreign technology. As a result the domestic economy benefits from outward FDI due to increased competitiveness of the investing companies and associated productivity spill-over to local firms. The analysis shows that for every 1 per cent increase in outward FDI stock, local GDP increases by 0.19 per cent.
- Korea Institute for International Economic Policy (2008) studies the relationship of inward FDI and productivity using Ireland as a case study. They find that FDI advances new foreign technology or import of new intermediary goods and enhances growth by accumulation of human capital by means of labour training or absorption of technology and new management techniques. Their analysis shows that for a 1 per cent increase in inward FDI stock, local GDP increases by 0.24 per cent.

Based on the quantitative analysis we reviewed, we make the following assumptions:

- a 1% increase in inward FDI increases productivity and thus, GDP by 0.24 %; and
- a 1% increase in outward FDI increases productivity and thus, GDP by 0.19%.

B.4.3 GDP and employment

The relationships between trade, FDI and GDP give us a percentage change in GDP resulting from the change in trade and FDI. To estimate the value of this impact in money terms, we use GDP forecasts for the UK based on inputs from the IMF and HSBC.

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