CAA H7 Forecast Review

Final Report

October 2021

SKYLARK consulting group

Scope of the Report and Limitation of Liability

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Skylark Consulting Group Limited

September 2021

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Executive Summary

This report responds to the request from the CAA to provide a high level and independent review of their response to the traffic forecasts provided by Heathrow Airport Limited (HAL) in support of the 7th quinquennial regulatory review (H7), as per the scope of work described in the Appendix.

Skylark concludes that the approach and specific challenges developed by the CAA are reasonable and proportionate. In some areas Skylark believes that the CAA should challenge further and in others that the Heathrow assumptions are reasonable but require further clarification or supporting evidence.

Market Share

The CAA disagrees with HAL's assumption and forecast output that LHR's market share will not return to 2019 levels during H7. Skylark regards the CAA assumptions as reasonable, owing to market shocks historically forcing concentration at LHR.

Airline Trends

HAL argues that the impact of the pandemic will reduce widebody activities at LHR and that airlines will also be limited in the speed at which they can provide additional capacity to meet recovery in demand. The CAA disagrees with both of these assumptions and has made upwards adjustments to the forecast of 7.3 million passengers as a result. Skylark views the CAA assumptions as reasonable; although HAL's B747 retirement assumptions are reasonable, Skylark is more optimistic surrounding the use of A380 aircraft. Skylark also believe that airlines present at LHR will provide additional capacity as soon as demand increases or that any spare capacity will be filled by new entrants, given the attractiveness of capacity at LHR.

Airline Fares

HAL have included airline fares as an input to their forecast model. There is no industry consensus on approaches to quantitative forecasting analysis using airline fares; some commentators and organisations utilise airline fares as an input, while others believe that airline fares are better viewed as an output. The CAA accepts the use of assumed impact of carbon prices on fares but have removed the impact on fares as a result of the proposed reduction in business travel. The CAA believes that in the case of LHR, business fares will adjust according to the market. Skylark believes that the CAA's assumption is reasonable, as LHR is a congested airport and operates within a competitive multi-airport system. Ticket prices are likely market driven and difficult to forecast accurately over the regulatory period.

Slot Allocation Impact

Skylark believes that HAL's assumption that slots will go un-utilised over the regulatory period is overly pessimistic. Skylark believes that airlines will either reallocate capacity to profitable routes or partner airlines or sell slots to new entrants. Skylark recommends that the CAA request additional scenarios in this regard to be modelled.

Economic Forecast Scenarios

Skylark supports the underlying importance of GDP forecasts as a fundamental driver of HAL's traffic growth, and the combination of regression analysis utilising those econometric drivers for a globally important hub airport such as Heathrow would represent industry best practice. Skylark believes the CAA are correct in maintaining HAL's methodology of matching GDP and traffic scenarios given the variance in recovery outlooks.

Executive Summary

Skylark's recommendation is for the CAA to continue with their current approach, but request for HAL to provide the most up-to-date GDP forecasts, given the speed at which Covid-19 recovery outlooks change.

Business Traffic

HAL models a 10%-30% permanent reduction of business travel customers based on individual market share thresholds which has been accepted by the CAA as part of the H7 assumption base. Skylark believes there is little empirical evidence to support a permanent shift in business behaviour based on the supporting evidence provided, and would consider forecasts underpinned by GDP growth to be a more appropriate mechanism to capture any potential changes in business activity.

Decay Function

Skylark concurs with HAL and the CAA with the principle of introducing an additional travel restrictions model to reflect the continuing uncertainty of government interventions related to Covid -19. However, Skylark believes the use of the overlay Decay Function model potentially leads to an underestimate of traffic recovery which the CAA could challenge further.

Monte Carlo Analysis

The CAA should consider whether the lower performing scenarios are weighted appropriately given the material impact this has on the output.

Should the mooted risk-sharing arrangement be entered between HAL and Heathrow's airlines, it would seem reasonable to remove the upper and lower scenarios from the forecast altogether, and retain the mid case only.

Otherwise, Skylark believes the CAA's adjustment to be consistent with Q6, and reasonable. This is particularly so as applying a truncated distribution is even less appropriate during H7 given the headroom between the forecast and LHR capacity caps.

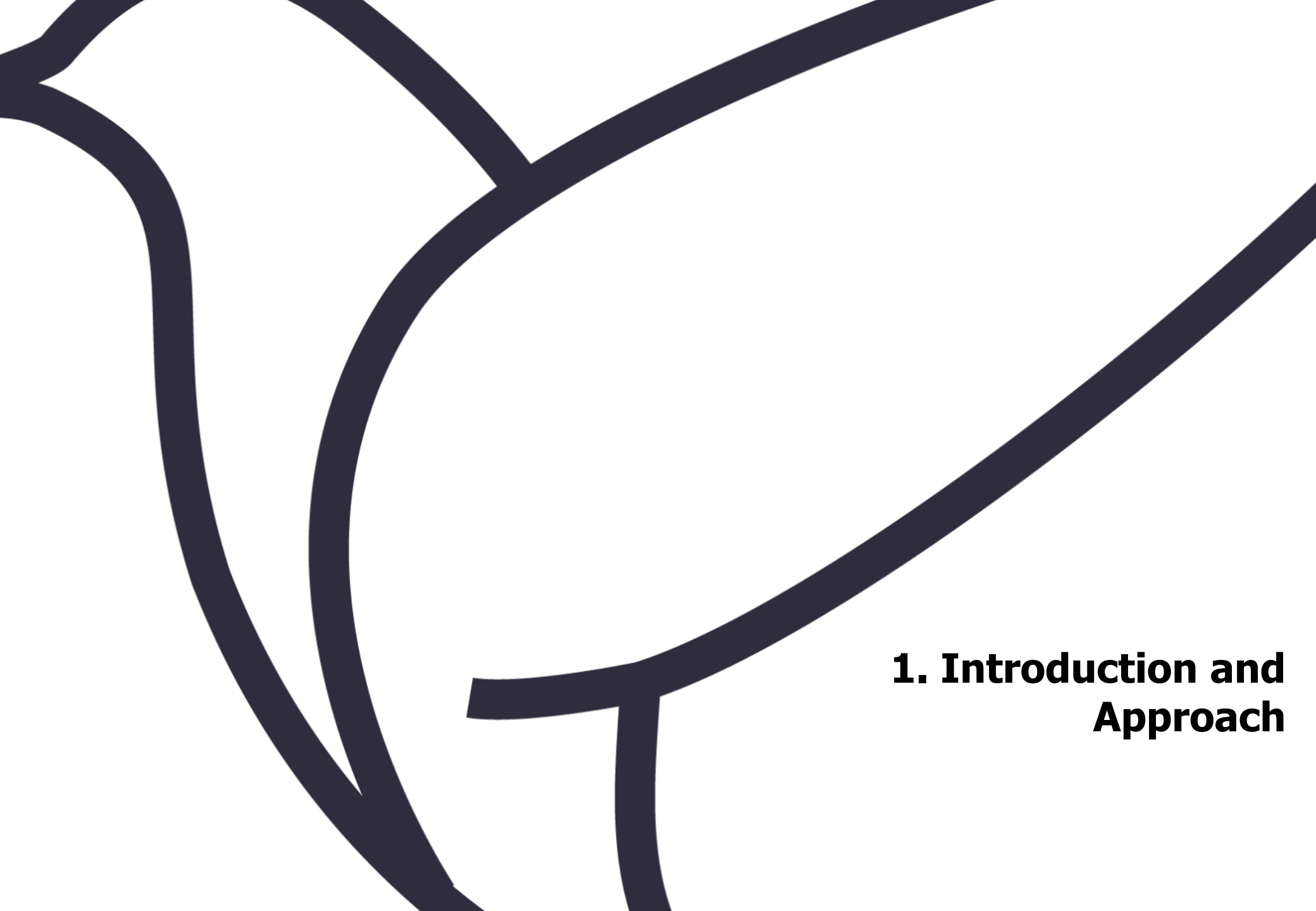
Shock Factor

Shock Factors are not, in Skylark's experience, a conventional part of a 'mid' forecast, as the presence of shocks is included in the outputs of a regression analysis of traffic drivers. This does not imply that their use is invalid, but if an additional factor is included, drivers should exclude the impact of shocks to avoid double-counting. It is understood that this exclusion is done by HAL and is part of the CAA model.

Assuming other drivers do exclude shocks, Skylark accepts the CAA's inclusion of a shock factor as reasonable, and also considers the application of a value of -1.07% to be reasonable.

Model Complexity

The model appears to have undergone a lengthy evolution with functionality gradually added. The various additions and overlays implemented to account for the pandemic, along with additional manual adjustments, reduces transparency and makes examination of the underlying inputs and drivers complex, compounding the asymmetry of information.



1. Introduction and Approach

Introduction

- Skylark was selected by the CAA to provide an independent third-party review of their current traffic forecast of Heathrow Airport ("LHR"). A later iteration of this forecast will be used to set Heathrow Airport Limited's ("HAL") price control arrangements for the upcoming regulatory period ("H7").
- The review is intended to improve confidence in forecast outputs by improving the robustness of the forecast approach and the associated model.
- The CAA's forecast model is based on HAL's forecast model with assumptions modified where the CAA's view diverged from that of HAL. Skylark has *not* undertaken a detailed review or audit of the model itself. The task as communicated by the CAA was to:
  - Review the CAA's use of the model as fit for purpose
  - Review the reasonableness, appropriateness, and completeness of the model drivers and input assumptions.
- Skylark does not offer an opinion on the absolute correctness of the CAA model outputs, or their relative correctness compared to the HAL Revised Business Plan.
- As well as reviewing the 'conventional' aspects of the forecast, Skylark has examined issues around the Covid-19 pandemic and the ongoing recovery. This factor dominates the short-term forecast.
- The review was conducted over a short term of three weeks which restricted the methodology to a high level analysis and precluded the opportunity to carry out a detailed interrogation of the HAL models or interviews of airlines and HAL itself.
- The review has been undertaken independently, with the CAA providing limited guidance such as outlining the model structure and answering specific queries. As detailed above no discussion, either verbal or written, has been entered into with HAL, airport users, or any other party.

Approach

Top-Down Review

- The overall approach was compared to industry best practice and conventional methodologies. Specifically the key assumptions and drivers of demand were verified. While all assumptions were reviewed, particular attention was applied to those assumptions where the CAA view varied materially from the HAL view.
- Consideration was given to:
  - The specifics of Heathrow's traffic mix (such as the relative bias to long-haul flights, the proportion of passenger transfers, and the business/leisure mix)
  - The relationship between Heathrow and other commercial airports serving London
  - The position of Heathrow as a transfer hub competing with other hubs such as Frankfurt or Paris CDG

Secondary Analysis

- To support Skylark's top-down views, a number of secondary analyses were conducted to test hypotheses. For example, the recovery profile related to other supply shocks was examined to inform views on general recovery behaviour at LHR. Relevant analyses are presented later in this document.

Review of Model Behaviour

- Skylark examined the materiality of major factors by varying input conditions to determine the impact on model outputs. Due to the project's time constraint and model complexity, this analysis was limited as previously described. However Skylark notes that, as far as it is aware, the CAA believes the model operates and performs in line with expectations. The Skylark findings supported this conclusion.
- The appropriateness of the Monte Carlo analysis was reviewed. Skylark also provided a view on the probability distributions and weighting of the factors (where known).

Primary Data Sources

- In addition to using subscription data sources and publicly available information, Skylark was granted access to:
  - The HAL RBP model (as updated in June 2021)
  - The CAA adjusted version of the HAL model (including a description of the amendments made to the HAL model)
  - Limited CAA correspondence on their model
  - Limited sections of RBP documentation concerning assumptions and model functionality

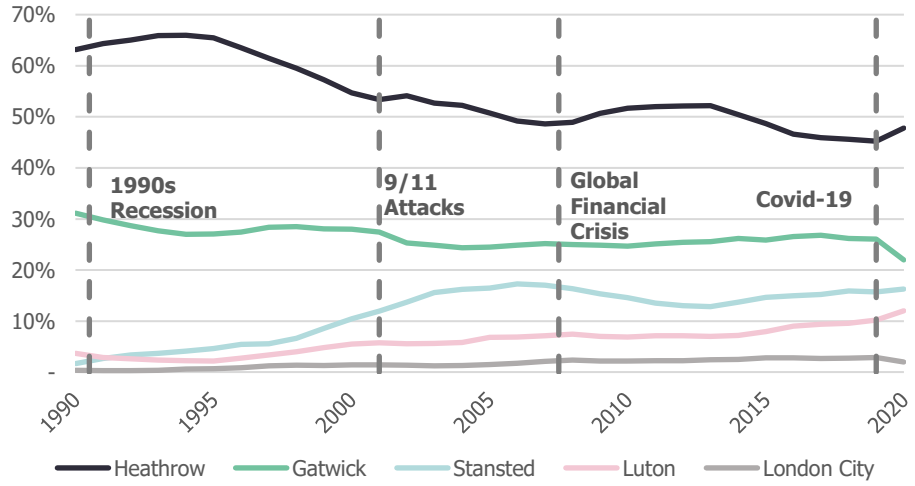
2. Market Share

Market Share

London System Shock Concentration

- The CAA believes that HAL is understating the strengthening of LHR's share of the London market during the recovery period. The CAA also disagrees with HAL's assumption and forecast output that LHR's market share will not return to 2019 levels during H7.
- Skylark regards the CAA's views as reasonable and justified by the following evidence:
  - Historically, previous shocks have forced concentration on LHR at the expense of other airports in the London system.
  - Heathrow's share of the London airport system increased following major crises, including the 1990s recession, 11th September 2001 attacks, and the Global Financial Crisis.
  - Concentration towards Heathrow is occurring again, with the withdrawal of British Airways and Virgin Atlantic from LGW.
  - The ending of Norwegian's long-haul services in January 2021 has significantly reduced transatlantic capacity at LGW, increasing LHR's share of the London-transatlantic market. This has been further reinforced by JetBlue's recent commencement of services at LHR.
- Skylark believes that in the absence of additional runway capacity at Heathrow in the longer term, market share will decrease as total London demand rises.

Market Share of London Airport System Passengers, 1990 - 2020



11 *Source: CAA*

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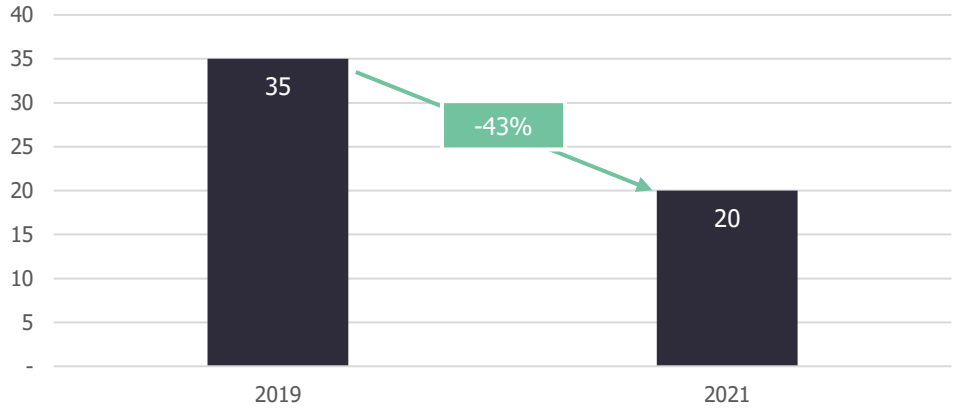
Market Share

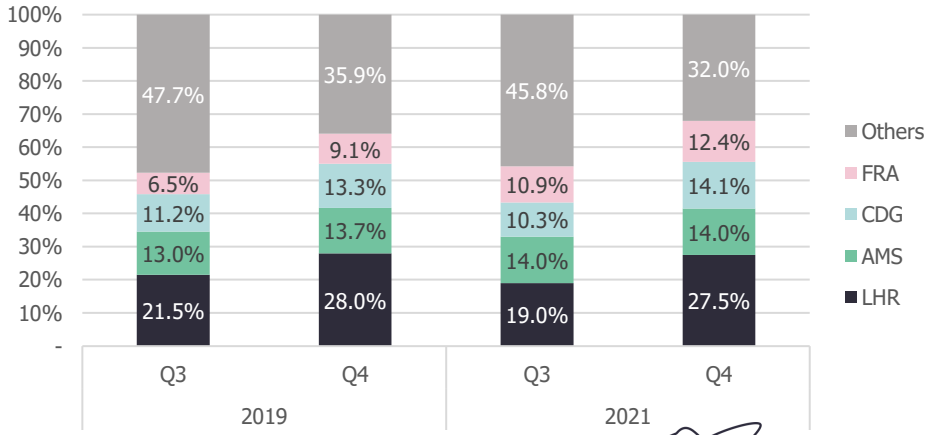
Transatlantic Operations to European Hubs

- HAL traffic forecasts result in Heathrow losing market share to competing hubs over the forecast. Skylark believes that this is unlikely to occur over the H7 period to the extent that HAL claim, due to the capacity currently available.
- American, Delta, and United have sharply reduced the number of European routes they offer, decreasing from 35 in H2 2019 to 20 in H2 2021.
- The decrease in routes has directed traffic towards the four main European hubs: LHR, AMS, CDG, and FRA. This saw the hubs' market share of transatlantic operations increase from 52.3% in Q3 of 2019 to 54.2% in Q3 of 2021 at the expense of secondary and tertiary airports.
- Frankfurt has capitalised most on the concentration, increasing its 2019 share from 6.5% to 10.9% in Q3, expected to rise to 12.4% in Q4 of 2021. This is due to the less onerous restrictions in Germany compared to the rest of Europe.
- OAG schedule data for Q4 2021 shows Heathrow recovering market share to 2019 levels and remaining in line with other European hubs.
- Skylark concludes that the gradual recovery of traffic from the Covid-19 pandemic supports the trend of hub airports benefitting in terms of market share compared to non-hub airports. Heathrow is consistent with that trend and does not appear to be losing market share to other hubs.
- This leads Skylark to believe that the CAA is reasonable in its assumption that LHR's share of the London market will return to and surpass 2019 levels during the H7 period.

Number of European Destinations Served by AA, DL, UA H2 2019 vs. H2 2021



European Hub Share of Transatlantic Arriving Seats 2019 vs. 2021



 Source: OAG

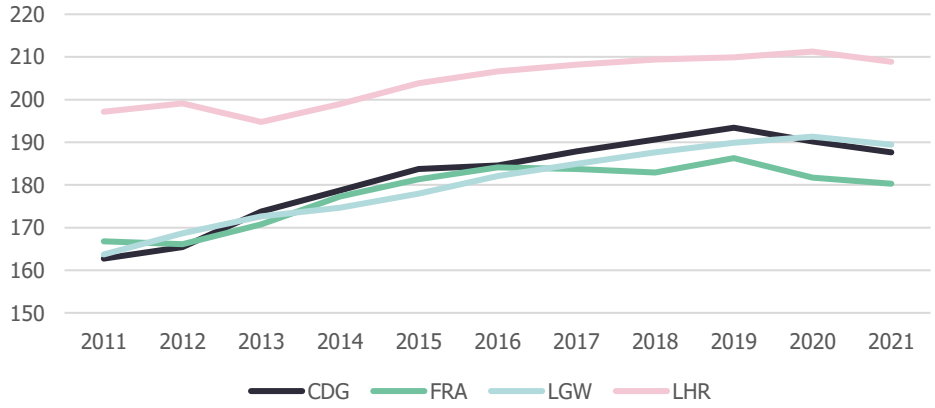
3. Airline Trends

Airline Trends

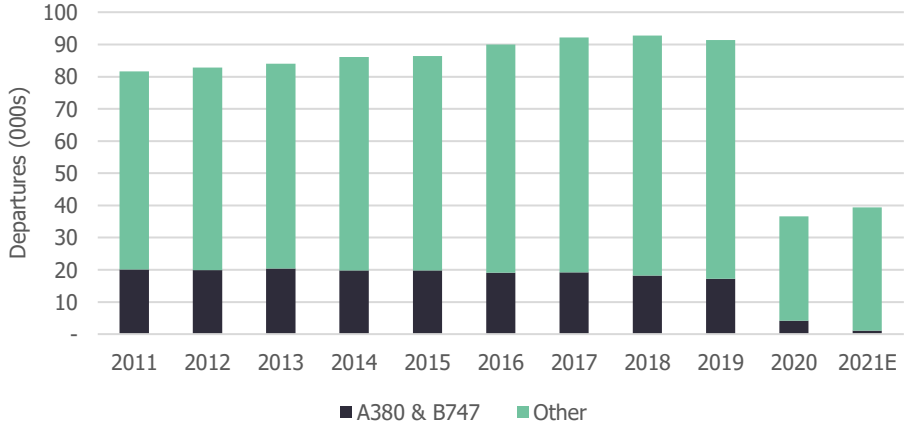
Widebody Trends

- HAL argues that the pandemic will reduce widebody use by their airlines and so will adversely affect the traffic forecasts. The CAA agrees that widebody usage will reduce as a result of the pandemic but will not impact traffic to the extent forecast by HAL.
- Due to the capacity constraint at Heathrow, the airport has seen increased numbers of widebody operations as airlines try to increase the number of passengers per flight. B747 and A380 aircraft accounted for 25% of widebody seat capacity in 2019.
- B747 operations have been declining over the last 5 years, with the Covid-19 pandemic forcing the last B747 aircraft based at Heathrow into retirement.
- A380 operations have seen a slight decline in recent years from a peak of 9,268 movements in 2017 down to 8,003 movements in 2019. The future use of A380s is uncertain for many airlines following the Covid-19 pandemic.
- Combined B747 and A380 retirements may result in a short-term reduction of seats per ATM at Heathrow as the aircraft are replaced with smaller widebodies. A typical BA seating configuration may yield 469 passengers on A380s, and 345 passengers on B747s.
- B787 and A350 deliveries are expected to comprise the majority of future widebody deliveries. Typical configurations may yield 215 and 330 passengers for these aircraft respectively though this can vary substantially depending on the configuration.
- In the long term, Skylark expects the reduction of seats per ATM by B747 and A380 retirements to be offset largely by the increase in other widebody operations.
- Furthermore, the reduced separation distances required following lighter aircraft, as per the eTBS* system, could lead to better slot utilisation during popular hours and would improve resilience at the airport, though the total number of movements would still be limited by the 480,000 ATM cap.

Average Seats per ATM



Widebody Operations at LHR, 2011 – 2021E



Source: OAG, British Airways

**The Enhanced Time-Based Separation (eTBS) system used at Heathrow determines the minimum time between movements based on the wake turbulence interaction of aircraft pairs.*

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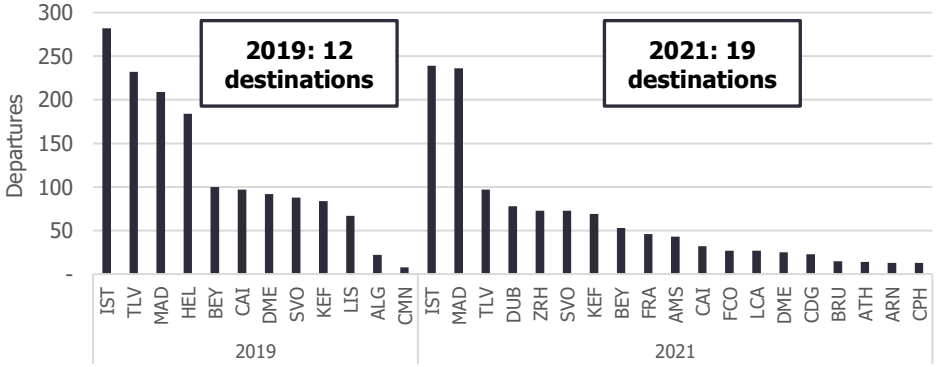
Airline Trends

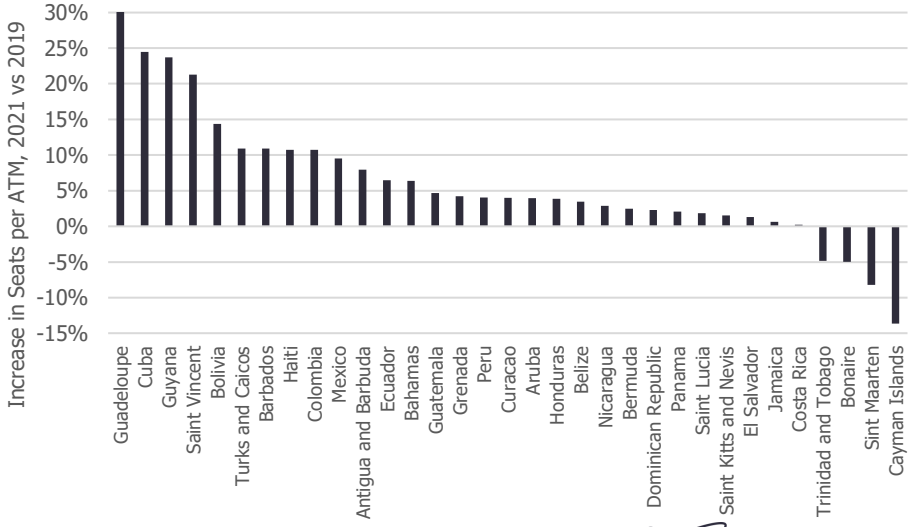
Route Network

- Heathrow has benefited from airlines consolidating to LHR using mid-size widebody and large narrowbody aircraft.
- This is supported by recent British Airways and industry statements that BA will operate leisure and VFR routes to short-haul European destinations utilising larger aircraft.
- While operating widebody on these routes is not sustainable in the long term, airlines are able to offset some of their fixed costs by operating them on shorter routes until profitable long-haul operations are able to resume.
- The number of short-haul (<5 hour) destinations served by British Airways widebody aircraft has increased from 3 in Q3 2019 to 12 in Q4 2021.
- Notable examples of new widebody BA routes to European destinations include B787 services to Larnaca, Amsterdam, and Stockholm, and B777 services to Rome–Fiumicino.
- Iberia widebody operations to Madrid have more than doubled, increasing from 95 operations in Q3 2019 to 224 in Q3 2021.
- The overall share of widebody aircraft serving routes <5 hours increased by 86% between Q3 2019 and Q3 2021. This resulted in an increase in average seats per ATM of 4.8% from 165 in Q3 2019 to 173 in Q3 2021 for these routes.
- Further evidence of airlines reallocating widebody aircraft on shorter routes can be seen in US routes to South and Central American destinations.
- Use of widebody aircraft on US international (excl. Canada) routes <5 hours more than doubled, increasing by 117% between Q3 2019 and Q3 2021. This resulted in an increase in average seats per ATM of 8.1% from 146 in Q3 2019 to 158 in Q3 2021 for these routes.
- This also leads Skylark to believe that the CAA's assumption that widebody activities at LHR will not decrease is a reasonable and appropriate assumption.

Widebody Operated Short-Haul (<5 hour) Routes at LHR



US International Short-Haul Seats per ATM, 2021 vs. 2019



 Source: OAG, British Airways

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Airline Trends

Specific Aircraft Type Assumptions

- HAL have assumed the retirement of larger aircraft, most notably the B747 and A380, in their forecast.
- Travel restrictions as a result of Covid-19 have resulted in the largest aircraft, including A380 and B747, being the least utilised. This has led to the early retirement of many of these aircraft with several airlines suspending operations of these aircraft from LHR.
- The CAA believes that HAL is justified in its assumptions of the retirement of B747 aircraft. British Airways accounted for nearly all B747 movements at LHR in 2019 and has since retired all of its B747 fleet.
- However, the CAA believes HAL's assumptions regarding the retirement of A380 aircraft is overly pessimistic and have added capacity to the forecast to account for airlines that plan to continue utilising A380 aircraft.
- Emirates currently operate four A380 flights from LHR to Dubai daily, increasing to six daily by November 2021. British Airways has announced plans to resume A380 operations from Heathrow, with aircraft leaving storage in Madrid to begin checks.
- Similarly, Qantas are reactivating five A380s for UK and US services next year, while schedule data shows the resumption of daily A380 operations to Singapore through Singapore Airlines in November 2021.
- British Airways, Emirates, Qantas, and Singapore accounted for approximately 73% of A380 operations in 2019.
- The CAA have made an upward adjustment of 2.0 million passengers in the mid case to account for the change in assumption of retiring A380 aircraft. Given the described plans of key airlines, Skylark regards this assumption as reasonable, proportionate and appropriate.

Plans of Airlines Utilising A380s at LHR

Airline	Airline Plans
British Airways	Committed to continuing A380 operations. Signed contract with Lufthansa Technik to extend maintenance contract for its twelve A380s for at least 5 years from August 2022.
Emirates	Six A380 flights daily from November 2021.
Qantas	Reactivating five A380s for UK and US services mid-2022.
Singapore	Currently performing maintenance and upgrading cabins in aircraft. Schedule data shows resumption of daily A380 operations to SIN from LHR in November 2021.

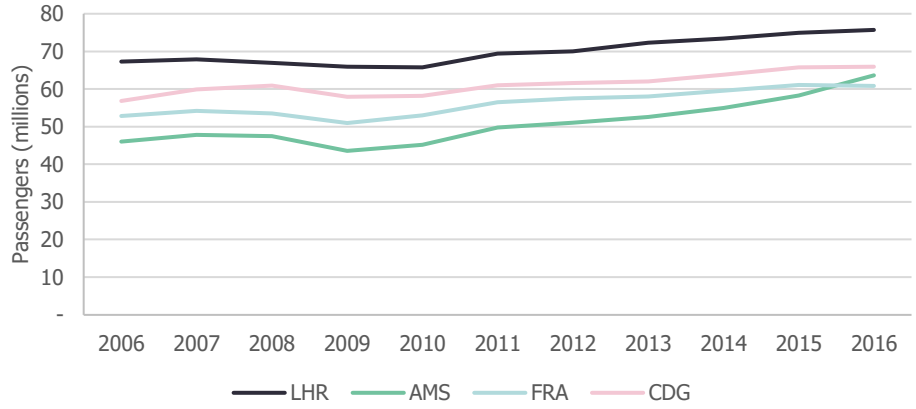
 Source: Lufthansa Technik, Emirates, Qantas, OAG

Airline Trends

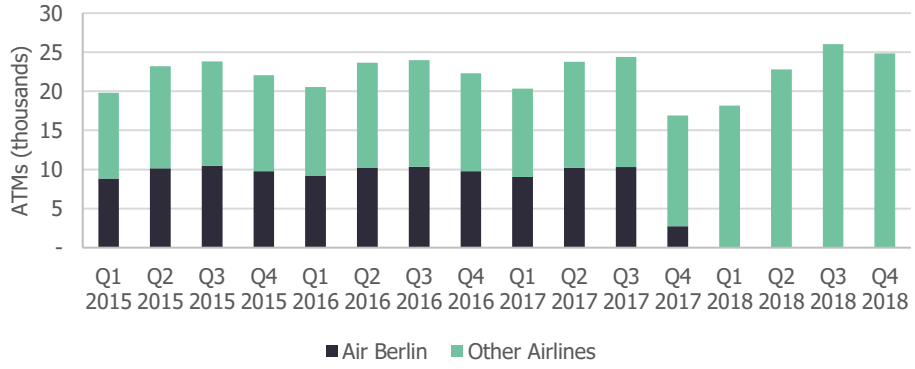
Capacity Recovery

- HAL have assumed that airlines will be limited in the speed at which they can adjust the capacity they provide at LHR to meet recovery in demand.
- The CAA believes that airlines present at LHR will be able to extend capacity to meet increases in demand and that spare capacity at Heathrow will be a draw for new entrants.
- Airlines have historically shown rapid recovery of capacity to meet passenger demand following previous shocks to the aviation industry. Existing airlines will cater to leisure and VFR until business demand picks up to offset fixed costs (i.e., aircraft) as long as variable costs such as labour and fuel are also covered.
- While airlines taking aircraft out of storage and ensuring pilot availability may slow the return of capacity, Skylark does not consider this an issue when taking into account the recovery timescale.
- Following the Global Financial Crisis, Heathrow's passenger traffic recovered in line with other European hubs, surpassing 2007 traffic in 2011.
- This trend is expected to remain following the pandemic, with Heathrow recovering at a rate comparable to major European hubs.
- Liquidity and profitability issues amongst airlines currently operating at LHR can lead to alternative airlines entering the markets to opportunistically take up demand; for example, JetBlue recently initiated a programme to John F. Kennedy International Airport from Heathrow in August.
- The trend of new entrants entering the markets of major European airports to fill capacity is also shown in the context of airline bankruptcies. Following Air Berlin's collapse in October 2017, capacity at Berlin Tegel was quickly replaced by other airlines as seen in the adjacent figure. Capacity limitations and high slot demand at Heathrow would serve to further increase the speed at which any spare capacity is taken up by other airlines.
- The impact of this assumption change is material and the CAA estimates this to account for approximately 5.3 million more passengers over H7 which Skylark concludes is reasonable.

European Hub Traffic Performance Post-Global Financial Crisis



Outbound ATMs at Berlin Tegel Airport Following Air Berlin Collapse



 Source: Airport websites

4. Airline Fares

Airline Fares

Fares as Modelling Inputs

- As part of their forecasting methodology, HAL have included airline fares as an input to their model.
- There is no accepted industry consensus on approaches to quantitative forecasting analysis using airline fares; many industry players such as ICAO incorporate airline fares as an input into their forecasting techniques, whereas other scholars of the subject believe that fares are better viewed as an output of a forecast.
- Rejections of airline fares as input assumptions are typically based on one of several factors:
  - In competitive markets such as congested airports or multi-airport systems, airlines often have limited control over airline fares (O'Connor 1982)
  - Forecasting air fares can be difficult as factors such as oil prices are volatile and hard to forecast (Doganis, 2004)
  - Using average fares can prove to be challenging since fares often depend on factors such as competition, distance, travel time, and fare class (Lee 2003)
- The CAA accepts the use of assumed impact of carbon prices on fares as an input but has removed the impact on fares as a result of the proposed reduction in business travel. The CAA is of the opinion that the effect of reduced travel on average fares will adjust according to the market and thus should not be included as an input assumption to the forecast.
- In the case of Heathrow Airport, Skylark believes that the CAA are reasonable in their decision to remove the impact of the proposed reduction in business traffic since Heathrow Airport is a congested airport and operates within a competitive multi-airport system. Skylark believes that airline fares are likely to be market driven over the period of the regulatory review.

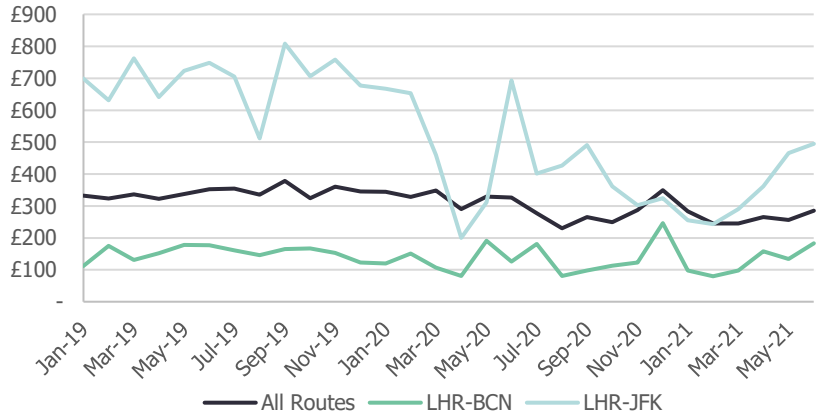
Source: Journal of Air Transport Management, 'Gravity Models for Airline Passenger Volume Estimation', Grosche, Rothlauf, and Heinzl (2007)

Airline Fares

Fare Increases

- In its forecast scenarios, HAL assumes fare increases due to the expected impact of carbon prices, and further increases of either 10% or 15% from 2024 (except in the Pent-Up Demand case) due to the effect of business demand on average fares. This results in a material reduction in passengers.
- The airline community raised concerns over the forecast increases of fares during the H7 period as they are experiencing little business demand, typically the driver of higher fares, and they expect that business demand will have the slowest recovery. As long-haul and business traffic recovery is currently trailing short- and medium-haul, Skylark would expect average fares to decrease in the short- and medium-term as shorter flights typically have cheaper fares.
- Although HAL do not assume fare increases until 2024, there is little evidence currently to support any such increase. As seen in the charts, average fares on routes from Heathrow were 19% lower in June 2021 than they were in June 2019.[1] Average fares on high-yielding business routes such as Heathrow-New York JFK remain substantially lower than they were before the pandemic.
- That said, care should be taken with this data for two reasons. Firstly, the very low volumes seen during the pandemic lead to price volatility, as which can clearly be seen in the charts. Secondly, during the pandemic passengers were likely to be travelling for essential reasons; this means they are less price-sensitive which allows the airlines to charge higher fares which are not representative of future behaviour. This may be the reason behind the rise in average full-price economy fares, which is not mirrored in either business or discounted economy fares, or in the total average.
- Given the questionable reliability and variability of recent data, and the refutation of the assumption of fare rises by the airlines themselves, Skylark is of the opinion that the fare rises are not currently a supportable driver of the model.
- Skylark would recommend that average fares are reviewed once fare data is available for the full summer and early autumn period, as traffic recovers more significantly and non-essential, price-sensitive traffic returns.

Average Monthly Fares at London Heathrow by Route, Jan 2019 – June 2021



Average Monthly Fares at London Heathrow by Cabin Class, Jan 2019 – June 2021

1. MIDT data accessed through OAG. Source: OAG

5. Forecasting Techniques

Forecasting Techniques

Slot Allocation Impact

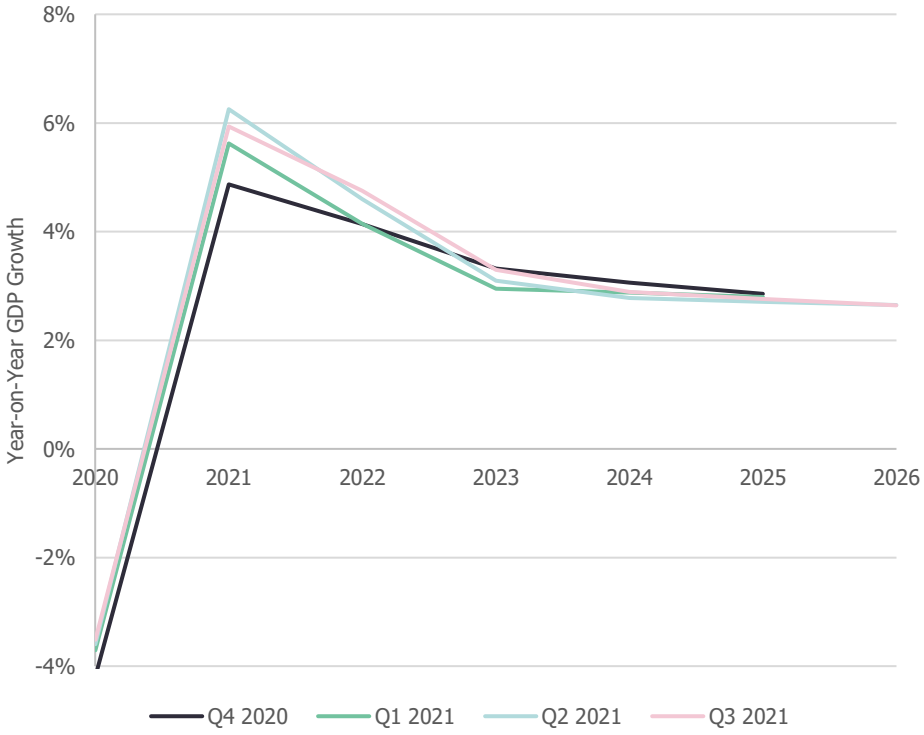
- Slot allocation rules and slot trading at Heathrow are important during periods of low availability in terms of the supply model.
- HAL states that while slot rules are suspended, airlines may retain unused slots, restricting capacity and slowing recovery. Skylark considers this position overly cautious when considering the long-term value of slots at Heathrow and the profitability pressures on airlines holding these slots.
- Skylark considers that airlines will either reallocate capacity to new profitable routes or partner airlines, and in the absence of this opportunity, trade the slots to new airlines wishing to enter the Heathrow market.
- Slots at Heathrow are highly valued and are often traded and sold between airlines, with slots frequently exceeding values of £10 million. For example, Air New Zealand sold a single slot pair for $27 million in March 2020.
- Furthermore, Heathrow slots are higher yielding than at other airports in the London system which may see airlines shift operations to Heathrow should the slots become available.
- Skylark believes that HAL's assumption that slots will go unutilised is overly pessimistic and recommends that the CAA modify their forecast to account for this.

Forecasting Techniques

Economic Forecast Scenarios

- In their model, HAL have matched forecast scenarios to GDP scenarios from Oxford Economics.
- The CAA has accepted the use of Oxford Economics GDP scenario forecasts.
- Skylark believes that the CAA are correct in maintaining the methodology of matching GDP and traffic scenarios. Given the variability in recovery outlooks, it is right and reasonable to include varying GDP scenarios.
- However, given the speed at which the Covid-19 recovery outlook changes, there has been some variance in GDP outlooks. The adjacent graph displays the variance in Oxford Economics' baseline GDP forecasts produced between Q4 of 2020 and Q3 of 2021.
- Skylark supports the underlying importance of GDP forecasts as a fundamental driver of HAL traffic growth, and the combination of regression analysis utilising those econometric drivers for a globally important hub airport such as Heathrow would represent appropriate industry practice.
- Skylark's recommendation is for the CAA to continue with their current approach and methodology. Given the variability in forecasts throughout the pandemic, the CAA should request for HAL to provide the most up-to-date GDP forecasts.

Variability in Baseline GDP Forecasts



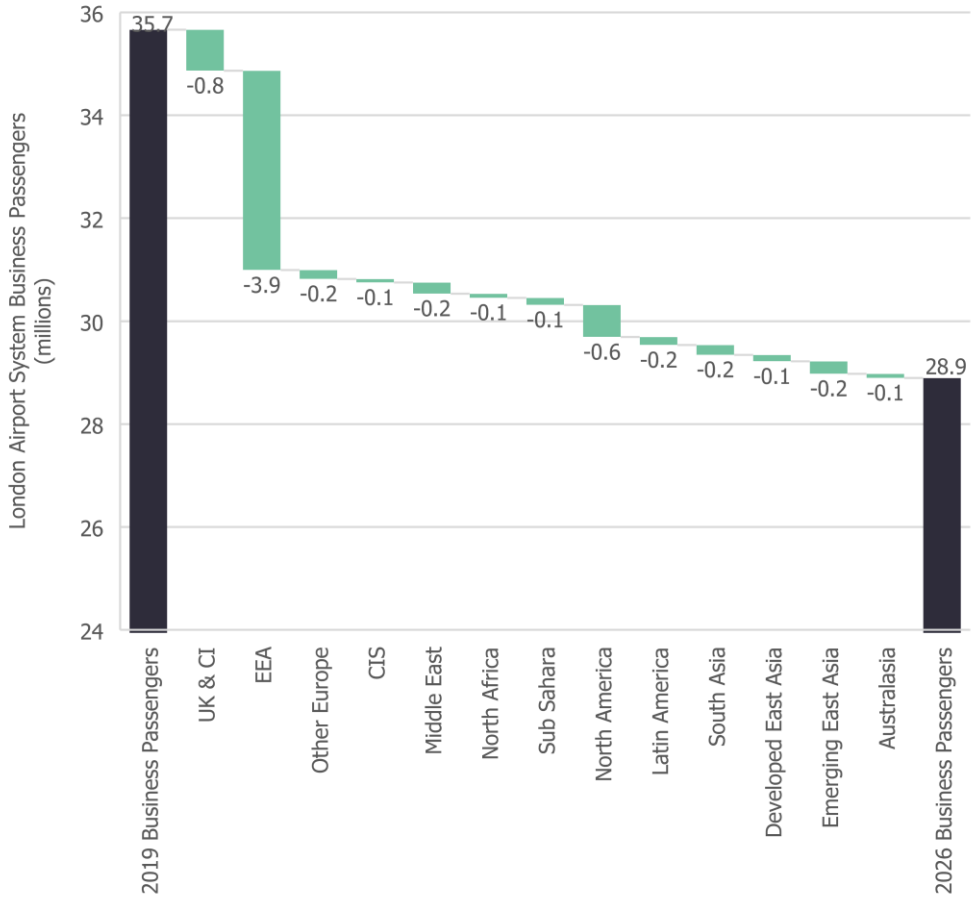
Source: Oxford Economics. Note: Forecasts for Q4 2020 and Q1 2021 only extend to 2025

Forecasting Techniques

Business Traffic Assumptions

- HAL models a 10%-30% permanent reduction of business travel customers in the London airport market based on individual market share thresholds which has been accepted by the CAA as part of the H7 assumption base.
- The adjacent graph depicts the modelled reduction in business passengers at London system airports across the H7 period. Across H7, in HAL's Steady Build scenario with medium impact on business travel, business passengers are forecast to fall by 19% and are forecast to fall in every global market.
- Whilst the concept has some qualitative and anecdotal support from IATA and technology-based commentators, there is little empirical evidence to support a permanent shift in business behaviour based on the supporting details HAL provide.
- The airlines refute this assumption and assume that business traffic returns to trend following leisure recovery, which would be a more traditional approach.
- Skylark considers the business traffic assumption as a speculative one which unusually assumes a permanent shift in business behaviour as a result of a health-related shock to the system (rather than the supporting case study of the global financial crisis).
- Skylark would consider forecasts underpinned by GDP growth to be a more appropriate mechanism to capture any potential changes in business activity.

HAL's Forecast Reduction in London System Business Passenger Traffic[1] by Region



 1: 2019 Business Passengers taken from 2019 CAA Passenger Survey. Source: HAL

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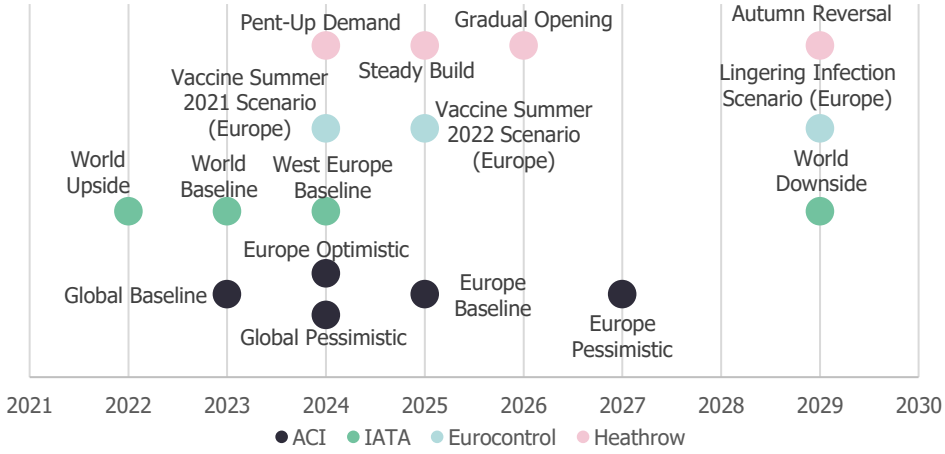
Forecasting Techniques

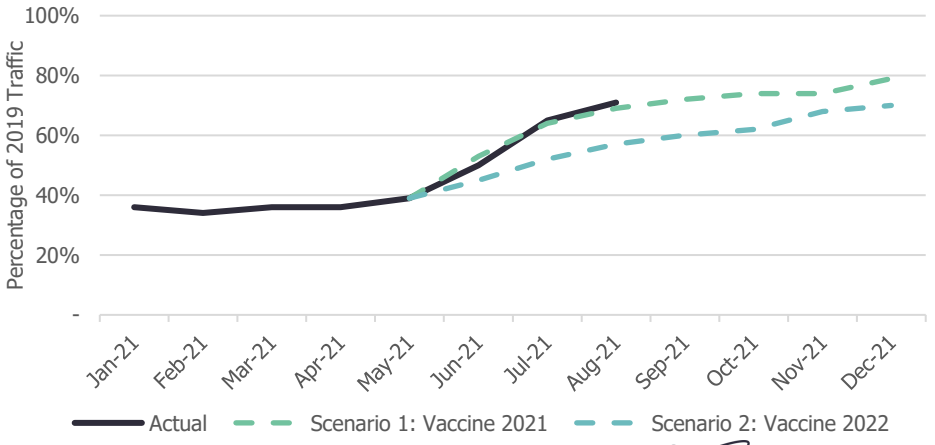
Use of Decay Function Overlay Model

- HAL uses an overlay on the global demand model referred to as the Decay Function. This aims to capture global demand recovery factors achieving 2019 traffic levels and uses as a guide a combination of four industry forecasts together with a speed of recovery profile.
- The approach applies a date at which 2019 traffic levels are achieved and, based on the recovery profile from April 2020 to December 2021 at Heathrow, smooths the profile of that recovery (speed factor).
- While Skylark understands the desire to adjust the forecasts to take into account the wider global demand recovery in which Heathrow operates, it is not clear how this approach adds reliability or accuracy to those forecasts.
- Recent updates to the industry forecasts or alternative industry forecasts, which are more positive than those used in the Heathrow RBP and where recovery to 2019 levels are generally one to two years earlier, would have a material impact on any overlay adjustment.
- For example, the Eurocontrol four-year forecast released in May 2021 presented three scenarios. HAL selected "Scenario 2: Vaccine 2022, Recovery ~2025" as a guide for their forecast. In fact, actual data matches the "Scenario 1: Vaccine 2021, Recovery 2024" scenario much more closely, as seen in the adjacent figure.
- As a result, there is an argument that if a Eurocontrol forecast is used as a guide, the year of return levels should therefore be adjusted to 2024 to reflect the more accurate (so far) scenario, bringing it in line with the other updated forecast sources.
- It is common industry practice to compare and contrast specific airport forecasts with established wider industry aviation forecasts; however, the appropriateness of this as an overlay model adjustment is questionable.

Industry Recovery Forecasts



Eurocontrol Traffic Scenarios (Base year 2019)



 Source: ACI, Eurocontrol, IATA, Fitch Ratings

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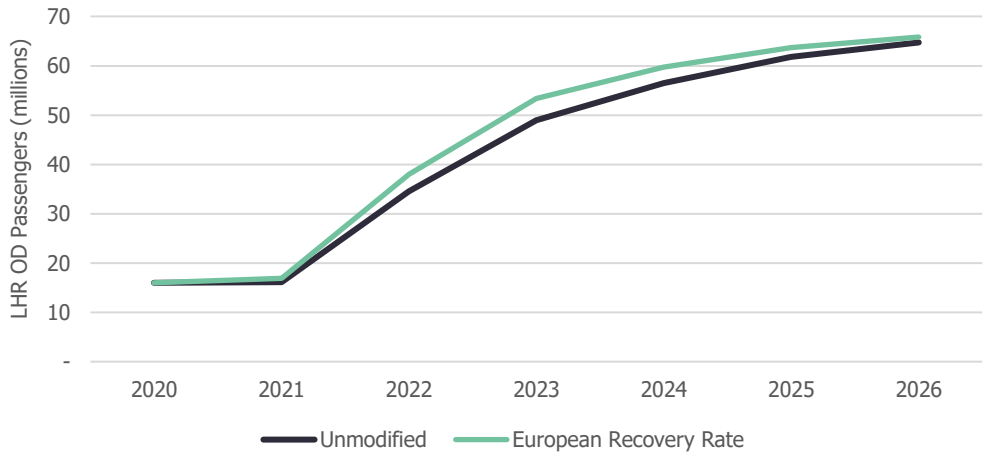
Forecasting Techniques

Model Sensitivity to Decay Function

- The HAL outputs to the traffic forecasts are sensitive to inputs into the decay function overlay model.
- Adjusting the power and scale inputs of the market segment can significantly change the profile of the recovery curves. The sensitivity of the forecast to the decay function is significant as illustrated in the adjacent figure.
- The adjacent figure shows the O&D passenger forecast for LHR with the rates in the current CAA model, and, as an illustrative example, an adjusted curve which assumes the European Economic Area decay profile is applied to all markets.
- The profile difference affects the entire H7 period, reducing to a difference of under one percent in 2027.
- The result of this change is an increase of 5.2% in O&D passengers at Heathrow between 2022 and 2026, or 14.7 million passengers.
- This demonstrates the sensitivity of the model to shape of the decay curve, and the materiality of assumptions on recovery year and recovery traffic input data.
- This analysis is supportive of the airline position that input assumptions in this model are of materiality to the traffic forecasts over the H7 period.
- Skylark recommends that the use of this overlay factor is reviewed in the context of changing industry views on the timing of recovery to 2019 traffic levels and Heathrow's leading position in the global aviation market.

Decay Function Perturbation Example



	2022	2023	2024	2025	2026	Total
Current CAA model (pax m)	34.6	49.0	56.5	61.8	64.7	**266.6**
All at European rate (pax m)	38.0	53.4	59.7	63.7	65.8	**280.6**
Difference (pax m)	3.4	4.4	3.2	1.9	1.1	**14.0**

Forecasting Techniques

Use of Shock Factor

- The CAA accepted a traffic shock factor of -1.2% per annum which was included in the assessment of the traffic forecast for Q6. The CAA refuted airline claims that such a shock factor double counted with the Beta factor in WACC.
- Shock Factors are not, in Skylark's experience, a conventional part of a 'mid' forecast, as the presence of shocks is included in the outputs of a regression analysis of traffic drivers. If an additional factor is included, drivers should exclude the impact of shocks to avoid double-counting; Skylark understands that HAL did do this prior to their regression analysis.
- The shock factor sums historical deviations from LHR's long term traffic trend and expresses such deviations on an annualised basis. As LHR was operating at capacity, all such shocks are on the downside.
- Given this, it would appear reasonable that Covid should be included in the analysis. HAL has calculated that this would result in a 5.16% reduction in annual traffic to account for long-term average shock levels. Excluding the Covid shock from the analysis results in a value of -1.07%.
- The CAA recognises that the risk of a future pandemic (i.e. separate and distinct from the current Covid pandemic) should be part of the overall regulatory settlement. However, the CAA has also stated to Skylark that this will *not* be through a shock-based amendment to the traffic forecast, and thus the traffic forecast shock factor should be calculated with the Covid impact excluded.
- Given this, Skylark accepts the CAA's inclusion of a shock factor as reasonable, and also considers the value of -1.07% to be reasonable.
- Further consideration of a separate, future pandemic as a risk to traffic falls outside of Skylark's scope and is not considered further.

Forecasting Techniques

Use of Monte Carlo

- The use of Monte Carlo ("MC") analysis was established during the Q6 process. By combining multiple probability distributions of driving variables and applying these distributions over a large number of model runs, a predictable and more robust series of outcomes can be selected based on likelihood of occurrence.
- While MC analysis is useful in understand the risk of a sizeable deviation from the mid forecast, its utility in setting a single "charge per passenger" value in the regulatory settlement is questionable as risk elements are considered outside of the passenger forecast.
- In H7, the analysis has been complicated by the inclusion of four scenarios which look at alternative recovery paths from the pandemic. HAL has chosen not to use MC simulation alone to model the range of uncertainty in its forecasts, and instead has opted to run four reference scenarios each with their own MC simulation. The final output table is assembled by randomly selecting outputs from each scenario's MC analysis. The number of outputs selected from each scenario is chosen to match the scenario's weighting.
- This approach does not appear an unreasonable workaround to the modelling limitations, but would, in Skylark's view, benefit from a comparison to a single-run analysis on a more capable system. This would alleviate concerns over the validity of the current two-phase MC analysis, and the potential – though inadvertent – introduction of any bias.
- Skylark notes that the variance between outputs is large, with the P90 output being 65% above the P10 output. This is a consequence of the large variation between the four scenarios, and illustrates the sensitivity of the outputs to the relative weighting of the scenarios.
- The CAA should consider whether the lower scenarios are weighted appropriately. Indeed, should the mooted risk-sharing arrangement be entered between the CAA and HAL, it would seem reasonable to remove the lower scenarios from the forecast altogether.
- The CAA is reliant on HAL's outputs from the MC analysis, which is then subject to an amendment to remove the bias introduced by the use of asymmetric variable distributions. While detailed calculations have not been undertaken, it seems reasonable to assume that the size of the bias correlates with the spread between P10, P50, and P90 outputs.
- Skylark's understanding (based on CAP 1027 from the Q6 process) is that the CAA produced a forecast using the mid value of the variables' truncated normal distributions (the modes), and deducted the difference between this and the full MC analysis remove the bias.
- The CAA has adopted the same approach for H7. Skylark believes this approach is both consistent and reasonable. This is particularly so as applying a truncated distribution is less appropriate during H7 given the headroom between the forecast and LHR capacity caps.

Appendix

Scope of Work

- Skylark has been appointed to independently review the current CAA traffic forecast of Heathrow Airport. A later iteration of this forecast will be used to set HAL's price control arrangements for the upcoming regulatory period, H7. The review is intended to improve confidence in forecast outputs by improving the robustness and defensibility of the forecast approach and the associated model.
- The task is to review the CAA's use of the model as fit for purpose and to evaluate the reasonableness, appropriateness, and completeness of the model drivers and input assumptions. Skylark will not offer an opinion on the absolute correctness of the CAA model outputs, or their relative correctness compared to the HAL RBP.
- Skylark approached the task through three main workstreams:
  - A top-down review of the approach and its implementation in the model, comparing the overall approach to industry best practice and verifying key assumptions.
  - A review of the model behaviour and consistency provided by looking at the model response to input perturbations.
  - A review of model robustness to large changes which may occur should the CAA wish to examine alternative scenarios. This is particularly important given the uncertainties around the post-Covid recovery.

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